Sun. May 26, 2019

[J] Oral | O (Public)：Public

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | IC 2F

[O-01] Exploring Buratamori - How to make science accessible

convener:Kazutaka Mannen(Hot Springs Research Institute of Kanagawa Prefecture), Takayuki Ogata(Disaster Prevention Research Center for Island Regions, University of the Ryukyus), Chairperson:Takayuki Ogata

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[O01-01] Lessons from Buratamori – An introduction to the session

★Invited Papers

*Kazutaka Mannen[1] (1.Hot Springs Research Institute of Kanagawa Prefecture)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[O01-02] **The history of Buratamori**

★Invited Papers

*Mikio Hayashi[1] (1.Japan Broadcasting Corporation)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[O01-03] My experience as a geoscientific guide for the NHK-TV program Buratamori

★Invited Papers

*Masato Koyama[1] (1.Shizuoka Univ.)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[O01-04] A Visualized History by Buratamori

★Invited Papers

*Noriko Matsuda[1] (1.Kyoto Prefectural University)

2:45 PM - 3:15 PM JST | 5:45 AM - 6:15 AM UTC

[O01-05] General discussion 1

*Takayuki Ogata[1] (1.Disaster Prevention Research Center for Island Regions, University of the Ryukyus)

[J] Oral | O (Public)：Public

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | IC 2F

[O-01] Exploring Buratamori - How to make science accessible

convener:Kazutaka Mannen(Hot Springs Research Institute of Kanagawa Prefecture), Takayuki Ogata(Disaster Prevention Research Center for Island Regions, University of the Ryukyus), Chairperson:Kazutaka Mannen(Hot Springs Research Institute of Kanagawa Prefecture)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[O01-06] The role of experiment in NHK's entertainment / educational program "Buratamori"

★Invited Papers

*Shintaro Hayashi[1] (1.Akita University Graduate School of Education)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[O01-07] An attempt of field work for middle and high school students to comprehend an “area” in an integrated manner

★Invited Papers

*Takeshi Uemura[1], Shigeyuki Yokoi[2] (1.Osaka Prefectural Otemae Senior High School part-time course, 2.Kaijo Junior and Senior High School)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[O01-08] Desirable way of outreach activities in the Museum,learn by participating in the making process of "Buratamori".

★Invited Papers

*Inoue Motoko[1] (1.Saitama Museum of Natural History)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[O01-09] Methodology of Geoscientific Outreach of “Buratamori”

★Invited Papers

*Takayuki Ogata[1] (1.Disaster Prevention Research Center for Island Regions, University of the Ryukyus)

4:30 PM - 5:00 PM JST | 7:30 AM - 8:00 AM UTC

[O01-10] General discussion 2

*Kazutaka Mannen[1] (1.Hot Springs Research Institute of Kanagawa Prefecture)

[J] Oral | O (Public)：Public

10:15 AM - 11:25 AM JST | 1:15 AM - 2:25 AM UTC | IC 2F

[O-02] Recent Advances in Earth and Planetary Science

convener:Tatsuhiko Hara(International Institute of Seismology and Earthquake Engineering, Building Research Institute), Katsuyoshi Michibayashi(Department of Earth and Planetary Sciences, Nagoya University), Hajime Naruse(Department of Geology and Mineralogy, Graduate School of Science, Kyoto University), Yasuhito Sekine(Earth-Life Science Insitute, Tokyo Institute of Technology), Chairperson:Kou Yamada

10:15 AM - 10:50 AM JST | 1:15 AM - 1:50 AM UTC

[O02-01] The challenges of Asteroid Exploration Mission Hayabusa2 and its results up to now

★Invited Papers

*Makoto Yoshikawa[1] (1.Japan Aerospace Exploration Agency)

10:50 AM - 11:25 AM JST | 1:50 AM - 2:25 AM UTC

[O02-02] Earth's core revealed by ultrahigh-pressure experiments

★Invited Papers

*Kei Hirose[1,2] (1.Earth-Life Science Institute, Tokyo Institute of Technology, 2.Department of Earth and Planetary Science, The University of Tokyo)

[J] Oral | O (Public)：Public

11:30 AM - 12:15 PM JST | 2:30 AM - 3:15 AM UTC | IC 2F

[O-03] Poster presentations by senior high school students

convener:Tatsuhiko Hara(International Institute of Seismology and Earthquake Engineering, Building Research Institute), Katsuyoshi Michibayashi(Department of Earth and Planetary Sciences, Nagoya University), Miwa Kuri(International Research Institute of Disaster Science, Tohoku University), Kou Yamada(Waseda University), Chairperson:Kou Yamada, Katsuyoshi Michibayashi, Hajime Naruse(Kyoto University), Keiko Konya, Miwa Kuri(東北大学災害科学国際研究所)

11:30 AM - 12:15 PM JST | 2:30 AM - 3:15 AM UTC

[O03-01] Poster presentations by senior high school students

[J] Oral | O (Public)：Public

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 106 1F

[O-04] New earth and planetary science education created by hybrid community between society and JpGU

convener:Yasushi Fujiwara(Evening Classes; Integrated Course, Kanagawa Prefectual Mukainooka Technical High School), Hiroaki Akimoto(Faculty of Economics,Dokkyo University), Chairperson:Yasushi Fujiwara(Evening Classes; Integrated Course, Kanagawa Prefectual Mukainooka Technical High School), Hiroaki AKIMOTO(Dokkyo University)

1:45 PM - 2:15 PM JST | 4:45 AM - 5:15 AM UTC

[O04-01] In the next Course of Study, let's send information on world standard "geography / geography" from Japan to the world

★Invited Papers

*YOJI TAKIKAWA[1] (1.NPO Association of Science Curriculum Initiative NPO Galileo Science Workshop)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[O04-02] What a mantle scientist hopes geoscience education

★Invited Papers

*Natsue Abe[1] (1.R&D Center for Ocean Drilling Science Japan Agency for Marine-Earth Science and Technology)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[O04-03] New high-school compulsory subject “General Geography” and related cooperation of geographers and earth scientists for human resource development

★Invited Papers

*Takashi Oguchi[1] (1.Center for Spatial Information Science, The University of Tokyo)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[O04-04] Visualization of terrain by Red Relief Image Map(RRIM) and geoscience education

★Invited Papers

*Tatsuro Chiba[1] (1.Asia Air Survey Co., Ltd.)

[J] Oral | O (Public)：Public

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 106 1F

[O-04] New earth and planetary science education created by hybrid community between society and JpGU

convener:Yasushi Fujiwara(Evening Classes; Integrated Course, Kanagawa Prefectual Mukainooka Technical High School), Hiroaki Akimoto(Faculty of Economics,Dokkyo University), Chairperson:Yasushi Fujiwara(Evening Classes; Integrated Course, Kanagawa Prefectual Mukainooka Technical High School), Hiroaki AKIMOTO(Dokkyo University)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[O04-05] A lesson plan using Tsunami to cultivate the ability to think critically about a subject based on the data given in New government curriculum guidelines for "Basic Earth Science"

★Invited Papers

*Kodama Hidefumi[1] (1.Chiba Prefectural Matudokokusai High School)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[O04-06] The planning of “Integrated Geography” and its aimed competency

★Invited Papers

*Yasutaka Kogawa[1] (1.Okayama Prefectural Tsuyama High School)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[O04-07] Earth and planetary science education considered by the current student

★Invited Papers

*Hideto Otsuka[1] (1.Geology Course, Department of Science, Faculty of Science, Shinshu University, National University Corporation)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[O04-08] Invitation to Geography —Relationship Between Geography and Intellectual Curiosity in Daily Life–

★Invited Papers

*Takuya Miyao[1] (1.Master Program in Education, University of Tsukuba)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[O04-09] Let's build a bridge between "Rika" and society with new geography and geology education in class

★Invited Papers

*Naoki Hosaka[1] (1.science writer)

[J] Oral | O (Public)：Public

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 101 1F

[O-05] English improvement tips for Japanese scientists

convener:Chisato Yoshikawa(Japan Agency for Marine-Earth Science and Technology), Wonsuh Song(Waseda University), Rumi Ohgaito(Japan Agency for Marine-Earth Science and Technology), Chairperson:Chisato Yoshikawa(JAMSTEC), Wonsuh Song, RUMI OGAITO(JAMSTEC)

10:45 AM - 11:05 AM JST | 1:45 AM - 2:05 AM UTC

[O05-01] Giving a successful presentation in English: Mission Possible!

★Invited Papers

*Joel Laurier[1] (1.University of Tsukuba)

11:05 AM - 11:25 AM JST | 2:05 AM - 2:25 AM UTC

[O05-02] How to deliver good presentations in a foreign language

★Invited Papers

*S. Lan Smith[1] (1.Marine Ecosystem Dynamics Research Group, Research Centre for Global Change, Japan Agency for Marine-Earth Science and Technology)

[J] Oral | O (Public)：Public

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 103 1F

[O-06] How to cope with intensifyng storm and flood disasters

convener:Jun Matsumoto(Deaprtment of Geography, Tokyo Metropolitan University), Yukihiro Takahashi(Department of Cosmosciences, Graduate School of Science, Hokkaido University), Akira Wada(Tokyo Institute of Technology), Chairperson:Jun Matsumoto(Tokyo Metropolitan University)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[O06-01] Extreme rainfall and heat wave over Japan in 2018 summer: A series of extreme events and underlying global warming

★Invited Papers

*Hisashi Nakamura[1] (1.Research Center for Advanced Science and Technology, University of Tokyo)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[O06-02] Influence of meteorological disasters on marine ecosystem

★Invited Papers

*Yu Umezawa[1,2] (1.Tokyo University of Agriculture and Technology, 2.Study Group on Marine Environmental Problems, the Oceanographic Society of Japan)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[O06-03] Understanding of geomorphic condition indicating the flooding disaster and hazard mapping

★Invited Papers

*Yohta KUMAKI[1] (1.Senshu University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[O06-04] A role of free satellite remote sensing data as a case study of heavy rain disaster in July 2018

★Invited Papers

*Yuji Sakuno[1] (1.Graduate School of Engineering, Hiroshima University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[O06-05] State of the Crisis Mapping for heavy rain in west of Japan, 2018.

★Invited Papers

*Taichi Furuhashi[1] (1.Aoyama Gakuin University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[O06-06] A Study on Spatial and Temporal Resolution of Evacunation Infomation for Effective Evacuation Behavior

★Invited Papers

*Michinori Hatayama[1] (1.Disaster Prevention Research Institute, Kyoto University)

[J] Oral | O (Public)：Public

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 103 1F

[O-06] How to cope with intensifyng storm and flood disasters

convener:Jun Matsumoto(Deaprtment of Geography, Tokyo Metropolitan University), Yukihiro Takahashi(Department of Cosmosciences, Graduate School of Science, Hokkaido University), Akira Wada(Tokyo Institute of Technology), Chairperson:Akira Wada(Tokyo Institute of Technology), Yukihiro Takahashi(Hokkaido University)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[O06-07] Multi-layered Countermeasures against Widespread Devastating Flood Disasters

★Invited Papers

*Koike Toshio[1] (1.International Centre for Water Hazard and Risk Management)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[O06-08] Technologies and wisdom in housings and buildings for protecting our lives from river floods

★Invited Papers

*Kazuo Tamura[1] (1.Seismic Design Laboratory)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[O06-09] State and Challenges of Disaster Waste Management - Lessons from Recent Disasters –

★Invited Papers

*Yuichi Moriguchi[1], Masahiro Osako[2] (1.Graduate School of Engineering, The University of Tokyo, 2.Center for Material Cycles and Wasre Management Research, National Institute for Environmental Studies)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[O06-10] Evacuation Planning for School Children and Community Residents

★Invited Papers

*Takeshi Sato[1], Yoshiaki Yazaki[2] (1.Tohoku University, 2.Institute of Safety Education for School Children)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[O06-11] Health Emergency and Nursing on Flood Disaster

★Invited Papers

*Sakiko Kanbara[1], Aiko Yamamoto[2] (1.University of Kochi, 2.Shitennoji University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[O06-12] General discussion

*Jun Matsumoto[1,2], Yukihiro Takahashi[3], Akira Wada[4] (1.Tokyo Metropolitan University, 2.JAMSTEC, 3.Hokkaido University, 4.Tokyo Institute of Technology)

[J] Oral | O (Public)：Public

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Convention Hall B 2F

[O-07] Kitchen Earth Science: Let's stimulate your brain by hands-on experiments!

convener:Ichiro Kumagai(School of Science and Engineering, Meisei University), Miwa Kuri(International Research Institute of Disaster Science, Tohoku University), Kei Kurita, Mie Ichihara(Earthquake Research Institute, University of Tokyo), Chairperson:Ichiro Kumagai(Meisei University), Miwa Kuri(東北大学災害科学国際研究所), Mie Ichihara(Earthquake Research Institute, The University of Tokyo), Kei Kurita

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[O07-01] Analogue experiments for understanding a crystal morphology variation of igneous rocks using a no-calorie sweetener

*Kuniyuki Furukawa[1], Ririka Watanabe[1], Risa Ito[1], Saori Kotani[1] (1.Faculty of Business Administration, Aichi University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[O07-02] Making volcanic edifice with edible lava

*Tatsuo Kanamaru[1], Akihiko Fujinawa[2] (1.Department of Earth and Environmental Sciences, College of Humanities & Sciences, Nihon University, 2.Department of Earth Sciences, Faculty of Science, Ibaraki University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[O07-03] Columnar joint: Geometric pattern analysis and analogue experiment using starch pastes

*Yuri Akiba[1], Aika Takashima[1], Hiroyuki Shima[2] (1.Graduate School of Life and Environmental Sciences, University of Yamanashi, 2.Department of Environmental Sciences, University of Yamanashi)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[O07-04] Viscoelastic characterization of a solid projectile impact onto a dense potato starch suspension

Kazuya Egawa[2], *Hiroaki Katsuragi[1] (1.Graduate School of Environmental Studies, Nagoya University, 2.Department of Earth and Planetary Sciences, Nagoya University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[O07-05] Pattern formation within a sandpile formed by a mixture of grains: The selection of stratification and segregation patterns

★Invited Papers

*Michiko Shimokawa[1], Hidestugu Sakaguchi[2] (1.Fukuoka Institute of Technology, 2.Kyushu University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[O07-06] Measuring radiation by DIY Geiger Counter Kit GC10

*George HASHIMOTO[1], Yusuke KOSHIO[1] (1.Department of Earth Sciences, Okayama University)

[J] Oral | O (Public)：Public

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Convention Hall B 2F

[O-08] How to make the image of the earth's phenomenon to the general people in the Geopark

convener:Noritaka Matsubara(Graduate School of Regional Resource Management, University of Hyogo), Yayoi ICHIHASHI(Sado Island Geopark Promotion Office), Hokuto Obara(Mine-Akiyoshidai Karst Plateau Geopark Promotion Council), Marekazu OHNO(Unzen Volcanic Area Geopark Promotion Office), Chairperson:Yayoi Ichihashi, Hokuto Obara, Hiroko Imai, Suzuka Koriyama(San'in Kaigan Geopark Promotion Council), Noritaka Matsubara(兵庫県立大学大学院)

10:45 AM - 11:15 AM JST | 1:45 AM - 2:15 AM UTC

[O08-01] Significance of the guide to introduce the landscape interestingly

★Invited Papers

*Daisuke Fukushima[1] (1.Sakurajima Museum)

11:15 AM - 11:45 AM JST | 2:15 AM - 2:45 AM UTC

[O08-02] Understanding of "geology" without difficult explanation. - Let's conduct experiment to tell about geology more easily. -

★Invited Papers

*Hikaru Yokoyama[1] (1.Hokusho University)

11:45 AM - 12:15 PM JST | 2:45 AM - 3:15 AM UTC

[O08-03] The appealing points and challenges of Japanese geoparks, as seen from a foreigner’s point of view.

★Invited Papers

*Jagoda Woloszyn[1] (1.Oki Islands UNESCO Global Geopark Promotion Committee)

[J] Oral | O (Public)：Public

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Convention Hall B 2F

[O-08] How to make the image of the earth's phenomenon to the general people in the Geopark

convener:Noritaka Matsubara(Graduate School of Regional Resource Management, University of Hyogo), Yayoi ICHIHASHI(Sado Island Geopark Promotion Office), Hokuto Obara(Mine-Akiyoshidai Karst Plateau Geopark Promotion Council), Marekazu OHNO(Unzen Volcanic Area Geopark Promotion Office), Chairperson:Yayoi Ichihashi, Hokuto Obara, Hiroko Imai, Noritaka Matsubara(兵庫県立大学大学院), Suzuka Koriyama(San'in Kaigan Geopark Promotion Council)

1:45 PM - 2:15 PM JST | 4:45 AM - 5:15 AM UTC

[O08-04] What do we need to do fun geotours that interests the earth?

★Invited Papers

*kana nishitani[1] (1.Global nature club)

2:15 PM - 2:45 PM JST | 5:15 AM - 5:45 AM UTC

[O08-05] The Important Things in Communicating Earth's Activity to Local Residents: the Awareness during Four Years after Changing a Job from a Geoscience Postdoc to a Curator

★Invited Papers

*Kyoko Kanayama[1] (1.San'in Kaigan Geopark Museum of the Earth and Sea, Tottori Prefectural Government)

2:45 PM - 3:15 PM JST | 5:45 AM - 6:15 AM UTC

[O08-06] "Blatamori" How to communicate the earth activities valued by guide guides

★Invited Papers

*Makoto Hasuoka[1], Yusuke Suzuki[2], Hiroko Imai[3] (1.Bandai-san Geopark Council, 2.Izu Peninsula Geopark Promotion Council, 3.COM SUPPORT OFFICE)

[J] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[P-PS07] Formation and evolution of planetary materials in the Solar System

convener:Yoko Kebukawa(Faculty of Engineering, Yokohama National University), Wataru Fujiya(Ibaraki University, College of Science), Shin Ozawa(Department of Earth Science, Graduate School of Science, Tohoku University), Megumi Matsumoto(Graduate School of Science, Tohoku University), Chairperson:Megumi Matsumoto, Wataru Fujiya

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[PPS07-01] Investigation of sugars in meteorites

★Invited Papers

*Yoshihiro Furukawa[1], Yoshito Chikaraishi[2], Naohiko Ohkouchi[3], Nanako O. Ogawa[3], Tomoki Nakamura[1] (1.Graduate School of Science, Tohoku University, 2.Institute of Low Temperature Science, Hokkaido University, 3.JAMSTEC)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[PPS07-02] Establishment of ice sublimation method for detection of soluble organic matter contained in Antarctic micrometeorites in Antarctic glacier ice

*Yui Ishikawa[1], Yamamoto Kota[1], Hiroshi Naraoka[2], Toru Yada[3], Tatsuaki Okada[1,3] (1.Graduate School of Science, The University of Tokyo, 2.Graduate School of Science, Kyushu University, 3.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[PPS07-03] Magnesium-containing organic compounds in the Tagish Lake and Murchison meteorites.

*Minako Hashiguchi[1], Hiroshi Naraoka[2,1] (1.Research Center for Planetary Trace Organic Compounds, Kyushu University, 2.Department of Earth and Planetary Sciences, Kyushu University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[PPS07-04] Interactions between minerals and organic materials on thermal processes in meteorite parent bodies

*Naoki Hirakawa[1], Yoko Kebukawa[1], Kensei Kobayashi[1] (1.Yokohama National University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[PPS07-05] Organic matter in carbonaceous chondrite lithologies of Almahata Sitta meteorite, a polymict ureilite

*Yoko Kebukawa[1], Michael Zolensky[2], Cyrena Anne Goodrich[3], Motoo Ito[4], Nanako O. Ogawa[5], Yoshinori Takano[5], Naohiko Ohkouchi[5], Hiroki Suga[9], Matthew Marcus[6], David Kilcoyne[6], Takuji Ohigashi[7], Zia Rahman[2], Muawia H. Shaddad[8], Kensei Kobayashi[1] (1.Yokohama National University, 2.NASA Johnson Space Center, 3.Lunar and Planetary Institute, 4.Kochi Institute for Core Sample Research JAMSTEC, 5.Japan Agency for Marine-Earth Science and Technology, 6.Lawrence Berkeley National Laboratory, 7.Institute for Molecular Science, 8.University of Khartoum, 9.The University of Tokyo)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[PPS07-06] Thermal Evolution of Hydrous Minerals on Small Bodies: To Understand Thermal Histories of Ryugu and Bennu

*Kana Ishimaru[1], Shogo Tachibana[2] (1.University of Tokyo, 2.UTokyo Organization for Planetary and Space Science, University of Tokyo)

[J] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[P-EM19] Frontiers in the solar physics

convener:Shinsuke Imada(Institute for Space-Earth Environmental Research, Nagoya University), Takaaki Yokoyama(School of Science, University of Tokyo), Toshifumi Shimizu(Institute of Space and Astronautical Science, JAXA), Yukio Katsukawa(National Astronomical Observatory of Japan, National Institute of Natural Sciences), Chairperson:Shinsuke Imada

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[PEM19-01] The Sun-Geospace connection: toward the 25th solar cycle

★Invited Papers

*Yoshizumi Miyoshi[1], Shinsuke Imada[1] (1.Institute for Space-Earth Environmental Research, Nagoya University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[PEM19-02] Unsolved problems of the solar wind turbulence

★Invited Papers

*Munehito Shoda[1] (1.Graduate School of Science, University of Tokyo)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[PEM19-03] The Solar-C_EUVST Epsilon mission

*Toshifumi Shimizu[1] (1.Institute of Space and Astronautical Science, JAXA)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[PEM19-04] Advanced Observations of the Solar Atmosphere by a Balloon-Borne Telescope SUNRISE-3

*Yukio Katsukawa[1], Carlos Quintero Noda[2], Masahito Kubo[1], Hirohisa Hara[1], Toshifumi Shimizu[2] (1.National Astronomical Observatory of Japan, 2.ISAS/JAXA)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[PEM19-05] Radiation magnetohydrodynamic modeling of solar coronal dynamics

*Haruhisa Iijima[1] (1.Institute for Space-Earth Environmental Research, Nagoya University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[PEM19-06] Detection and energy derivation of nano-flares based on deep learning

*Toshiki Kawai[1], Shinsuke Imada[1] (1.Institute for Space-Earth Environmental Research, Nagoya University)

[J] Oral | P (Space and Planetary Sciences)：P-AE Astronomy & Extrasolar Bodies

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 105 1F

[P-AE20] Exoplanet

convener:Masahiro Ikoma(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Norio Narita(University of Tokyo), Chairperson:Norio Narita(University of Tokyo), Masahiro Ikoma(The University of Tokyo)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[PAE20-01] Gravitational Microlensing Surveys for Exoplanets

★Invited Papers

*Daisuke Suzuki[1] (1.Institute of Space and Astronautical Science / Japan Aerospace Exploration Agency)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[PAE20-02] Doppler planet searches targeting stars in solar neighborhood

★Invited Papers

*Bunei Sato[1] (1.Tokyo Institute of Technology)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[PAE20-03] Development of MuSCAT3 for ground-based follow-up observations of TESS candidate exoplanets

*Norio Narita[1,2,3], Akihiko Fukui[2], Masahiro Ikoma[2], Motohide Tamura[1,2], Nobuhiko Kusakabe[1], Mayuko Mori[2], Tomoyasu Yamamuro[4] (1.Astrobiology Center, 2.University of Tokyo, 3.JST, 4.OptCraft)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[PAE20-04] Effect of metallicity and eddy diffusion on transmission spectra of hazy exoplanet atmospheres

*Yui Kawashima[1], Masahiro Ikoma[2] (1.SRON Netherlands Institute for Space Research, 2.The University of Tokyo)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[PAE20-05] Mineral clouds of fluffy aggregates: how they form in exoplanetary atmospheres and influence transmission spectra

*Kazumasa Ohno[1], Satoshi Okuzumi[1], Ryo Tazaki[2] (1.Department of Earth and Planetary Science, Tokyo Institute of Technology, 2.Astronomical Institute, Tohoku University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[PAE20-06] Orbital Architecture of Planetary Systems Formed by Giant Impacts

★Invited Papers

*Eiichiro Kokubo[1] (1.Division of Theoretical Astronomy, National Astronomical Observatory of Japan)

[J] Oral | P (Space and Planetary Sciences)：P-AE Astronomy & Extrasolar Bodies

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 105 1F

[P-AE20] Exoplanet

convener:Masahiro Ikoma(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Norio Narita(University of Tokyo), Chairperson:Masahiro Ikoma(The University of Tokyo), Norio Narita(University of Tokyo)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[PAE20-07] Thermal convection in the mantle of super-Earths

★Invited Papers

*Takehiro Miyagoshi[1], Masanori Kameyama[2], Masaki Ogawa[3] (1.Japan Agency for Marine-Earth Science and Technology, 2.Ehime University, 3.University of Tokyo)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[PAE20-08] Atmospheric escape from M-dwarf exoplanets and implications for habitability

*Chuanfei Dong[1] (1.Princeton University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[PAE20-09] Theoretical emission spectra of hot rocky super-Earths: Lack of alkali metals due to atmospheric escape

*Yuichi Ito[1,2], Masahiro Ikoma[2] (1.Department of Cosmosciences, Graduate school of Science, Hokkaido University, 2.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[PAE20-10] Hot Rocky Super-Earths atmospheres, a revision of gas phase metal chemistry and the relevance of reverse chemistry

*Sebastian Danielache[1,2], Takahashi Yuta[1], Miguel Yamila[3], Simoncini Eugenio[4], Grassi Tommaso[5] (1.Department of Materials & Life Sciences, Faculty of Science & Technology, Sophia University, 2.Tokyo Institute of Technology, Earth-Life Institute , 3.Leiden Observatory, Leiden University, 4.Simoncini Telai Gambassi Terme, 5.University Observatory Munich, Ludwig-Maximilians-University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[PAE20-11] A Climate of tidally locked terrestrial exoplanets

*Takanori Kodama[1] (1.University of Bordeaux)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[PAE20-12] Current status of WSO-UV/UVSPEX for discovery of Earth-like planets

*Shingo Kameda[1], Osada Naoya[1], Takanori Kodama[2], Go Murakami[3], Keigo Enya[3], Masahiro Ikoma[4], Norio Narita[5], Naoki Terada[6], Hitoshi Fujiwara[7] (1.School of Science, Rikkyo University, 2.University of Bordeaux, 3.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 4.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 5.National Astronomical Observatory of Japan, 6.Graduate School of Science, Tohoku University, 7.Faculty of Science and Technology, Seikei University)

[J] Oral | P (Space and Planetary Sciences)：P-CG Complex & General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 201B 2F

[P-CG23] Origin and evolution of materials in space

convener:Hitoshi Miura(Graduate School of Natural Sciences, Department of Information and Basic Science, Nagoya City University), Hideko Nomura(Department of Earth and Planetary Sciences, Tokyo Institute of Technology), Takafumi Ootsubo(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Aki Takigawa(Division of Earth and Planetary Science, Kyoto University), Chairperson:Ryo Tazaki, Aoi Takahashi

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[PCG23-01] Origin of cosmic dust: Galaxy-scale perspective

★Invited Papers

*Akio Inoue[1,2] (1.Osaka Sangyo University, 2.Waseda University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[PCG23-02] SPICA and future infrared observations of cosmic matters

★Invited Papers

*Issei Yamamura[1] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[PCG23-03] Engineering first light of a new mid-infrared instrument MIMIZUKU

*Takafumi Kamizuka[1], Takashi Miyata[1], Shigeyuki Sako[1], Ryou Ohsawa[1], Masahito S. Uchiyama[1], Tomohiro Mori[1], Yutaka Yoshida[1] (1.Institute of Astronomy, School of Science, the University of Tokyo)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[PCG23-04] Properties and space exposure of Quenched Nitrogen-included Carbonaceous Composite (QNCC)

*Izumi Endo[1], Itsuki Sakon[1], Takashi Onaka[1], Yoko Kebukawa[2], Kensei Kobayashi[2], MITA Hajime[4], Hajime Yano[3] (1.University of Tokyo, 2.Yokohama National University, 3.ISAS/JAXA, 4.Fukuoka Institute of Technology)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[PCG23-05] Shape dependence of dust absorption opacity in the Rayleigh domain

*Ryo Tazaki[1], Hidekazu Tanaka[1] (1.Astronomical Institute, Tohoku University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[PCG23-06] Modeling of the H_2 ortho-para spin conversion on grain surfaces in star- and planet-forming regions

*Kenji Furuya[1], W. M. C. Sameera[2], Tetsuya Hama[2], Naoki Watanabe[2], Yuri Aikawa[3] (1.Center for Computer Sciences, University of Tsukuba, 2.Institute of Low Temperature Science, Hokkaido University,, 3.The University of Tokyo)

[J] Oral | P (Space and Planetary Sciences)：P-CG Complex & General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 201B 2F

[P-CG23] Origin and evolution of materials in space

convener:Hitoshi Miura(Graduate School of Natural Sciences, Department of Information and Basic Science, Nagoya City University), Hideko Nomura(Department of Earth and Planetary Sciences, Tokyo Institute of Technology), Takafumi Ootsubo(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Aki Takigawa(Division of Earth and Planetary Science, Kyoto University), Chairperson:Kenji Furuya, Yuki Hibiya

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[PCG23-07] Thermal processes of primary silicate dust in protoplanetary disk: Constraints from oxygen isotope exchange kinetics between amorphous silicate and water vapor

★Invited Papers

*Daiki Yamamoto[1], Shogo Tachibana[2], Noriyuki Kawasaki[1], Minami Kuroda[1], Naoya Sakamoto[3], Hisayoshi Yurimoto[1,4] (1.Department of Natural History Sciences ,Hokkaido University, 2.UTokyo Organization for Planetary Space Science, The University of Tokyo , 3.Creative Research Institution, Hokkaido University , 4.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[PCG23-08] Birth-place of comet 17P/Holmes from its mass fractions of minerals

★Invited Papers

*Shinnaka Yoshiharu[1], Takafumi Ootsubo[2], Hideyo Kawakita[1], Mitsuru Yamaguchi[1], Mitsuhiko Honda[3], Jun-ichi Watanabe[4] (1.Kyoto Sangyo University, 2.JAXA/ISAS, 3.Kurume University, 4.NAOJ)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[PCG23-09] Comparison of grain properties in interplanetary dust from different types of parent bodies by mid-infrared spectroscopic observations with AKARI

*Aoi Takahashi[1], Takafumi Ootsubo[2], Hideo Matsuhara[2], Fumihiko Usui[3], Itsuki Sakon[4], Hiroki Chihara[5] (1.The Graduate University for Advanced Studies, 2.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 3.Kobe University, 4.University of Tokyo, 5.Osaka Sangyo University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[PCG23-10] Formation of forsterite crystal induced by ultraviolet irradiation of water ice ice on amorphous Mg_2SiO_4 particles

*Akira Kouchi[1], Yuki Kimura[1], Yasuhiro Oba[1], Tetsuya Hama[1], Naoki Watanabe[1], Shogo Tachibana[2], Akira Tsuchiyama[3], Satomi Enju[3], Takafumi Ootsubo[4] (1.Institute of Low Temperature Science, Hokkaido University, 2.UTokyo Organization for Planetary and Space Science, University of Tokyo, 3.Graduate School of Science, Kyoto University, 4.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[PCG23-11] Condensation experiments in the sytem Fe-Mg-Si-O-S using induction thermal plasma: implication to GEMS forming condition

*Satomi Enju[1], Hayate Kawano[1], Hisashi Komaki[2], Akira Tsuchiyama[1] (1.Department of Earth and Planetary Sciences, Graduate School of Science, Kyoto University, 2.JEOL Ltd.)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[PCG23-12] **The initial abundance of ^{92}Nb in the outer solar system.**

*Yuki Hibiya[1,2], Tsuyoshi Iizuka[2], Hatsuki Enomoto[2] (1.Japan Agency for Marine-Earth Science and Technology, 2.The University of Tokyo)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 301A 3F

[A-AS06] Progress in dense observation and numerical modeling of micro-scale meteorology

convener:Junshi Ito(Atmosphere and Ocean Research Institute, The University of Tokyo), Kentaro Araki(Meteorological Research Institute), Jun-ichi Furumoto(Research Institute for Sustainable Humanosphere, Kyoto University), Kuniaki Higashi(Research Institute for Sustainable Humanosphere, Kyoto University Metroweather Co., Ltd.), Chairperson:Junshi Ito(The University of Tokyo), Kentaro Araki(Meteorological Research Institute)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[AAS06-01] A Linear Array of Wind and Pressure Sensors for High Resolution in situ Measurements in Winter Tornadoes

★Invited Papers

*Kusunoki Kenichi[1], Hanako Inoue[1], Naoki Ishitsu[2], Chusei Fujiwara[3] (1.Meteorological Research Institute, 2.Alpha-denshi Co., Ltd. / Meteorological Research Institute, 3.East Japan Railway Company)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[AAS06-02] Mesoscale fixed point weather observation architecture by Drone fleet

*Yuichi Yaguchi[1], Masayuki Itaha[4], Shuzo Nakano[3], Kazuhiko Yamagishi[2], Tatsuya Iyobe[5] (1.The University of Aizu, 2.e-Robotics Fukushima Co., Ltd., 3.East-Japan Accounting Center Co., Ltd., 4.Japan Environment Research Co., Ltd., 5.Iyobe Shoji Ltd.)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[AAS06-03] Potential of dense weather event observation using surface optical fiber cable and DAS technology

*Tsunehisa KIMURA[1] (1.Schlumberger)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[AAS06-04] Case study of environmental conditions and cloud microphysical properties of winter convective clouds developed in the Kanto plain

*Kentaro Araki[1], Shinsuke Satoh[2], Takuya Tajiri[1] (1.Meteorological Research Institute, 2.National Institute of Information and Communications Technology)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[AAS06-05] Numerical simulation of the urban effect on the atmospheric boundary layer structure in Tokyo using the SPUC urban canopy scheme

*Naoko Seino[1] (1.Meteorological Research Institute)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[AAS06-06] Surface layer model for instantaneous wind speeds designed by deep learning

*Junshi Ito[1,2], Hideaki Mouri[2] (1.Atmosphere and Ocean Research Institute, The University of Tokyo , 2.Meteorological Research Institute)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 303 3F

[A-OS21] Physical, biogeochemical, and ecological aspects and their mutual relations in the Indian Ocean

convener:Yukio Masumoto(Graduate School of Science, The University of Tokyo), Hiroaki Saito(Atmosphere and Ocean Research Institute, The University of Tokyo), Iwao Ueki(JAMSTEC Japan Agency for Marine-Earth Science and Technology), Chairperson:Yukio Masumoto

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[AOS21-01] Coastal upwelling events and barrier layer observed along the southwestern coast of Sumatra

*Takanori Horii[1], Iwao Ueki[1], Kentaro Ando[1] (1.Research and Development Center for Global Change (RCGC), Japan Agency for Marine-Earth Science and Technology (JAMSTEC))

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[AOS21-02] Mechanisms of the sea surface temperature cooling in the Somalia-Oman upwelling region during the summer monsoon

*Kusumi Takahiro[1], Shoichiro Kido[1], Tomoki Tozuka[1], Yukio Masumoto[1] (1.the Unversity of Tokyo)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[AOS21-03] Generation of meso-scale eddies in the southern Indian ocean

*Takuro Matsuta[1], Yukio Masumoto[1] (1.Graduate School of Science, The University of Tokyo)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[AOS21-04] Summary of R/V Hakuho-Maru observations (KH-18-6) for Integrated physical, biogeochemical, and ecosystem research in the eastern Indian Ocean

*Yukio Masumoto[1], Hiroaki Saito[2] (1.Graduate School of Science, The University of Tokyo, 2.Atmosphere and Ocean Research Institute)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[AOS21-05] Distribution and photodegradation of fluorescent dissolved organic matter in the eastern Indian Ocean

*Shigenobu Takeda[1] (1.Nagasaki University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[AOS21-06] Observed subsurface Chlorophyll maximum in the tropical eastern Indian Ocean during KH18-6 Leg3 cruise

*Iwao Ueki[1], Kosei Sasaoka[1] (1.JAMSTEC Japan Agency for Marine-Earth Science and Technology)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 301A 3F

[A-CG43] Adaptation for climate change and social implementation

convener:Yoichi Ishikawa(JAPAN Agency for Marine-Earth Science and Technology), Shingo Watanabe(Japan Agency for Marine-Earth Science and Technology), KOJI DAIRAKU(National Research Institute for Earth Science and Disaster Resilience), Chairperson:KOJI DAIRAKU(National Research Institute for Earth Science and Disaster Resilience), Yoichi Ishikawa(JAPAN Agency for Marine-Earth Science and Technology)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[ACG43-01] **Effects of afforestation and climate warming on evapotranspiration and river discharge in the upper Chao Phraya River basin**

*Kumiko TAKATA[1], Naota Hanasaki[1] (1.National Institute for Environmental Studies)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[ACG43-02] Hybrid downscaling using high-resolution RCM information and rainfall-runoff-inundation model simulations

*Yasutaka Wakazuki[1,2], Shiori Abe[4], Yosuke Nakamura[3,4] (1.Ibaraki University, 2.Japan Agency for Marine-Earth Science and Technology, 3.Public Works Research Institute, 4.Mitsui Consultants Co., Ltd.)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[ACG43-03] Development of a global water risk assessment tool to support investigation of adaptation to climate change in the private sector: Calibrating parameters of a global water resources model by Approximate Bayesian Computation

*Naota Hanasaki[1] (1.NIES National Institute of Environmental Studies)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[ACG43-04] Verification of SI-CAT ocean products around Japan

*Goro Yamanaka[1], Hideyuki Nakano[1], Kei Sakamoto[1], Takahiro Toyoda[1], Shogo Urakawa[1], Hiroyuki Tsujino[1], Shiro Nishikawa[2], Tsuyoshi Wakamatsu[2,3,4], Yoichi Ishikawa[2] (1.Meteorological Research Institute, 2.JAMSTEC, 3.Nansen Environmental and Remote Sensing Center, 4.Bjerknes Centre for Climate Research)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[ACG43-05] Downscaling and Reanalysis of Coastal Current System on the Ibaraki Coast with Included Freshwater Impact

*Josko Troselj[1], Yuki Imai[2], Junichi Ninomiya[3], Nobuhito Mori[1] (1.Coastal Engineering Laboratory, Disaster Prevention Research Institute, Kyoto University, 2.Graduate School of Engineering, Kyoto University, 3.Kanazawa University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[ACG43-06] Estimation of the Japanese sardine stock in relation to the future Kuroshio variability

*Haruka Nishikawa[1], Shiro Nishikawa[1], Tsuyoshi Wakamatsu[2,3], Yoichi Ishikawa[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Nansen Environmental and Remote Sensing Center, 3.Bjerknes Center for Climate Research)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 301A 3F

[A-CG43] Adaptation for climate change and social implementation

convener:Yoichi Ishikawa(JAPAN Agency for Marine-Earth Science and Technology), Shingo Watanabe(Japan Agency for Marine-Earth Science and Technology), KOJI DAIRAKU(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Yoichi Ishikawa(JAPAN Agency for Marine-Earth Science and Technology), KOJI DAIRAKU(National Research Institute for Earth Science and Disaster Resilience)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[ACG43-07] Recent progress of Japan's regional downscaling project (SI-CAT) and CORDEX Asia Empirical-Statistical Downscaling (ESD)

*KOJI DAIRAKU[1] (1.National Research Institute for Earth Science and Disaster Resilience)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[ACG43-08] Assessment of Flood Risk in Hokkaido, northern Japan, Associated with Climate Change

*Hoshino Tsuyoshi[1], Tomohito J Yamada[1], Dzung Nguyen-Le[1], Masaru Inatsu[1], Tomonori Satou[1], Hiroaki Kawase[2] (1.Hokkaido University, 2.Meteorological Research Institute)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[ACG43-09] Intensification of sub-daily and daily rainfall extremes from densely distributed records for Japan

*Megumi Watanabe[1], Sayaka Yoshikawa[1], Shinjiro Kanae[1] (1.Tokyo Institute of Technology)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[ACG43-10] A Content-Based Database System for Large Ensemble Future Climate Simulations

*Yujin Nakagawa[1], Shintaro Kawahara[1], Fumiaki Araki[1], Daisuke Matsuoka[1], Yoichi Ishikawa[1], Mikiko Fujita[1], Shiori Sugimoto[1], Yasuko Okada[1], Sho Kawazoe[1], Shingo Watanabe[1], Masayoshi Ishii[2], Ryo Mizuta[2], Akihiko Murata[2], Hiroaki Kawase[2] (1.Japan Agency for Marine-Earth Science and Technology, 2.Meteorological Research Institute)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[ACG43-11] Climate change impact assessment in Shikoku with the ensemble climate prediction database d4PDF

*kouhei yoshimura[1], Nasu Seigo[1], Patricia Sanchez[2] (1.Kochi University of Technology, 2.University of the Philippines Los Baños)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[ACG43-12] Caution zone quantification risk to sediment disaster adaptation due to climate change

*SEIKI KAWAGOE[1], YOSUKE SAITO[1], HIROMICHI SUZUKI[1] (1.Fukushima university)

[J] Oral | H (Human Geosciences)：H-GG Geography

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 102 1F

[H-GG02] Use, change, management of natural resources and environment: Interdisciplinary perspectives

convener:Yoshinori OTSUKI(Institute of Geography, Graduate School of Science, Tohoku University), Gen Ueda(Graduate School of Social Sciences, Hitotsubashi University), Takahisa Furuichi(Graduate School of Science, Hokkaido University), Toru Sasaki(Miyagi University of Education), Chairperson:Yoshinori OTSUKI, Gen UEDA

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[HGG02-01] Source identification of pottery based on chemical analysis of volcanic glass contained in ceramic paste
- Example for Usultan pottery in Chalchuapa, El Salvador, Central America -

*Shigeru Kitamura[1], Masakage Murano[2] (1.Faculty of Social Welfare, Hirosaki Gakuin University, 2.The Museum of Kyoto)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[HGG02-02] Preliminary magnetic biomonitoring study of the spatial distribution of roadside pollution using *Cryptomeria japonica* tree bark

*Nagisa Sawada[1], Kazuo Kawasaki[1] (1.University of toyama)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[HGG02-03] Preliminary environmental magnetic results from heavy metal contamination around the Erdenet Cu-Mo deposit, Mongolia.

*Kazuo Kawasaki[1], Ryuki Tonami[2], Solongo Tsetsgee[3], Baasansuren Gankhurel[3], Keisuke Fukushi[4] (1.Graduate School of Science and Engineering for Research, University of Toyama, 2.Department of Earth Sciences, University of Toyama, 3.Kanazawa University, 4.Institute of nature & Environmental Technology, Kanazawa University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[HGG02-04] Sediment and its movement as natural resources and environment

*Takahisa Furuichi[1], Sachi Wakasa[2], Shigeru Mizugaki[3], Masanori Nunokawa[3] (1.Graduate School of Agriculture, Hokkaido University, 2.Graduate School of International Resource Sciences, Akita University, 3.Civil Engineering Research Institute for Cold Region)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[HGG02-05] Reutilization of waste bamboo from oyster farming

*KIYOSHI SAIJO[1] (1.Miyagi University of Education)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[HGG02-06] Regional Impacts of Globally Important Agricultural Heritage Systems in Osaki City, Miyagi Prefecture

*Toru Sasaki[1] (1.Miyagi University of Education)

[J] Oral | H (Human Geosciences)：H-QR Quaternary research

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 102 1F

[H-QR05] Quaternary, Diachronic dynamics of human-environment interactions

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Ken Ikehara(Institute of Geology and Geoinformation, National Institute of Advanced Industrial Science and Technology), Masayuki Hyodo(Research Center for Inland Seas, Kobe University), Chairperson:Ken Ikehara(AIST), Kaori Aoki

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[HQR05-01] Disturbance of sea floor by large earthquake and formation of earthquake-induced event deposit: Where is a suitable location for deep-sea turbidite paleoseismology

★Invited Papers

*Ken Ikehara[1] (1.Institute of Geology and Geoinformation, National Institute of Advanced Industrial Science and Technology)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[HQR05-02] The Diatom Assemblages as the Indicators for Huge Tsunami Sedimentations and Recover Processes of Environment at Kesennuma Bay, Tohoku, Japan

*Kaoru Kashima[1], Ryozo Shiomi, Yu Fukumoto[3], Tsuyoshi Haraguchi[2] (1.Department of Earth and Planetary Sciences, Kyushu University, 2.Department of Geosicneces, Graduate School of Science, Osaka City University, 3.Ritsumeikan University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[HQR05-03] **Niger Delta dynamic phase in the Gulf of Guinea during the last 20 ka: Panacea for the sustainable development of the region**

*Onema Christopher Adojoh[1], Marret-Davies Fabienne[2], Tetsuji Muto[3] (1.Missouri Univetrsity of Science and Technology, Rolla, USA, Dept of Geoscience, Geological and Petroleum Engineering, 1400 North Bishop, Post Code 65401, 2.School of Environmental Sciences, University of Liverpool, L69 7ZT, UK, 3.Nagasaki University, Japan, Dept of Environmental Science and Fisheries, 1-14 Bunkyomachi, Nagasaki, 8528521)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[HQR05-04] K-feldspar post-IR IRSL ages suggest the presence of MIS 5a–c marine terraces in the eastern margin of the Kanto Plain, central Japan

★Invited Papers

*Toru Tamura[1,2], Hiroko Okazaki[3], Hiroomi Nakazato[4], Tomonori Naya[1], Rei Nakashima[1] (1.Geological Survey of Japan, AIST, 2.Graduate School of Frontier Sciences, University of Tokyo, 3.Natural History Museum and Institute, Chiba, 4.National Agriculture and Food Research Organization)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[HQR05-05] Tephrostratigraphy of drilled core C9010E off the Boso Peninsula: as a preliminary report

*Kaori Aoki[1], Makoto Kobayashi[1], Masanori Murata[1], Takehiko Suzuki[1] (1.Research Center for Volcanic Hazards and Their Mitigation, Tokyo Metropolitan University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[HQR05-06] Late Quaternary fluvial terraces and piracies in the Tanagura area, along the upper reaches of Kuji River, NE Japan

*Yuichi Kato[1], Takehiko Suzuki[1] (1.Graduate school of Urvan Environmental Sciences, Tokyo Metropolitan University)

[J] Oral | H (Human Geosciences)：H-QR Quaternary research

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 102 1F

[H-QR05] Quaternary, Diachronic dynamics of human-environment interactions

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Ken Ikehara(Institute of Geology and Geoinformation, National Institute of Advanced Industrial Science and Technology), Masayuki Hyodo(Research Center for Inland Seas, Kobe University), Chairperson:Mamoru KOARAI(Ibaraki University), Tomonori Naya(産業技術総合研究所)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[HQR05-07] Landform features of Okinoshima of Munakata city

*Takahito Kuroki[1] (1.Faculty of Education, Univ. of Teacher Edu. Fukuoka)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[HQR05-08] Revision of geomorphology and geology of Tokyo Upland and Lowland, based on boring data and precise landform analysis

★Invited Papers

*Kunihiko Endo[1], Yusuke Suginaka[2], Shinzaburo Hori[2], Toshihiko Sugai[3], Takehiko Suzuki[4], Shigeko Ishiwata, Yo Uesugi, Reisuke Kondo[5], Tatsuro Chiba[6], Toshio Nakayama[7], Shigeto Osato[8], Marie Noguchi[9], Akio Sato[3], Takato Takemura[10] (1.Nihon University, 2.Research Center of Computational Mechanics, Inc., 3.Graduate School of Frontier Science, The University of Tokyo, 4.Faculty of Urban Environmental Sciences, Tokyo Metropolitan University, 5.Educational Development Center, Kogakkan University, 6.Asia Air Survey, 7.Civil Engineering Support & Training Center, Tokyo Metropolitan Government,, 8.Doshitsu Research Corporation, 9.Paleo Labo co.,ltd., 10.College of Humanities and Sciences, Nihon University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[HQR05-09] Sedimentological characteristics of the Ome Formation exposed on the western margin of Musasino Upland, central Japan

*Takako UTSUGAWA[1], Masaaki Shirai[2], Hiroka Kato[2], Sayuri Kato[3] (1.Department of Geography, Rissho University, 2.Department of Geography, Tokyo Metropolitan University, 3.Hamura City)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[HQR05-10] Stratigraphy of Tokyo Formation: re-examination of Kita-Ku Central Park core

*Tomonori Naya[1], Kentaro Sakata[1], Tsutomu Nakazawa[1], Takehiko Suzuki[2], Toshio Nakayama[3] (1.Geological Survey of Japan, AIST, 2.Tokyo Metropolitan University, 3.Tokyo Metropolitan Government)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[HQR05-11] S-wave veolocity structure and ground motion characteristics of "loam terraces": Examples from the eastern part of Utsunomiya City, Tochigi Prefecture, central Japan

★Invited Papers

*Tsutomu Nakazawa[1], Ikuo Cho[1], Kentaro Sakata[1] (1.Geological Survey of Japan, AIST)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[HQR05-12] The relationship between liquefaction distribution and microtopography classification during the 1948 Fukui earthquake - Toward improvement of liquefaction hazard map -

*Haruka Tani[1], Masanobu Shishikura[2] (1.Housei University, 2.Institute of Earthquake and Volcano Geology, National Institute of Advanced Industrial Science and Technology)

[J] Oral | H (Human Geosciences)：H-CG Complex & General

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 104 1F

[H-CG30] Safety of nuclear power plants against inland earthquakes

convener:Daisuke Suetsugu(Department of Deep Earth Structure and Dynamics Research, Japan Agency for Marine-Earth Science and Technology), Satoshi Kaneshima(Department of Earth and Planetary Sciences, Kyushu University), Takeshi Sagiya(Disaster Mitigation Research Center, Nagoya University), Kohta Juraku(Department of Humanities, Social and Health Sciences, School of Engineering, Tokyo Denki University), Chairperson:Daisuke Suetsugu, Kohta Juraku

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[HCG30-01] Thickness of the seismogenic layer beneath the Japanese Islands and its relation to crustal earthquakes

*Junichi Nakajima[1] (1.Department of Earth and Planetary Sciences, Tokyo Institute of Technology)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[HCG30-02] Problems with active fault evaluation in nuclear safety regulation

*Yasuhiro Suzuki[1] (1.Nagoya University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[HCG30-03] The longer active fault is, is the larger ground motion generated? – Surface and buried rupture earthquakes-

*Takao Kagawa[1] (1.Tottori University Graduate School of Engineering)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[HCG30-04] Seismic safety of nuclear power plants against inland crustal earthquakes and the "science vs. engineering problem"

*Katsuhiko Ishibashi[1] (1.Emeritus Professor, Kobe University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[HCG30-05] Challenges to Seismic Safety of Nuclear Power Plants

*Tatsuya Itoi[1] (1.The University of Tokyo)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[HCG30-06] Strong motion at Ooi nuclear power plant

*Kunihiko Shimazaki[1] (1.University of Tokyo)

[J] Oral | H (Human Geosciences)：H-CG Complex & General

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 105 1F

[H-CG32] Interdisciplinary approach to earth surface processes related to deposition, erosion and sediment transport

convener:Koji Seike(Geological Survey of Japan, AIST), Naofumi Yamaguchi(Center for Water Environment Studies, Ibaraki University), Hajime Naruse(Department of Geology and Mineralogy, Graduate School of Science, Kyoto University), Hideko Takayanagi(Institute of Geology and Paleontology, Graduate School of Science, Tohoku University), Chairperson:Koji Seike

1:50 PM - 2:20 PM JST | 4:50 AM - 5:20 AM UTC

[HCG32-01] Long-term beach observation and future shoreline prediction

★Invited Papers

*Masayuki Banno[1] (1.Port and Airport Research Institute)

2:20 PM - 2:35 PM JST | 5:20 AM - 5:35 AM UTC

[HCG32-02] Migration of sand waves observed in Okinose area of Osaka Bay

*Kojima Hibiki[1], Tetsuo Matsuno[2,3], Mamoru Sano[2], Nobukazu Seama[3,2], Noritaka Endo[4], Ken'ichi Ohkushi[1], Atsushi Tani[1] (1.Graduate School of Human Development and Environment, Kobe University, 2.Kobe Ocean Bottom Exploration Center(KOBEC), Kobe University, 3.Graduate School of Science / Faculty of Science, Kobe University, 4.School of Geoscience and Civil Engineering College of Science and Engineering, Kanazawa University)

2:35 PM - 2:50 PM JST | 5:35 AM - 5:50 AM UTC

[HCG32-03] Inverse analysis of lobe/gully on Mars: examination by 2D Voellmy fluid model

Kyohei Noumura[1], *Hajime Naruse[1] (1.Department of Geology and Mineralogy, Graduate School of Science, Kyoto University)

2:50 PM - 3:05 PM JST | 5:50 AM - 6:05 AM UTC

[HCG32-04] Development of provenance study using quartz shapes and surface microtextures

*Hiromi Itamiya[1], Ritsuko Sugita[1], Toshihiko Sugai[2] (1.National Research Institute of Police Science, 2.The University of Tokyo)

[J] Oral | H (Human Geosciences)：H-CG Complex & General

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 105 1F

[H-CG32] Interdisciplinary approach to earth surface processes related to deposition, erosion and sediment transport

convener:Koji Seike(Geological Survey of Japan, AIST), Naofumi Yamaguchi(Center for Water Environment Studies, Ibaraki University), Hajime Naruse(Department of Geology and Mineralogy, Graduate School of Science, Kyoto University), Hideko Takayanagi(Institute of Geology and Paleontology, Graduate School of Science, Tohoku University), Chairperson:Hideko Takayanagi(Tohoku University), Koji Seike

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[HCG32-05] Detrital heavy mineral record and Nd-Sr isotopic signature in Bengal Fan

*Kohki Yoshida[1], Cruz Jarrett[2], Manoj M.C.[3], Nozomi Hatano[5], Christian France-Lanord[4], Takeshi Kuritani[6] (1.Department of Geology, Faculty of Science, Shinshu University, 2.Florida State University, 3.Birbal Sahni Institute of Palaeosciences, 4.CNRS- Universite de Lorraine, 5.Graduate School of Science and Technology, Shinshu University, 6.Hokkaido University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[HCG32-06] Evaluation of plant-fragment concentration mechanism in the turbiditic sediments in the Bouma Sequence by biomarker analysis in the Kawabata Formation, Yubari area, central Hokkaido, Japan.

*Hiroyasu Asahi[1], Satoshi Furota[2], Ken Sawada[3] (1.Graduate School of Science, Hokkaido University, 2.Japan Agency for Marine-Earth Science and Technology, 3.Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[HCG32-07] Tectonic behavior of a forearc basin reconstructed using turbidites: an example from the Plio-Pleistocene Kakegawa Group, central Japan

*Sone Haruki[1] (1.Graduate school of Shimane University, Natural Science and Technology, Major in Science of Environmental systems, Geoscience corse)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[HCG32-08] Most benthos floats up in liquefied sandy substrates: quantitative evaluation by measuring living-organism density

*Koji Seike[1], Shinji Sasa[2], Kotaro Shirai[3], Kaoru Kubota[4] (1.Geological Survey of Japan, AIST, 2.Port and Airport Research Institute, 3.AORI, The University of Tokyo, 4.Kochi Institute for Core Sample Research, JAMSTEC)

[J] Oral | H (Human Geosciences)：H-CG Complex & General

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 202 2F

[H-CG33] Useful life-support systems in closed bio-ecosystems

convener:Kaori Tomita-Yokotani(Faculty of Life and Environmental Sciences University of Tsukuba), Masanori Shinohara(Teikyo University of Science), Shunta Kimura(Graduate School of Life and Environmental Sciences, University of Tsukuba), Chairperson:Shunta Kimura

3:32 PM - 3:47 PM JST | 6:32 AM - 6:47 AM UTC

[HCG33-01] Closed bio-ecosystems in extraterrestrial environments-Research in closed bio-ecosystems

*Kaori Tomita-Yokotani[1] (1.Faculty of Life and Environmental Sciences University of Tsukuba)

3:47 PM - 4:07 PM JST | 6:47 AM - 7:07 AM UTC

[HCG33-02] Concept and Studies of Aquaculture in Space -In the Past and Future-

★Invited Papers

*Masato Endo[1] (1.Tokyo University of Marine Science and Technology)

4:07 PM - 4:27 PM JST | 7:07 AM - 7:27 AM UTC

[HCG33-03] Protection effects of gasotransmitters against oxidation damager in vascular endothelial cells

★Invited Papers

*Shigeki Yoshida[1] (1.University of Tsukuba)

4:27 PM - 4:42 PM JST | 7:27 AM - 7:42 AM UTC

[HCG33-04] Study on nutrition intake and food selection to maintain health for habitation in space

*Yasuko Kimura[1], Shunta Kimura[2,3], Hiroshi Katoh[4], Kaori Tomita-Yokotani[2] (1.Jumonji University, 2.University of Tsukuba, 3.The University of Tokyo, 4.Mie University)

4:42 PM - 4:57 PM JST | 7:42 AM - 7:57 AM UTC

[HCG33-05] Limit of "rational optimism", Earth as CELSS, and sustainability of human-being

*Masanori Shinohara[1] (1.Teikyo University of Science)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Convention Hall A 2F

[S-SS13] Strong Ground Motion and Earthquake Disaster

convener:Masayuki Kuriyama(Central Research Institute of Electric Power Industry), Kazuhiro Somei(Geo-Research Institute), Chairperson:Yoshinari Hayashi(Faculty of Safety Science, Kansai University), Dianshu Ju(Ohsaki Research Institute, Inc.)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SSS13-01] Investigation of the effect of jog deviations on Riedel fractures by three-dimensional elasto-plastic analysis

*Tomohiro Toyoda[1], Toshihiro Noda[2], Shotaro Yamada[1], Akira Asaoka[3] (1.Nagoya University, Graduate School of Engineering, 2.Nagoya University, Disaster Mitigation Research Center, 3.Association for the development of earthquake prediction)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SSS13-02] A survey on earthquake prediction and public warning in seismological community

*Yoshinari Hayashi[1] (1.Faculty of Societal Safety Sciences, Kansai University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SSS13-03] Long-period strong ground motion of the Tokyo Bay area during the events occurred in the plate triple junction area

*Tomiichi Uetake[1] (1.R&D Department, TEPCO research Institute, Tokyo Electric Power Company)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SSS13-04] **Time-frequency and engineering characteristics on offshore ground motion**

*CHEN Su[1], FU Lei[1], LI Xiaojun[1] (1.Institute of Geophysics, China Earthquake Administration)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SSS13-05] **Long-period Ground Motion from Hypothetical Megathrust Earthquakes along the Nankai Through using the Ambient Seismic Field**

*Loic Viens[1], Tomotaka Iwata[1] (1.Disaster Prevention Research Institute, Kyoto University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SSS13-06] Fault model and strong ground motion evaluation for the Nankai megathrust earthquake

*Dianshu Ju[1], Hiroyuki Fujiwara[2], Nobuyuki Morikawa[2] (1.Ohsaki Research Institute, Inc., 2.National Research Institute for Earth Science and Disaster Resilience)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Convention Hall A 2F

[S-SS13] Strong Ground Motion and Earthquake Disaster

convener:Masayuki Kuriyama(Central Research Institute of Electric Power Industry), Kazuhiro Somei(Geo-Research Institute), Chairperson:Susumu Kurahashi(Aichi Institute of Technology), Masahiro Korenaga(Railway Technical Research Institute)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SSS13-07] One cause of the strong ground motion characteristics in Mukawa town during the 2018 Hokkaido eastern Iburi earthquake

*Nobuo TAKAI[1], Michiko Shigefuji[2], Takahiro Maeda[3], Masayoshi Ichiyanagi[1], Hiroaki Takahashi[1] (1.Hokkaido University, 2.Kyushu University, 3.NIED)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SSS13-08] Estimation of SMGA source model during the 2018 Hokkaido Eastern Iburi (Mw6.6) earthquake

*Susumu Kurahashi[1], Kojiro Irikura[1] (1.Aichi Institute of Technology)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SSS13-09] Strong ground motion prediction for the source fault model of Futagawa and Hinagu active fault zones (1) -Construction of the basin velocity structure model-

*Kimiyuki Asano[1], Tomotaka Iwata[1], Masayuki Yoshimi[2], Hiroe Miyake[3], Haruko Sekiguchi[1], Shinichi Matsushima[1], Hiroshi Kawase[1], Fumiaki Nagashima[1], Hiroaki Yamanaka[4], Kosuke Chimoto[4], Nobuyuki Yamada[5], Tatsuo Kanno[6], Michiko Shigefuji[6], Shigeki Senna[7], Takahiro Maeda[7], Atsushi Wakai[7], Asako Iwaki[7], Kaoru Jin[9], Hidetaka Saomoto[2], Seiji Tsuno[8], Masahiro Korenaga[8], Takeshi Sugiyama, Haruhiko Suzuki[9], Hisanori Matsuyama[9], Shunpei Manabe[9], Atsushi Yatagai[9], Shigeru Okamoto[10], Masaki Suehiro[10] (1.Disaster Prevention Research Institute, Kyoto University, 2.Geological Survey of Japan, AIST, 3.University of Tokyo, 4.Tokyo Institute of Technology, 5.Kochi University, 6.Kyushu University, 7.National Research Institute for Earth Science and Disaster Resilience, 8.Railway Technical Research Institute, 9.OYO Corporation, 10.Hanshin Consultants Co., Ltd.)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SSS13-10] Strong ground motion prediction for the source fault model of Futagawa and Hinagu active fault zones (2)-Strong ground motion prediction -

*Tomotaka Iwata[1], Kimiyuki Asano[1], Masayuki Yoshimi[2], Hiroe Miyake[3], Haruko Sekiguchi[1], Shinichi Matsushima[1], Hiroshi Kawase[1], Fumiaki Nagashima[1], Hiroaki Yamanaka[4], Kosuke Chimoto[4], Nobuyuki Yamada[5], Tatsuo Kanno[6], Michiko Shigefuji[6], Shigeki Senna[7], Takahiro Maeda[7], Asako Iwaki[7], Kaoru Jin[7], Hidetaka Saomoto[2], Seiji Tsuno[8], Masahiro Korenaga[8], Syunpei Manabe[9], Haruhiko Suzuki[9], Hisanori Matsuyama[9], Yatagai Atsushi[9] (1.Disaster Prevention Research Institute, Kyoto University, 2.Geological Survey of Japan, AIST, 3.University of Tokyo, 4.Tokyo Institute of Technology, 5.Kochi University, 6.Kyushu University, 7.National Research Institute for Earth Science and Disaster Resilience, 8.Railway Technical Research Institute, 9.OYO Corporation)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SSS13-11] Near-surface geophysical survey and hearing survey of housing damages at Yasunaga district, Mashiki Town stricken by the 2016 Kumamoto Earthquakes

*Tomio INAZAKI[1], Takanori Ogahara[1], Hiroshi Kisanuki[2] (1.Public Works Research Institute, Tsukuba Central Institute, 2.PWRI (Present Address: OYO Corporation))

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SSS13-12] Evaluation on Influence of Shallow Subsurface Structures to Earthquake Ground Motions in the Kumamoto Plain, Using the Borehole Seismic Data

*Masahiro Korenaga[1], Seiji Tsuno[1], Hiroaki Yamanaka[2], Kosuke Chimoto[2] (1.Railway Technical Research Institute, 2.Tokyo Institute of Technology)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Convention Hall A 2F

[S-SS13] Strong Ground Motion and Earthquake Disaster

convener:Masayuki Kuriyama(Central Research Institute of Electric Power Industry), Kazuhiro Somei(Geo-Research Institute), Chairperson:Kentaro Kasamatsu(Kajima Corporation), Kazuhito Hikima(Tokyo Electric Power Company Holdings, Inc.)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SSS13-13] Factors of large amplitude ground motions excited by small to moderate earthquakes - Examination of KiK-net Kuriyama-nishi of the 2013 Tochigi-ken Hokubu Earthquake (Mj6.3) -

*Kentaro Kasamatsu[1], Kenichi Kato[2], Tetsushi Watanabe[2], Tetsuo Shiota[3] (1.Kajima Corporation, 2.Kobori Research complex inc., 3.Shikoku Electric Power CO.,Inc.)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SSS13-14] Source modeling and strong ground motion simulation in the Tokyo metropolitan area of the 1923 Kanto earthquake based on seismic intensity inversion analysis

*Fumino Suzuki[1], Kenichi Kato[1], Katsuhisa Kanda[1], Takashi Ikeda[1] (1.KOBORI RESEARCH COMPLEX INC.)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SSS13-15] A Simple Fault Model to Calculate Strong Ground Motions Including Fling Steps for the Main Shock of the 2016 Kumamoto Earthquake

*Atsushi Nozu[1], Yosuke Nagasaka[1], Shuanglan Wu[1] (1.Port and Airport Research Institute)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SSS13-16] Fling-steps displacements by the discrete wavenumber method

*SHUANGLAN WU[1], Atsushi Nozu[1], Yosuke Nagasaka[1] (1.PORT AND AIRPORT RESEARCH INSTITUTE)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SSS13-17] Extension of characterized source model for long-period strong motions near surface-rupture-earthquakes

*Kojiro Irikura[1], Susumu Kurahashi[1], Yasuhiro Matsumoto[2] (1.Aichi Institute of Technology, 2.KOZO_KEIKAKU Engineering, Inc.)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SSS13-18] A Study for the cause of earthquake damages by the 2014 Nakagano-ken Hokubu earthquake (M_J6.7) – consideration using the strong motion simulation –

*Kazuhito Hikima[1], Ryoichi Nakamura[2], Tomiichi Uetake[1] (1.Tokyo Electric Power Company Holdings, Inc., 2.Earthquake Research Institute, Univ. of Tokyo)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Convention Hall A 2F

[S-SS13] Strong Ground Motion and Earthquake Disaster

convener:Masayuki Kuriyama(Central Research Institute of Electric Power Industry), Kazuhiro Somei(Geo-Research Institute), Chairperson:Yosuke Nagasaka(Port and Airport Research Institute), Masumi Yamada(Disaster Prevention Research Institute, Kyoto University)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SSS13-19] Strong ground motion simulation of the Northern Osaka earthquake of June 18, 2018

*Yosuke Nagasaka[1], Atsushi Nozu[1] (1.Port and Airport Research Institute)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SSS13-20] **Strong Motion of the 2018 Mw 6.4 Hualien, Taiwan Earthquake and Its Impact on Seismic Design Code in Taiwan**

*Chun-Hsiang Kuo[1], Jyun-Yan Huang[1], Che-Min Lin[1], Kuo-Liang Wen[2] (1.NCREE National Center for Research on Earthquake Engineering of Taiwan, 2.NCU National Central University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SSS13-21] Simulation of Rupture Directivity Effect for the February 6, 2018 Hualien, Taiwan Earthquake

*Cheng-Feng Wu[1], Huey-Chu Huang[1] (1.Department of Earth and Environmental Sciences, National Chung Cheng University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SSS13-22] Strong motions and estimation of the sursurface soil structure for the 2018 Hualien earthquake in Taiwan

*Masumi Yamada[1], Ikuo Cho[2], Chun-Hsiang Kuo[3], Che-min Lin[3], Ken Miyakoshi[4], Yujia Guo[4], Takumi Hayashida[5], Yasuhiro Matsumoto[6], James Mori[1], Yin-Tung Yen[7], Keng-Chang Kuo[8] (1.Disaster Prevention Research Institute, Kyoto University, 2.National Institute of Advanced Industrial Science and Technology , 3.National Center for Research on Earthquake Engineering, 4.Geo-Research Institute, 5.Building Research Institute, 6.Kozo Keikaku Engineering, 7.Sinotech Engineering Consultants, 8.Kaohsiung university of Science and Technology)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SSS13-23] **Effect of Near Surface Geology on the Recorded Ground Motion of the Nepal Earthquake in Kumaon Himalaya**

*SOHAN LAL[1], Anand Joshi[1], M.L. Sharma[1] (1.Indian Institute of Technology Roorkee)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SSS13-24] Broadband Source Modeling for the Himalayan Collision Zone

*Hiroe Miyake[1], Babita Sharma[2], Kazuki Koketsu[1], Soma Nath Sapkota[3] (1.Earthquake Research Institute, University of Tokyo, 2.National Centre for Seismology, Ministry of Earth Sciences, India, 3.Department of Mine and Geology, Nepal)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[S-SS16] Crustal Deformation

convener:Mako Ohzono(Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido University), Tadafumi Ochi(Institute of Earthquake and Volcano Geology, Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Masayuki Kano(Graduate school of science, Tohoku University), Chairperson:Yoshiyuki Tanaka(Earth and Planetary Science, The University of Tokyo), Masayuki Kano(東北大学 大学院理学研究科 地球物理学専攻)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SSS16-01] Development of New GEONET Analysis Strategy

*yasuaki kakiage[1], satoshi abe[1], kazuyuki ohashi[1], hideo hamazaki[1], kazuyuki tanaka[1], satoshi kawamoto[1], yuki hatanaka[1] (1.GSI of Japan)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SSS16-02] Relationship between deformation of the forearc wedge of Southwest Japan and the 1707 Hoei earthquake

*Yukinobu Okamura[1], Masanobu Shishikura[1] (1.Research Institute of Earthquake and Vocano Geology, National Institute of Advanced Industrial Science and Technology)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SSS16-03] A possible slow slip event beneath the Kii Peninsula inferred from historical tilt records in 1970's

*Masayuki Kano[1], Yasuyuki Kano[2] (1.Graduate school of science, Tohoku University, 2.Earthquake Research Institute, The University of Tokyo)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SSS16-04] The effect of the steady plate subduction in the case of southwest Japan

*Yuto Iwase[1], Takeo Ito[1] (1.Graduate School of Environmental Science, Nagoya University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SSS16-05] Development of Mechanical Coupling Model on Subducting Plate Interfaces

*Hiroshi Kimura[1], Takeo Ito[1], Keiichi Tadokoro[1], Ryohei Sasajima[2] (1.Department of Earth and Planetary Sciences, Nagoya University, 2.Research Center For Earthquake Prediction, Disaster Prevention Research Institute, Kyoto University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SSS16-06] Monitoring vertical deformation with optical lattice clock –an application of relativistic geodesy

*Yoshiyuki Tanaka[1], Yuichi Imanishi[2], Yoshiaki Tamura[3] (1.Earth and Planetary Science, The University of Tokyo, 2.Earthquake Research Institute, The University of Tokyo, 3.Mizusawa VLBI Observatory, National Astronomical Observatory of Japan)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[S-SS16] Crustal Deformation

convener:Mako Ohzono(Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido University), Tadafumi Ochi(Institute of Earthquake and Volcano Geology, Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Masayuki Kano(Graduate school of science, Tohoku University), Chairperson:Yuji Himematsu(Graduate School of Science, Hokkaido University), Atsushi Mukai(Faculty of Urban Management, Fukuyama City University)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SSS16-07] Surface Deformation before and after the 2016 Kumamoto Earthquake Detected by SAR

*Manabu Hashimoto[1] (1.Disaster Prevention Research Institute, Kyoto University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SSS16-08] Co- and post-seismic crustal deformations associated with the 2016 Kumamoto earthquake sequence using ALOS-2/PALSAR-2 data

*Yuji Himematsu[1], Masato Furuya[1] (1.Graduate School of Science, Hokkaido University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SSS16-09] GNSS time series analysis of postseismic deformation induced by 2016 Kumamoto earthquake (M7.3)

*Satoshi Fuwa[1], Mako Ohzono[1] (1.Hokkaido University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SSS16-10] **The viscoelastic crustal response to the magma discharge/recharge in the upper crust: implications for the uplift of the Aira caldera before and after the 1914 eruption of the Sakurajima volcano**

*Tadashi Yamasaki[1], Freysteinn Sigmundsson[2], Masato Iguchi[3] (1.Geological Survey of Japan, AIST, 2.Nordic Volcanological Center, University of Iceland, 3.DPRI, Kyoto University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SSS16-11] Factors controlling annual changes in groundwater migration in the fault fracture zone of Manpukuji fault

*Atsushi Mukai[1], Shigeaki Otsuka[2], Yoichi Fukuda[3] (1.Faculty of Urban Management, Fukuyama City University, 2.Kobe Gakuin University, 3.Graduate School of Science, Kyoto Univ.)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[S-SS16] Crustal Deformation

convener:Mako Ohzono(Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido University), Tadafumi Ochi(Institute of Earthquake and Volcano Geology, Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Masayuki Kano(Graduate school of science, Tohoku University), Chairperson:Takao Tabei(Department of Global Environment and Disaster Prevention, Faculty of Science and Technology, Kochi University), Takeo Ito

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SSS16-12] Rapid uplift in SW Taiwan caused by fold growth

*Yoshiki Takei[1], Youichiro Takada[2] (1.Department of Natural History Sciences, Graduate School of Science, Hokkaido University, 2.Hokkaido University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SSS16-13] Construction of GNSS monitoring system in Nepal for the earthquake potential evaluation in the Himalayan Frontal Zone

*Takao Tabei[1], Mako Ohzono[2], Kazuki Koketsu[3], Hiroe Miyake[3], Rajendra Bhandari[4], Janak B. Chand[4], Bishow R. Silwal[4], Soma N. Sapkota[4] (1.Department of Global Environment and Disaster Prevention, Faculty of Science and Technology, Kochi University, 2.Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido University, 3.Earthquake Researech Institute, University of Tokyo, 4.Department of Mines and Geology, Nepal)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SSS16-14] The kinematic model along the Sumatran fault using a new dense GNSS observation (AGNeSS+) in Banda Aceh

*Takeo Ito[1], Takao Tabei[2], Fumiaki Kimata[3], Makoto OKUBO[2], Tadashi Yamashina[2], Cecep Pratama[4], Didik Sugiyanto[5], Mukusin Umar[5], Nazli Ismail[5], Irwandi Nurdin[5] (1.Nagoya Univ, 2.Kochi Univ, 3.Tono Research Institute of Earthquake Science, 4.Gadjah Mada University, 5.Syiah Kuala University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SSS16-15] Mechanical modeling of interseismic deformation in the Central Andes: implications for back-arc shortening

*Shaoyang Li[1,2], Fuqiang Shi[3], Marcos Moreno[4], Jun'ichi Fukuda[1] (1.Earthquake Research Institute, University of Tokyo, Tokyo, Japan, 2.Department of Earth and Environmental Sciences, The University of Iowa, Iowa City, IA, USA, 3.Shaanxi Earthquake Agency, Xi'an, China, 4.Departamento de Geofísica, Facultad de Ciencias Físicas y Matemáticas, Universidad de Concepción, Concepción, Chile)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SSS16-16] Inferring regional stress field based on SAR analysis and dynamic simulation of the 2018 Palu earthquake

*Takafumi Yokota[1], Ryosuke Ando[1], Yosuke Aoki[2] (1.Graduate School of Science, University of Tokyo , 2.Earthquake Research Institute, University of Tokyo)

[J] Oral | S (Solid Earth Sciences)：S-EM Earth's Electromagnetism

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[S-EM18] Geomagnetism, paleomagnetism and rock magnetism

convener:Hisayoshi Shimizu(Earthquake Research Institute, University of Tokyo), Masahiko Sato(Department of Earth and Planetary Science, The University of Tokyo), Chairperson:Masahiko Sato(Department of Earth and Planetary Science, University of Tokyo), Akira Baba(山梨県富士山科学研究所)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SEM18-01] On the formation process of the Mt.Hoei, Fuji volcano.
A scenario based on the emplacement temperature inferred from paleomagnetic method.

*Akira Baba[1], Hidetoshi Shibuya[2], Toshitsugu Fujii[1], Tatsuro Chiba[3] (1.Mount Fuji Research Institute, 2.Department of Earth and Environmental Sciences, Faculty of Advanced Science and Technology, Kumamoto University, 3.Asia Air Survey Co., Ltd.)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SEM18-02] Reconstruction of paleointensity during 5 to 9 th century from Mt. Fuji lavas

Hiromichi Komatsu[2], *Tadahiro Hatakeyama[1,4], Akira Baba[3] (1.Information Processing Center, Okayama University of Science, 2.Faculty of Biosphere-Geosphere Science, Okayama University of Science, 3.Mount Fuji Research Institute, Yamanashi Prefecture, 4.Graduate School of Biosphere-Geosphere Science, Okayama University of Science)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SEM18-03] Reconstruction of full-vector archaeomagnetic reference curve in East Asia from 200 CE to 1100 CE

*Yu Kitahara[1], Daiki Nishiyama[2], Masao Ohno[1], Yuhji Yamamoto[3], Tadahiro Hatakeyama[4] (1.Faculty of Social and Cultural Studies, Kyushu University, 2.Faculty of Science, Kochi University, 3.Center for Advanced Marine Core Research, Kochi University, 4.Information Processing Center, Okayama University of Science)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SEM18-04] A high resolution paleomagnetic record across and around the Matuyama-Brunhes polarity transition from the Chiba composite section

*Makoto Okada[1], Yuki Haneda[2], Yusuke Suganuma[3,4] (1.Department of Earth Sciences, Faculty of Science, Ibaraki University, 2.Graduate School of Scinece and Engineering, Ibaraki Univeristy, 3.National Institute of Polar Research, 4.Graduate University for Advanced Studies)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SEM18-05] Brunhes-Matuyama contact aureole surrounding the Kurobegawa Granite

*Koji Fukuma[1], Hisatoshi Ito[2], Mami Takehara[3], Ryuji Yamada[4], Takashi Kubo[5] (1.Department of Environmental System Science, Faculty of Science and Engineering, Doshisha University, 2.Central Research Institute of Electric Power Industry, 3.National Institute of Polar Research, 4.National Research Institute for Earth Science and Disaster Prevention, 5.MAIBUNKAN)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SEM18-06] Paleomagnetic study of the IODP Site U1335 sediments in the eastern equatorial Pacific - relative paleointensity and inclination anomaly over the last 8 Myr

*Yuhji Yamamoto[1], Toshitsugu Yamazaki[2] (1.Center for Advanced Marine Core Research, Kochi University, 2.Atmosphere and Ocean Research Institute, University of Tokyo)

[J] Oral | S (Solid Earth Sciences)：S-EM Earth's Electromagnetism

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[S-EM18] Geomagnetism, paleomagnetism and rock magnetism

convener:Hisayoshi Shimizu(Earthquake Research Institute, University of Tokyo), Masahiko Sato(Department of Earth and Planetary Science, The University of Tokyo), Chairperson:Yu Kitahara(Graduate School of Social and Cultual Studies, Kyushu University), Hisayoshi Shimizu(The University of Tokyo)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SEM18-07] Sensor Response Estimate and Calibration of Superconducting Rock Magnetometers

*Hirokuni Oda[1], Chuang Xuan[2] (1.Institute of Geology and Geoinformation, Geological Survey of Japan, AIST, 2.University of Southampton)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SEM18-08] Magnetic separation of ordinary solid particles using a pokcet size magnetic circuit

*Chiaki Uyeda[1] (1.Institute of earth and Space Science Graduate School of Science Osaka University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SEM18-09] Experimental evaluation of remanence carriers in coercivity-blocking temperature diagram

*Masahiko Sato[1], Takuma Terada[2], Nobutatsu Mochizuki[3], Ayako Ito[2], Hideo Tsunakawa[2] (1.The University of Tokyo, 2.Tokyo Institute of Technology, 3.Kumamoto University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SEM18-10] **Mineralogical study on magnetite exsolution and host plagioclase crystal**

*Yujiro Tamura[1], Ryoichi Nakada[2], Masahiko Sato[3], Shinji Yamamoto[4] (1.Graduate schoole of Environment and Information Sciences, Departmennt of Natural Environment, Yokohama National University, 2.Kochi Institute of Core Sample Reserch, Japan Agency for Marine-Earth Science and Technology, 3.Department of Earth and Planetary Science, The University of Tokyo, 4.Graduate schoole of Environment and Information Sciences, Yokohama National University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SEM18-11] Numerous nano-sized magnetite and hematite inclusions in muscovite in loess

*Masayuki Hyodo[1], Takuro Sano[2], Megumi Matsumoto[3], Yusuke Seto[2], Kota Suzuki[2], Tianshui Yang[4] (1.Research Center for Inland Seas, Kobe University, 2.Graduate School of Science, Kobe University, 3.Graduate School of Science, Tohoku University, 4.China University of Geosciences)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SEM18-12] Density separation and magnetic measurements of magnetotactic bacteria *Magnetospirillum magnetotacticum* MS-1

*Kohei Masaoka[1], Yuki Morono[2], Naotaka Tomioka[2], Go-Ichiro Uramoto[1], Yuhji Yamamoto[1] (1.Kochi University, 2.Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology)

[J] Oral | S (Solid Earth Sciences)：S-EM Earth's Electromagnetism

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[S-EM18] Geomagnetism, paleomagnetism and rock magnetism

convener:Hisayoshi Shimizu(Earthquake Research Institute, University of Tokyo), Masahiko Sato(Department of Earth and Planetary Science, The University of Tokyo), Chairperson:Masahiko Sato(Department of Earth and Planetary Science, University of Tokyo), Hisayoshi Shimizu(The University of Tokyo)

1:45 PM - 2:05 PM JST | 4:45 AM - 5:05 AM UTC

[SEM18-13] Effects of the intrinsic magnetic field on the atmospheric escape from terrestrial planets

★Invited Papers

*Kanako Seki[1], Shotaro Sakai[1], Shogo Inui[1], Ryoya Sakata[1], Naoki Terada[2], Hiroyuki Shinagawa[3], David A. Brain[4] (1.Graduate School of Science, University of Tokyo, 2.Graduate School of Science, Tohoku University, 3.NICT, 4.LASP, University of Colorado, Boulder)

2:05 PM - 2:20 PM JST | 5:05 AM - 5:20 AM UTC

[SEM18-14] Numerical modeling of a lunar dynamo and its long-term evolution

*Fumi Hyodo[1], Futoshi Takahashi[2], Satoshi Kaneshima[2], Hisayoshi Shimizu[3], Hideo Tsunakawa[4] (1.Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2.Department of Earth and Planetary Sciences, Kyushu University, 3.Earthquake Research Institute, University of Tokyo, 4.Deparment of Earth and Planetary Sciences, Tokyo Institute of Technology)

2:20 PM - 2:40 PM JST | 5:20 AM - 5:40 AM UTC

[SEM18-15] Investigation of sub-grid scale (SGS) model in dynamo simulations with small Ekman and magnetic Prandtl numbers

★Invited Papers

*Hiroaki Matsui[1] (1.Dept. of Earth and Planetary Sciences, University of California, Davis)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SEM18-16] Growth rates of kinematic dynamos in a finite domain

*Ataru Sakuraba[1] (1.Department of Earth and Planetary Science, University of Tokyo)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SEM18-17] Detection of jerk-like magnetic field variation in a numerical dynamo model using wavelet analysis

*Futoshi Takahashi[1], Yoshiki Manabe[2] (1.Faculty of Sciences, Kyushu University, 2.Department of Earth and Planetary Sciences, Kyushu University)

[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-VC36] Volcanic and igneous activities, and these long-term forecasting

convener:Teruki Oikawa(GSJ, National Institute of Advanced Industrial Science and Technology), Takeshi Hasegawa(Department of Earth Sciences, College of Science, Ibaraki University), Daisuke MIURA(Department of Physical Science, Graduate School of Science, Osaka Prefecture University), Nobuo Geshi(Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Chairperson:Daisuke Miura, Nobuo Geshi(GSJ/AIST)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SVC36-01] The entire magmatic history of the Toba Caldera Complex that influenced human evolution, northern Sumatra, inferred from zircon U-Pb geochronology

*Hisatoshi Ito[1] (1.Central Research Institute of Electric Power Industry)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SVC36-02] Pre-eruptive magmatic processes of "Hakone Tokyo Pumice eruption"

*Ryo Tsujihara[1,2], Tetsu Kogiso[1], Takashi Sano[3], Hidemi Ishibashi[4] (1.Graduate School of Human and Environmental Studies, Kyoto University, 2.Asia Air Survey Co., Ltd., 3.National Museum of Nature and Science, 4.Faculty of Science, Shizuoka University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SVC36-03] Transition of magma plumbing system deduced from the melt inclusions contained in tephra minerals originated from Aso central cones.

*ryota nagaishi[1], Toshiaki Hasenaka[2], Masayuki Torii[2], ATSUSHI YASUDA[3], Natsumi Hokanishi[3] (1.Graduate of Science and Technology, Kumamoto University, 2.Center for water cycle, marin environment and disaster management , 3.Earthquake Reserach Institute, The University of Tokyo)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SVC36-04] Pre-eruptive magma dynamics of the climactic 110ka eruption of Toya caldera, Japan

*Akihiko Tomiya[1], Yoshihiko Goto[2], Tohru Danhara[3], Shanaka L de Silva[4] (1.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2.Muroran Institute of Technology, 3.Kyoto Fission-Track Co., Ltd., 4.Oregon State University, College of Earth, Ocean and Atmospheric Sciences)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SVC36-05] Voluminous silicic magma formation for the 30 ka Aira catastrophic caldera-forming eruption: contributions of crust-derived mafic and felsic magmas

*Ayumu Nishihara[1], Yoshiyuki Tatsumi[2,1], Keiko Suzuki-Kamata[2,1], Katsuya Kaneko[1,2], Jun-Ichi Kimura[3], Qing Chang[3], Hironobu Hinata[4], Takashi Miyazaki[3], Bogdan Stefanov Vaglarov[3] (1.Department of Planetology, Graduate School of Science , Kobe University, 2.Kobe Ocean-Bottom Exploration Center, 3.Department of Solid Earth Geochemistry, Japan Agency for Marine-Earth Science and Technology, 4.Kobe Municipal Tarumi Junior High School)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SVC36-06] Stratigraphy and petrological relations of pre-Aso volcanic rocks in Tateno district, Minami-Aso village

*Shota Togawa[1], Toshiaki Hasenaka[2], Masayuki Torii[2], Yasushi Mori[3] (1.Graduate school of science and technology, 2.Center for Water Cycle, Marine Environment and Disaster management, Kumamoto University, 3.Kitakyushu Museum of Natural History and Human History)

[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-VC36] Volcanic and igneous activities, and these long-term forecasting

convener:Teruki Oikawa(GSJ, National Institute of Advanced Industrial Science and Technology), Takeshi Hasegawa(Department of Earth Sciences, College of Science, Ibaraki University), Daisuke MIURA(Department of Physical Science, Graduate School of Science, Osaka Prefecture University), Nobuo Geshi(Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Chairperson:Nobuo Geshi(GSJ/AIST), Daisuke Miura

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SVC36-07] Caldera structure delineated by airborne gravity gradiometry

*Atusi NINOMIYA[1], Hiromasa ISHIKAWA[1], Shunsuke NOGAMI[1], Yoshio NAKASATO[1] (1.Sumiko Resources Exploration and Development Co., Ltd.)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SVC36-08] The initial fine ash deposit of the Shikotsu caldera-forming eruption at ca. 45 ka

*Chiharu Tomijima[1], Daisuke MIURA[1], Shimpei Uesawa[2], Mizuho Amma-Miyasaka[3] (1.Department of Physical Science, Graduate School of Science, Osaka Prefecture University, 2.Central Research Institute of Electric Power Industry, 3.Graduate School of Sciences, Hokkaido University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SVC36-09] Characterization of the Small-volume Pyroclastic Flows from the Kuchinoerabu-jima Volcano during 2018-2019, Southwest Japan

*Ryuta FURUKAWA[1], Teruki Oikawa[1], Nobuo Geshi[1] (1.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SVC36-10] An explanation of size and position of Mt. Fuji

*Yasushi Harada[1], Miyu Takahashi[1] (1.School of Marine Science and Technology, Tokai University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SVC36-11] Arc magmatism in the northernmost part of Kamchatka caused by the aseismic subducted Bering slab

*Tatsuji Nishizawa[1], Hitomi Nakamura[2,3,4,5], Tatiana Churikova[6,7], Boris Gordeychik[6,8], Maria Pevzner[9], Osamu Ishizuka[2,10], Hikaru Iwamori[3,4,11] (1.Volcanic Fluid Research Center, School of Science, Tokyo Institute of Technology, 2.Institute of Earthquake and Volcano Geology, Geological Survey of Japan, AIST, 3.Department of Solid Earth Geochemistry, Japan Agency for Marine-Earth Science and Technology, 4.Depeartment of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology, 5.ORCeNG, Chiba Institute of Technology, 6.GZG, Abt. Geochemie, Universität Göttingen, 7.Institute of Volcanology and Seismology, Far East Branch, Russian Academy of Sciences, 8.Institute of Experimental Mineralogy, Russian Academy of Sciences, 9.Geological Institute, Russian Academy of Sciences, 10.R & D Center for Ocean Drilling Science, Japan Agency for Marine-Earth Science and Technology, 11.Earthquake Research Institute, The University of Tokyo)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SVC36-12] Redox state of magma in the deep crust beneath NE Japan arc: constraints from cumulate xenoliths from Ichinomegata Maar

*Naoya Tsushima[1], Michihiko Nakamura[1], Yasuhiro Yanagida, Takeyoshi Yoshida[1] (1.Division of Earth and Planetary Materials Science, Department of Earth Science, Graduate School of Science, Tohoku University)

[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-VC36] Volcanic and igneous activities, and these long-term forecasting

convener:Teruki Oikawa(GSJ, National Institute of Advanced Industrial Science and Technology), Takeshi Hasegawa(Department of Earth Sciences, College of Science, Ibaraki University), Daisuke MIURA(Department of Physical Science, Graduate School of Science, Osaka Prefecture University), Nobuo Geshi(Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Chairperson:RYUTA FURUKAWA, Teruki Oikawa

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SVC36-13] Deformation of a rhyolite lava below the Curie temperature: the Sanukayam lava in Kouzusima Island, Japan

*Takuma Kamio[1], Kuniyuki Furukawa[2], Tatsuo Kanamaru[3], Koji Uno[1] (1.Okayama University, 2.Aichi University, 3.Nihon University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SVC36-14] Evolution of magmatic chemistry for the Asama-Maekake volcano since 10ka revealed by whole-rock chemical analysis of pumice obtained by the trenching of air-fall tephra deposits

*Masaki Takahashi[1], Maya Yasui[1], Tatsuo Kanamaru[1] (1.Department of Earth and Environmental Sciences, College of Humanities and Sciences, Nihon University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SVC36-15] Late Pleistocene–Holocene tephra ejecta in the trench log at the southern apron of Esan volcanic complex, Japan

*Daisuke MIURA[1], Ryuta FURUKAWA[2], Kenichi Arai[3] (1.Graduate School of Science, Osaka Prefecture University, 2.Institute of Earthquake and Volcano Geology, GSJ/AIST, 3.Asia Air Survey)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SVC36-16] **Transition of eruption sequence and magma plumbing system at the 1.4 ka Nakamachineshiri eruption of Me-Akandake volcano, eastern Hokkaido, Japan.**

*Kosuke Ishige[1,2], Mitsuhiro Nakagawa[1] (1.Department of Natural History Sciences, Graduate School of Science, Hokkaido University, 2.Mitsubishi Materials Corporation)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SVC36-17] Kilo-year-evolution of magma plumbing system with dominant modes of eruption at Suwanosejima volcano, Southwest Japan

*Taketo Shimano[1], ATSUSHI YASUDA[2] (1.Graduate School of Environment and Disaster Research, Tokoha University, 2.Earthquake Research Institute, University of Tokyo)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SVC36-18] Temporal variation of the magma compositions of the Miyakejima volcano during the last 2700 years

*Nobuo Geshi[1], Teruki Oikawa[1] (1.Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology)

[J] Oral | S (Solid Earth Sciences)：S-TT Technology & Techniques

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-TT44] Airborne surveys and monitoring of the Earth

convener:Shigekazu Kusumoto(Graduate School of Science and Engineering for Research, University of Toyama), Takao Koyama(Earthquake Research Institute, University of Tokyo), Yuji Mitsuhata(AdvancedIndustrial Science and Technology), Shigeo Okuma(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Chairperson:Shigekazu Kusumoto, Takao Koyama(東京大学 地震研究所 火山センター), Shigeo Okuma(産業技術総合研究所), Yuji Mitsuhata(国立研究開発法人　産業技術総合研究所)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[STT44-01] A Case Study on the Application of a Magnetic Survey Using Magnetometers Carried by Multicopter-type Drones

★Invited Papers

*Shiga Nobuhiko[1], Harada Haruo[1], Wada Kazushige[1] (1.Mitsui Mineral Development Engineering Co., Ltd.)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[STT44-02] Development for upgrading the generalization capability of the seismic damage detection of building based on the deep-learning utilizing aerial photographs

★Invited Papers

*Shohei Naito[1], Hiromitsu Tomozawa[2], Yuji Mori[2], Naokazu Monma[3], Hiromitsu Nakamura[1], Hiroyuki Fujiwara[1] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Mizuho Information and Research Institute, Inc., 3.Pasco Corporation)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[STT44-03] The resistivity distribution under the ground on bedrock creep slopes in Kii mountain area by the airborne electromagnetic survey

*Atsuhiko Kinoshita[1,2], Yasutaka Tanaka[2], Wataru Sakurai[1], Taro Uchida[1], Koichiro Hayashi[3], Katsushi Kawato[4], Minoru Okumura[4] (1.National Institute for Land and Infrastructure Management, 2.Sediment Disaster Prevention Technology Center, Kinki Developing Regional Bureau, Ministry of Land, Infrastructure, Transport and Tourism , 3.OYO Corporation, 4.NIPPON ENGINEERING CONSULTANTS CO.,LTD.)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[STT44-04] Study of UAV photogrammetry toward efficiently grasping volcanic landform

*Yuichi Iwasa[1], Takeshi Matsushima[2] (1.department of earth and planetary sciences, graduate school of sciences, Kyushu University, 2.SEVO, Kyushu Univ.)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[STT44-05] Volcanic gas measurements using UAVs

*Takeshi Hashimoto[1], Akihiko Terada[2], Toshiya Mori[3], Ryo Tanaka[1] (1.Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido University, 2.Volcanic Fluid Research Center, Tokyo Institute of Technology, 3.Geochemical Research Center, Graduate School of Science, The University of Tokyo)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[STT44-06] Repeated Drone Magnetic Survey over Usu Volcano, Hokkaido Japan

*Shigeo Okuma[1], Masahiko Makino[2], Tadashi Nakatsuka[1], Ayumu Miyakawa[1], Makoto Yanagida[3], Minoru Okumura[4] (1.Institute of Geology and Geoinformation, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST), 2.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST), 3.Hanshin Consultants Co., Ltd., 4.Nippon Engineering Consultants Co., Ltd.)

[J] Oral | S (Solid Earth Sciences)：S-TT Technology & Techniques

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 304 3F

[S-TT47] Creating future of solid Earth science with high performance computing (HPC)

convener:Takane Hori(R&D Center for Earthquake and Tsunami, Japan Agency for Marine-Earth Science and Technology), Yuji Yagi(Graduate School of Life and Environmental Sciences, University of Tsukuba, Tsukuba), Katsuhiko Shiomi(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Takane Hori

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[STT47-01] Expectations to more realistic Green's function with modeling errorfor the real-time estimation of the coseismic fault model

*Yusaku Ohta[1] (1.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[STT47-02] Development of high-performance low order unstructured implicit finite-element solvers for solid earth science problems

★Invited Papers

*Kohei Fujita[1], Tsuyoshi Ichimura[1], Takuma Yamaguchi[1] (1.Earthquake Research Institute, The University of Tokyo)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[STT47-03] Optimal spectral element method for elastic wave computation

*Kei Hasegawa[1], Nobuaki Fuji[2], Kensuke Konishi[3] (1.Earthquake Research Institute, University of Tokyo, 2.Institut de Physique du Globe de Paris, 3.Institute of Earth Sciences, Academia Sinica)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[STT47-04] Multi scale tsunami simulation from earthquake initiation to tsunami run-up into the coastal area and high performance particle simulator

*Mitsuteru Asai[1], Mikito Furuichi[2], Daisuke Nishiura[2] (1.Kyushu University, 2.JAMSTEC)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[STT47-05] Digital-Ensemble Concept for Making Resilient Society against Natural Hazard

*Satoru Oishi[1] (1.RIKEN Center for Computational Science)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[STT47-06] Expected Role of High Performance Computing to Promote Earthquake Research

★Invited Papers

*Naoshi Hirata[1] (1.Earthquake Research Institute, the University of Tokyo)

[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-CG56] Ocean Floor Geosciences

convener:Kyoko Okino(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:shuhei Totsuka, Ayanori Misawa

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SCG56-01] The restoration of precipitation record of iron hydroxide about seven years in Nagahama Bay, Satsuma Iwo-jima, Kagoshima.

*Naoya Sakamoto[1], Shoichi Kiyokawa[2] (1.Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2.Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SCG56-02] Mineralogical and geochemical study of hydrothermal deposits beneath the seafloor at the Gondou field in the Okinawa Trough

*Shuhei Totsuka[1], Jun-ichiro Ishibashi[2], Kazuhiko Shimada[2], Kei Ikehata[3], Hideaki Machiyama[4], Koichi Iijima[4], Hirofumi Yamamoto[4], Hidenori Kumagai[4], Ken Ikehara[5], Toru Yamasaki[5], Yutaro Takaya[6], Toshiro Nagase[7], Thomas Tindell[8], Kotaro Yonezu[8], Yuki Tada[8] (1.Department of Earth and Planetary Sciences, Graduate School of Sciences, Kyushu University, 2.Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University, 3.Faculty of Life and Environmental Sciences, University of Tsukuba, 4.Research and Development Center for Submarine Resources, JAMSTEC, 5.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 6.Department of Resources and Environmental Engineering School of Creative Science and Enginerring, Waseda University, 7.Tohoku University Museum, 8.Department of Earth Resources Engineering, Faculty of Engineering, Kyushu University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SCG56-03] Strontium isotope study of sulfate minerals obtained by scientific drilling from seafloor hydrothermal fields in the Okinawa Trough

Akihi Tsutsumi[1], Naru Tsukamoto[1], Kazuhiko Shimada[1], *Jun-ichiro Ishibashi[1], Ryuichi Shinjo[2] (1.Department of Earth and Planetary Sciences, Kyushu University, 2.Faculty of Science, University of Ryukyus)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SCG56-04] Numerical modeling of seafloor hydrothermal system in the Izena Caldron, Okinawa Trough

*Shohei Albert Tomita[1], Katsuaki Koike[1], Tada-nori Goto[1], Katsuhiko Suzuki[2], Takafumi Kasaya[2] (1.Graduate School of Engineering, Kyoto University, 2. Japan Agency for Marine-Earth Science and Technology)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SCG56-05] Electrical conductivity and spectral IP characteristics in the rock samples obtained in seafloor hydrothermal area and interpretation of them

*Yusuke Ohta[1], Tada-nori Goto[1], Katsuaki Koike[1], Weiren Lin[1], Koki Kashiwaya[1], Tadai Osamu[3], Takafumi Kasaya[2], Toshiya Kanamatsu[2], Hidenori Kumagai[2], Hideaki Machiyama[2] (1.Kyoto University, 2.Japan Agency for Marine-Earth Science and Technology, 3.Marine Works Japan)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SCG56-06] Geological structure north offshore Ishigaki-Jima estimated from seismic reflection survey

*Ayanori Misawa[1], Seishiro Furuyama[2,1], Masahiko Sato[3,1], Jih-Shin Chang[1], Takahiko Inoue[1], Kohsaku Arai[1] (1.Geological Survey of Japan, AIST, 2.Tokyo University of Marine Science and Technology, 3.The University of Tokyo)

[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-CG56] Ocean Floor Geosciences

convener:Kyoko Okino(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Keishiro Azami, Erika Tanaka

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SCG56-07] The first report of the evidence for hydrothermal activity in old oceanic plate

*Keishiro Azami[1], Shiki Machida[2], Naoto Hirano[3], Tetsu Kogiso[4], Yasuhiro Kato[1,2] (1.Department of System Innovation, School of Engineering, The University of Tokyo, 2.Ocean Resources Research Center for Next Generation, Chiba Institute of Technology, 3.Center for Northeast Asian Studies, Tohoku University, 4.Graduate School of Human and Environmental Studies, Kyoto University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SCG56-08] X-ray computed tomography characterization of the distribution of biogenic apatite and sedimentary structures in pelagic clay around Minamitorishima Island, western North Pacific

*Yoichi Usui[1], Koichi Iijima[1], Hideaki Machiyama[1], Yuji Ichiyama[2,1], Erika Tanaka[3], Koichiro Fujinaga[4,3], Kazutaka Yasukawa[3,4] (1.Japan Agency for Marine-Earth Science and Technology, 2.Chiba University, 3.The University of Tokyo, 4.Chiba Institute of Technology)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SCG56-09] Geochemistry and distribution of REY-rich mud in the eastern off the Takuyo-Daigo Seamount within the Minamitorishima EEZ

*Koichiro Fujinaga[1,2], Kazutaka Yasukawa[3,1], Tatsuo Nozaki[4,2,1,5], Shiki Machida[1,2], Yutaro Takaya[6,2,1], Junichiro Ohta[1,2], Moei Yano[3], Ryo Shimomura[3], Erika Tanaka[3], Kazuhide Mimura[3], Koichi Horinouchi[3], Kenji Matsumoto[3], Yoichi Usui[4], Hirofumi Yamamoto[4], Kentaro Nakamura[3], Yasuhiro Kato[2,3,1], KM17-14C cruise members (1.Ocean Resources Research Center for Next Generation, Chiba Institute of Technology, 2.Frontier Research Centerfor Energy and Resources, School of Engineering, The University of Tokyo, 3.Department of Systems Innovation, School of Engineering, The University of Tokyo, 4.Japan Agencyfor Marine-Earth Science and Technology, 5.Department of Planetology, Graduate Schoolof Science, Kobe University, 6.Department of Resources and Environmental Engineering School of Creative Science and Engineering, Waseda University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SCG56-10] Extended lateral correlation of deep-sea sediments around the Minamitorishima EEZ based on downhole variation of bulk chemical composition

*Erika Tanaka[1], Kentaro Nakamura[1], Kazutaka Yasukawa[1,2], Koichiro Fujinaga[2], Koichi Iijima[3], Shiki Machida[2], Yasuhiro Kato[1,2] (1.School of Engineering, The University of Tokyo, 2.ORCeNG, Chiba Institute of Technology, 3.JAMSTEC)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SCG56-11] Tectonics of the abyssal basins surrounding the Ontong Java Plateau

*Masao Nakanishi[1], Shoka Shimizu[2], Daisuke Suetsugu[3], Takashi Sano[4] (1.Department of Earth Sciences, Graduate School of Science, Chiba University, 2.Department of Earth Sciences, Graduate School of Science and Technology, Chiba University, 3. Department of Deep Earth Structure and Dynamics Research, Japan Agency for Marine-Earth Science and Technology, 4.Department of Geology and Paleontology, National Museum of Nature and Science)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SCG56-12] The Cretaceous Normal Superchron: records from the Pacific, Indian and Atlantic oceanic crust

*Nobukazu Seama[1,2], Jerome Dyment[3], Taichi Sato[4,5], Yves Gallet[6], Kyoko Okino[7], Roi Granot[8], Yoshifumi Nogi[9], Nobutatsu Mochizuki[10], Toshitsugu Yamazaki[7] (1.Department of Planetology, Kobe University, 2.KOBEC (Kobe Ocean-Bottom Exploration Center), Kobe University, 3.Institut de Physique du Globe de Paris, 4.National Institute of Advanced Industrial Science and Technology, 5.The Institute for Geoscience Research (TIGeR), Curtin University , 6.French Centre National de la Recherche Scientifique, 7.Atmosphere and Ocean Research Institute, The University of Tokyo, 8.Department of Geological and Environmental Sciences, Ben-Gurion University, 9.National Institute of Polar Research, 10.Priority Organization for Innovation and Excellence, Kumamoto University)

[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-CG56] Ocean Floor Geosciences

convener:Kyoko Okino(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Chie Honsho, Tadashi Ishikawa

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SCG56-13] Offshore Postseismic Deformation of the 2011 Tohoku Earthquake Revisited: Application of an Improved GPS-Acoustic Positioning Method Considering Sloping Sound Speed Structure

*Chie Honsho[1], Motoyuki Kido[2], Fumiaki Tomita[3], Naoki Uchida[1] (1.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University, 2.International Research Institute of Disaster Science, Tohoku University, 3.Graduate School of Science, Hokkaido University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SCG56-14] Comprehensive analysis for the forearc structure and dynamics by using the S-net data

*Naoki Uchida[1], Ryosuke Azuma[1], Akira Ishigami[1], Tomomi Okada[1], Ryota Takagi[1], Genti Toyokuni[1], Norihito Umino[1], Yusaku Ohta[1], Makiko Sato[1], Syuichi Suzuki[1], Hidenobu Takahashi[1], Kazuya Tateiwa[1], Dapeng Zhao[1], Takashi NAKAYAMA[1], Akira Hasegawa[1], Ryota Hino[1], Satoshi Hirahara[1], Toru Matsuzawa[1], Keisuke Yoshida[1] (1.Research Center for Prediction of Earthquakes and Volcanic Eruptions Graduate School of Science, Tohoku University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SCG56-15] Shallow slow slip event inferred from GNSS-A seafloor geodesy

*Tadashi Ishikawa[1], Yusuke Yokota[2] (1.Hydrographic and Oceanographic Department, Japan Coast Guard, 2.Institute of Industrial Science, the University of Tokyo)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SCG56-16] Assessing strike-slip motion at the Shionomisaki Canyon along the Nankai oblique subduction zone using acoustic ranging system

*Motoyuki Kido[1], Eiichiro Araki[2], Takeshi Tsuji[3], Ryusuke Yamamoto[4], Yoshifumi Kawada[1] (1.International Research Institute for Disaster Science, Tohoku University, 2.JAMSTEC, 3.Dept. Earth Resources Engineering, Kyushu University, 4.School of Science, Tohoku University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SCG56-17] Development of seafloor realtime observation network for crustal deformation in the Nankai Trough: tiltmeter installation

*Eiichiro Araki[1], Takashi Yokobiki[1], Toshinori Kimura[1], Shuhei Nishida[1], Yuya Machida[1], Shuichi Kodaira[1] (1.Japan Agency for Marine-Earth Science and Technology)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SCG56-18] Calibration of the DONET pressure sensor network in the Nankai trough seismogenic zone using a mobile pressure gauge

*Yuya Machida[1], Shuhei Nishida[1], Toshinori Kimura[1], Eiichiro Araki[1] (1.Japan Agency for Marine-Earth Science and Technology)

[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-CG56] Ocean Floor Geosciences

convener:Kyoko Okino(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Misae Imano, Tetsuo No

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SCG56-19] Analysis of GNSS/Acoustic geodetic data including the period of the transponder replacement

*Ikuta Ryoya[1], Koto Mizuno[1], Horng-Yue Chen[3], Masataka Ando[2], Takeru Komi[1] (1.Faculty of Science, Shizuoka University, 2.Center for Integrated Research and Education of Natural Hazards, Shizuoka University, 3.Institute of Earth Science, Academia Sinica)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SCG56-20] IPR (Indirect Path Ranging): a new approach for long-distance acoustic ranging with a moored relay node

*Ryusuke Yamamoto[1], Ryota Hino[1], Motoyuki Kido[2] (1.Graduate School of Science, Tohoku University, 2.International Research Institute of Disaster Science, Tohoku University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SCG56-21] Development of a kinematic GNSS-A positioning method using the extended Kalman-filter to detect precise vertical displacement

*Fumiaki Tomita[1], Motoyuki Kido[2], Chie Honsho[3], Ryo Matsui[3] (1.Graduate School of Science, Hokkaido University, 2.International Research Institute of Disaster Science, Tohoku University, 3.Graduate School of Science, Tohoku University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SCG56-22] DOP-based accuracy evaluation of GNSS-A positioning on a drifting moored buoy quantified using sea trial observation data

*Misae Imano[1], Motoyuki Kido[2,3], Chie Honsho[3], Yusaku Ohta[3], Ryota Hino[3] (1.Graduate School of Science, Tohoku University, 2.nternational Research Institute for Disaster Science, Tohoku University, 3.Reserch Center for Prediction of Earthquakes and Volcanic Eruptions Graduate School of Science, Tohoku University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SCG56-23] Analysis for GNSS/acoustic ocean bottom crustal deformation considering the heterogeneity of sound speed structure in ocean

*Natsuki Kinugasa[1], Keiichi Tadokoro[1], Yukihiro Terada[2], Teruyuki Kato[3] (1.Graduate School of Environmental Studies, Nagoya University, 2.National Institute of Technology, Kochi College, 3.Hot Springs Research Institute of Kanagawa Prefectural Government)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SCG56-24] Seismic imaging using ocean bottom nodes in the Ishikari Basin, Japan Sea

*Tetsuo No[1], Takeshi Sato[1], Shuichi Kodaira[1], Satoshi Shimizu[2], Tetsuya Yokota[2], Karl Hosgood[3], Masako Robb[3], Tetsuro Tsuru[4] (1.JAMSTEC, 2.Nippon Marine Enterprises, 3.Emerson E&P Software, 4.Tokyo University of Marine Science and Technology)

[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 304 3F

[S-CG62] Potentiality of Machine Learning in Solid Earth Sciences

convener:Takahiko Uchide(Research Institute of Earthquake and Volcano Geology, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Hirokuni Oda(Institute of Geology and Geoinformation, Geological Survey of Japan, AIST), Chairperson:Takahiko Uchide(Geological Survey of Japan, AIST), Hirokuni Oda

9:00 AM - 9:20 AM JST | 12:00 AM - 12:20 AM UTC

[SCG62-01] The Promise of Machine Learning in Solid Earth Geoscience: Examples from Seismology

★Invited Papers

*Gregory C Beroza[1], Mostafa Mousavi[1], Weiqiang Zhu[1], Karianne J Bergen[2], Paul A Johnson[3], Maarten V De Hoop[4] (1.Stanford University, 2.Harvard University, 3.Los Alamos National Laboratory, 4.Rice University)

9:20 AM - 9:35 AM JST | 12:20 AM - 12:35 AM UTC

[SCG62-02] **Automatic Approach to Low-Frequency Earthquakes Detection in Southwest Japan Based on Deep Learning Technique**

*Yu Junyu[1], Yuji Yagi[1], Takanori Matsuzawa[2], Ryo Okuwaki[1] (1.Graduate School of Life and Environmental Sciences,University of Tsukuba, Tsukuba, 2.National Research Institute for Earth Science and Disaster Resilience)

9:35 AM - 9:50 AM JST | 12:35 AM - 12:50 AM UTC

[SCG62-03] Broadband ground motion waveform synthesis utilizing AI-based upsampling technique (2)

*Takahiro Maeda[1], Asako Iwaki[1], Hiroyuki Fujiwara[1], Kazutoshi Matsuzaki[2], Hiromitsu Tomozawa[2], Yuji Mori[2], Misato Tsuchiya[2], Naofumi Miyata[2] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Mizuho Information & Research Institute, Inc.)

9:50 AM - 10:05 AM JST | 12:50 AM - 1:05 AM UTC

[SCG62-04] Forecast trial of postseismic deformetion after the 2011 Tohoku-Oki earthquake by recurrent neural network

*Norifumi Yamaga[1], Yuta Mitsui[2] (1.Graduate School of Science and Technology, Shizuoka University, 2.Shizuoka University)

10:05 AM - 10:25 AM JST | 1:05 AM - 1:25 AM UTC

[SCG62-05] Deep Learning Approaches for Eruption Prediction of Sakurajima

★Invited Papers

*Tsuyoshi Murata[1] (1.Tokyo Institute of Technology)

[J] Oral | G (General) : General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 104 1F

[G-01] Disaster prevention education

convener:Hitoshi Nakai(Kobuchisawa Research Institute for Nature and Education), Jiro Komori(Teikyo Heisei University), Shintaro Hayashi(Akita University Graduate School of Education), Chairperson:Jiro Komori(Teikyo Heisei University)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[G01-01] New high school compulsory subjects"Chiri-sougou(Comprehensive geography)"! : Possibility to promote disaster education

*Shintaro Hayashi[1] (1.Akita University Graduate School of Education)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[G01-02] Kyushu University's multidisciplinary disaster prevention education for students near nuclear power plants after 2016 Kumamoto earthquake

*Megumi Sugimoto[1,2], Silvia Peppoloni[2] (1.Kyushu University, 2.International Association for Promoting Geoethics)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[G01-03] The cases of the limit of dam impoundment during floods and necessity of information sharing at local disaster prevention

*Jiro Komori[1], Yuuri Masuhara[1] (1.Teikyo Heisei University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[G01-04] Disaster Tradition and Disaster Education of 2008 Sichuan Earthquake

★Invited Papers

*FU SIQI[1], Shiroshita Hideyuki[1] (1.Kansai University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[G01-05] Preparedness for Nankai Trough Earthquake: Incorporating Understandings of Uncertainties in Disaster Prevention Education Schemes

*Manabu Hashimoto[1], Mika Shimizu[2] (1.Disaster Prevention Research Institute, Kyoto University, 2.Center for the Promotion of Interdisciplinary Education and Research, Kyoto University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[G01-06] Importance of issuing evacuation for individual family

★Invited Papers

*Suzuki Shigeyuki[1] (1.Okayama University)

[J] Oral | G (General) : General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 103 1F

[G-02] Geoscinece Outreach

convener:Takeyuki Ueki(Faculty of Risk and Crisis Management, Chiba Institute of Science), Jiro Komori(Teikyo Heisei University), Naoko HASEGAWA(Ochanomizu University), Satoko Oki(Faculty of Environment and information Studies), Chairperson:Satoko Oki

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[G02-01] Outreach of geography on general books

*Naoko HASEGAWA[1], Yuuki NAKAGAWA[1] (1.Ochanomizu University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[G02-02] **Dissemination of geographical and archaeological thinking by museum exhibitions: Practical approaches using three-dimensional models**

*Yuichi S. Hayakawa[1,2], Sahoko Aki[2] (1.Faculty of Environmental Earth Science, Hokkaido University, 2.Center for Spatial Information Science, The University of Tokyo)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[G02-03] Introduction of Guide Skill Up Course and Its Effect in the Izu Peninsula Geopark

*Tsuda Kazuhide[1], Hiroshi Ono[1], Hiroshi Yamazaki[1], Akifumi Matsuo[1], Hideki Ono[2] (1.NPO Whole Earth Institute, 2.Izu Peninsula Geopark Promotion Conucil Bureau)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[G02-04] Testcase of Science Cafe with Confrontation Axis Considerd to Complex of Earth and Space Science

*Harufumi Tamazawa[1,2], Yuko Ikkatai[3] (1. Disaster Prevention Research Institute, Kyoto University, 2.Faculty of Fine Arts, Kyoto City University of Arts, 3.kabli Institute for the Physics and Mathematics of the Universe, University of Tokyo)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[G02-05] Literacy for Rumors of Earthquake Occurrence

*Yoshiaki Orihara[1], Masashi Kamogawa[2], Toshiyasu Nagao[1] (1.Institute of Oceanic Research and Development, Tokai University, 2.Department of Physics, Tokyo Gakugei University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[G02-06] **Regional crustal movements and gigantic tsunami traces recorded by ghost forests: Importance of outreach activities and education for disaster prevention**

★Invited Papers

*Kiyoyuki Shigeno[1], Futoshi Nanayama[2,6], Kazuaki Watanabe[2], Masayuki Ishii[3], Kazuhito Ishiwata[4], Shigeto Inokuma[5], Keita Fukatsu[7] (1.Meiji consultant co.,Ltd., 2.Geological Survey of Japan, AIST, 3.Ishii Professional Engineer Office, 4.Betsukai municipal museum, 5.Nemuro City museum history and nature, 6.CWMD, Kumamoto Univ., 7.Notsuke Peninsula Nature Center)

[J] Oral | G (General) : General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 103 1F

[G-02] Geoscinece Outreach

convener:Takeyuki Ueki(Faculty of Risk and Crisis Management, Chiba Institute of Science), Jiro Komori(Teikyo Heisei University), Naoko HASEGAWA(Ochanomizu University), Satoko Oki(Faculty of Environment and information Studies), Chairperson:Naoko HASEGAWA

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[G02-07] **Constructing quaking model in the geological club activity and discussion activities around crack investigation**

*Ryo S Nakamura[1] (1.Miyagi Rifu high school)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[G02-08] The Impact of Middle School Students' "BOSAI Narratives" on the Community of Tosashimizu City

*Risako Tokoro[1], Kei Usui[1], Ayana Kawasaki[2], Tosei Nagamatsu[3], Satoko Oki[2] (1.Keio University, Faculty of Policy Management, 2.Keio University, Faculty of Environment and Information Studies, 3.Keio Research Institute at SFC)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[G02-09] **Disaster Prevention Education Programs to Increase Risk Perception**

*Erina Hyuga[1], Hitomi Sasaki[1], Satoko Oki[1] (1.Keio University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[G02-10] Geoscience education for infants using geological specimen

*Naoki Morita[1,2], Mana Yasui[2,3], Hiroshi Hagiya[2,4] (1.Meisei University, 2.Non-Profit Organization Science and Art, 3.Waseda research institute for science and engineering, 4.Tokyo City University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[G02-11] Introducing Narrative Approach to Earthquake Disaster Prevention (BOSAI) Teacher Training: Practice in Saitama Prefecture

*Ami Pareek[1], Satoko Oki[1], Kohei Yamaguchi[1], Mirei Toba[1] (1.Keio University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[G02-12] Practice of Disaster Education in Mexico: "Cultural Tuning" Based on Comparative Study of Public Educational Curriculum Between Japan and Mexico

*Takuya Iwahori[1], Genta Nakano[1], Katsuya Yamori[1] (1.Disaster Prevention Research Insutitute, Kyoto University)

[J] Oral | G (General) : General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 104 1F

[G-03] Geoscience education from elementary school to university students

convener:Masatsune Hatakeyama(Seiko Gakuin High School), Chairperson:Toshihiro Niwa

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[G03-01] "Science reading" in the Oki Island Library Let's science reading! The story of Light deliver "science reading and demonstration experiments in the Oki Island Library

*Kunihiro Abe[1] (1.Shimane Penunsula Shinjiko Narumi, Kuibiki Geopark Promotion Committee)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[G03-02] Difference in elementary students' understanding of a solar eclipse by using different ICT devices

*Koji Imai[1], Yasuhiro Murayama[1], Takahiro Yamanishi[2] (1.National Institute of Information and Communications Technology, 2.MITSUBISHI MINATOMIRAI INDUSTRIAL MUSEUM)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[G03-03] Let's learn landform and disaster risk

*Yuki Kurisu[1] (1.Geospatial Information Authority of Japan)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[G03-04] Demonstration of the serpentinite dehydration at a laboratory in school

*Soichi Omori[1], Yukinobu Katsumata[2] (1.The Faculty of Liberal Arts, The Open University of Japan, 2.Natural and Environmental Sciences Program, The Open University of Japan)

10:00 AM - 10:20 AM JST | 1:00 AM - 1:20 AM UTC

[G03-05] Educational activities of the Earth and planetary science in the collaboration of schools, science museums, and scientists using digital globe

*Akinori Saito[1], Takuya Tsugawa[2] (1.Department of Geophysics, Graduate School of Science, Kyoto University, 2.National Institute of Information and Communications Technology)

[J] Oral | G (General) : General

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 104 1F

[G-03] Geoscience education from elementary school to university students

convener:Masatsune Hatakeyama(Seiko Gakuin High School), Chairperson:Masatsune Hatakeyama(Seikogakuin High school)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[G03-06] **Improving Awareness of Marine Conservation and Sustainability among Taiwanese Middle School Students by Teaching Slow Fish Movement**

*Ya-Yin Liao[1], Liang-Ting Tsai[2], Ting-Kuang Yeh[3], Cheng-Chieh Chang[1] (1.National Taiwan Ocean University Institute of Education , 2.Taiwan Marine Education Center, 3.National Taiwan Normal University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[G03-07] Prototyping of the teachable moment presetation for recent earthquakes in Japan (2) - - -The case of the 3 January 2019 Kumamoto earthquake (M5.1) on and improvement from the previous prototype- - -

*Reiji Kobayashi[1] (1.Graduate School of Science and Engineering, Kagoshima University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[G03-08] Development of web application for polarizing microscope observation

*Fumitoshi Morisato[1] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[G03-09] Usage and Utilization of 3D display function on GSI Maps

*Ryoichi Kojiroi[1] (1.Geospatial Information Authority of Japan)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[G03-10] Bringing field- and laboratory work into the classroom by using online modules in the edX platform

*Alejandra Quintanilla-Terminel[1], Matej Pec[1], Oliver Jagoutz[1] (1.Massachusetts Institute of Technology)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 301B 3F

[M-IS24] Integrated Analysis of Geoscience Observations from the Floor to Surface of the Ocean

convener:Keisuke Ariyoshi(Japan Agency for Marine-Earth Science and Technology), Motoyuki Kido(International Research Institute for Disaster Science, Tohoku University), Daisuke Inazu(Tokyo University of Marine Science and Technology), Narumi Takahashi(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Keisuke Ariyoshi, Motoyuki Kido

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[MIS24-01] Meteorological Observations at Shionomisaki in cooperation with “Chikyu”, Shinsei-maru and Seisui-maru

*Akira Kuwano-Yoshida[1], Keisuke Ariyoshi[2], Kosei Komatsu[3], Yoshihiro Tachibana[4], Mikiko Fujita[2], Masato I. Nodzu[5], Hatsumi Nishikawa[10], Yoshimi Kawai[2], Naoki Kishita[6], Lyndon Mark Olaguera[5], MIHARU KUBO[8], Kentaro Hase[7], Yuya Matsuyama[6], Minami Masuda[9], Kenta Irie[11], Tetsuji Yoshida[10], Yusuke Watanabe[7], Kosuke Matsuda[12], Syunsuke Aoki[7], Shingo Watanabe[2], Akira Kurisu[13], Shota Yamasaki[7], Hidetaka Hirata[14], Shizuka Akiyama[7], Yoshinori Shigeta[15], Akira Miyata[15], Kai Matsubara[15], Yoshitaka Tada[15], Yasushi Watarai[16], Yusuke Nakamura[16] (1.Disaster Prevention Research Institute, Kyoto University, 2.Japan Agency for Marine-Earth Science and Technology, 3.Graduate School of Frontier Sciences, The University of Tokyo, 4.Faculty of Bioresources, Mie University,, 5.Tokyo Metropolitan University, 6.Kyushu University, 7.Kyoto University, 8.University of The Ryukyus, 9.Hirosaki University, 10.Hokkaido University, 11.Tokyo Gakugei University, 12.Tokyo University of Marine Science and Technology, 13.Okayama University, 14.Nagoya University, 15.Tottori University of Environmental Studies, 16.Rissho University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[MIS24-02] GNSS-A data analysis to estimate the sound speed profile

*Tadashi Ishikawa[1], Yusuke Yokota[2], Shun-ichi Watanabe[1] (1.Hydrographic and Oceanographic Department, Japan Coast Guard, 2.Institute of Industrial Science, the University of Tokyo)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[MIS24-03] Comparison of Ocean Bottom Pressure Observation Timeseries with Result of Real Ocean Estimating Models around the Pacific Rim Earthquake Zone

*Yoichiro Dobashi[1], Daisuke Inazu[2] (1.Tokyo University of Marine Science and Technology, 2.Tokyo University of Marine Science and Technology department of marine resouces and energy)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[MIS24-04] Experimental challenges for interpretation of in-situ observation of bottom pressure recorders (BPRs) at the seafloor

★Invited Papers

*Hiroyuki Matsumoto[1], Toshinori Kimura[1], Shuhei Nishida[1], Yuya Machida[1], Eiichiro Araki[1] (1.Japan Agency for Marine-Earth Science and Technology (JAMSTEC))

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[MIS24-05] Continuous bottom pressure observation by real-time buoy system for tsunami and crustal displacement

*Narumi Takahashi[1], Kentaro Imai[2], Motoyuki Kido[3], Yusaku Ohta[3], Tatsuya Fukuda[2], Yasuhisa Ishihara[2], Hiroshi OCHI[2], Kensuke Suzuki[2], Ryota Hino[3] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Japan Agency for Marine-Earth Science and Technology, 3.Tohoku Univerisity)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[MIS24-06] Looking into the ocean and Earth’s interior from their boundary

★Invited Papers

*Yoshio Fukao[1] (1.CEAT / Japan Agency for Marine-Earth Science & Technology)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 301A 3F

[M-IS25] Recent weather disasters: factors and impact on the atmosphere, hydrosphere, and human beings

convener:Kazuaki Nishii(Graduate School of Bioresources, Mie University), Chairperson:Kazuaki Nishii(三重大学)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MIS25-01] Heavy Rainfall Event in Middle Viet Nam on 8-9 December 2018 and current QPE/QPF at VNMHA

★Invited Papers

*Kazuo Saito[1,2,3], Le Duc[4,3], Du Duc Tien[5], Mai Khanh Hung[5] (1.Japan Meteorological Business Suport Center, 2.Atmosphere and Ocean Research Institute, the University of Tokyo, 3.Meteorological Research Institute, 4.Japan Agency for Marine-Earth Science and Technology, 5.National Center for Hydro-Meteorological Forecasting, Viet Nam Meteorological and Hydrological Administration)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MIS25-02] High-resolution flow-simulation in Typhoon 21, 2018: tremendous loss of water plants in South Lake Biwa

★Invited Papers

*Satoshi Nakada[1], Hiroki Haga[2], Maho Iwaki[1], Keisuke Hatano[3], Koji Mabuchi[1], Noriko Takamura[1] (1.National Institute for Environmental Studies, 2.Lake Biwa Museum, 3.Japan Water Agency)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MIS25-03] Northern mid-latitude warming prolonged for more than 6 months in 2018 well-predicted by the JMA's operational seasonal prediction system

*Chiaki Kobayashi[1], Ichiro Ishikawa[1] (1.Meteorological Research Institute)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MIS25-04] Synoptic-scale Predictability of Heavy Rain over Western Japan in July 2018

*Akira Kuwano-Yoshida[1] (1.Disaster Prevention Research Institute, Kyoto University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MIS25-05] Anomalous Moisture Transport and Oceanic Evaporation during a Torrential Rainfall Event over Western Japan in Early July 2018

*Shion Sekizawa[1], Takafumi Miyasaka[1,2], Hisashi Nakamura[1], Akihiko Shinpo[3], Kazuto Takemura[3], Shuhei Maeda[3] (1.Research Center for Advanced Science and Technology, University of Tokyo, 2.Meteorological Research Institute, 3.Japan Meteorological Agency)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[MIS25-06] Leading modes of atmospheric circulation variability during the heavy rain event in July 2018

*Kazuaki Nishii[1], Bunmei Taguchi[2], Hisashi Nakamura[2] (1.Graduate School of Bioresources, Mie University, 2.Research Center for Advanced Science and Technology, The University of Tokyo)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 301B 3F

[M-GI37] Earth and planetary informatics with huge data management

convener:Ken T. Murata(National Institute of Information and Communications Technology), Rie Honda(Department of Science and Technology, System of Natual Science, Kochi University), Susumu Nonogaki(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Takeshi Horinouchi(Faculty of Environmental Earth Science, Hokkaido University), Chairperson:Susumu Nonogaki, Ken Murata(National Institute of Information and Communications Technology)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MGI37-01] Exploration of the earth environment using meteorological satellite "Himawari"

*ryuta ando[1], Shigeto Watanabe[1], Ken T. Murata[2] (1.Hokkaido Information University, 2.National Institute of Information and Communications Technology)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MGI37-02] Kochi radar network composed of compact X-band radars

*Koji Sassa[1], Toshiaki Takaki[2], Ken T Murata[3] (1.Natural Science Cluster, Kochi University, 2.Furuno Electric Co.,Ltd., 3.National Institute of Information and Communication Technology)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MGI37-03] Rain Echo Classification by Deep Learning Using Observation Big Data of Phased Array Weather Radar

*Shinsuke Satoh[1], Hiroshi HANADO[1], Seiji Kawamura[1], Tomohiko Konno[1], Michiaki Iwazume[1], Shigenori Otsuka[2], Takemasa Miyoshi[2] (1.National Institute of Information and Communications Technology, 2.RIKEN Center for Computational Science)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MGI37-04] Communication area map of LoRa in Chikuma city using community bus services

*Kohei Mizuani[1], Ken T. Murata[1], Yoshiaki Muroyama[1], Kazunori Yamamoto[1], Kazuya Muranaga[2], Takamichi Mizuhara[3], Praphan Pavarangkoon[1] (1.National Institute of Information and Communications Technology, 2.Systems Engineering Consultants Co., LTD., 3.CLEALINK TECHNOLOGY Co.,Ltd.)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MGI37-05] Development of an inexpensive and small balloon observation device, and its application in observing the Earth's upper atmosphere

*Taku Takada[1], Yui Sasaoka[1], Shiya Ueta[1], Ken T. Murata[2], Hidehiko Suzuki[3] (1.National Institute of Technology, Kochi College, 2.National Institute of Information and Communications Technology, 3.Meiji University)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 301B 3F

[M-GI37] Earth and planetary informatics with huge data management

convener:Ken T. Murata(National Institute of Information and Communications Technology), Rie Honda(Department of Science and Technology, System of Natual Science, Kochi University), Susumu Nonogaki(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Takeshi Horinouchi(Faculty of Environmental Earth Science, Hokkaido University), Chairperson:Rie Honda, Ken Murata(National Institute of Information and Communications Technology)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MGI37-06] Introduction of “ChOWDER”: A tiled display driver that augment large scale visualization of geoscience.

*Tomohiro Kawanabe[1], Kenji Ono[2], Atsushi Higuchi[3], Koichi Toyoshima[3], Kazunori Yamamoto[4], Kazuya Muranaga[5], Ken T. Murata[4] (1.RIKEN , 2.Kyushu Univ., 3.Chiba Univ., 4.NICT, 5.Systems Engineering Consultants Co.,LTD.)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MGI37-07] Data archive and integrated data analysis tools developed by ERG Science Center

*Tomoaki Hori[1], Yoshizumi Miyoshi[1], Masafumi Shoji[1], Mariko Teramoto[1], Tzu-Fang Chang[1], Satoshi Kurita[1], Shoya Matsuda[2], Yasunori Tsugawa[1], Tomonori Segawa[1], Norio Umemura[1], Nozomu Nishitani[1], Takako Kondo[1], Hiroyasu Yonaha[1], Yukinaga Miyashita[3], Kunihiro Keika[4], Kanako Seki[4], Yoshimasa Tanaka[5], Iku Shinohara[2] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Japan Aerospace Exploration Agency / Institute of Space and Astronautical Science, 3.Korea Astronomy and Space Science Institute, 4.Graduate School of Science, The University of Tokyo, 5.National Institute of Polar Research)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MGI37-08] KOSEN-1 CubeSat mission for Jupiter's radio science

*Kazumasa Imai[1], Nobuto Hirakoso[2], Taku Takada[1], Kentarou Kitamura[3], Masafumi Imai[4], KOSEN-1 Team[5], Charles A. Higgins[6], James R. Thieman[7], NASA Radio JOVE Team[8] (1.Department of Social Design Engineering, National Institute of Technology, Kochi College, 2.Department of Mechanical Engineering, National Institute of Technology, Gunma College, 3.Department of Mechanical and Electrical Engineering, National Institute of Technology, Tokuyama College, 4.University of Iowa, 5.KOSEN-1 Team, 6.Middle Tennessee State University, 7.University of Maryland Baltimore County, 8.NASA Radio JOVE Team)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MGI37-09] Problems of acquisition of auroral image data and data processing

*Ryuho Kataoka[1], Ken T. Murata[2], Yoshizumi Miyoshi[3], Herbert Akihito Uchida[1], Yoko Fukuda[4], Atsushi Yamashita[5], Masayuki Tanaka[6] (1.National Institute of Polar Research, 2.National Institute of Information and Communication Technology, 3.Nagoya University, 4.National Institute for Environmental Studies, 5.The University of Tokyo, 6.Tokyo Institute of Techonology)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MGI37-10] Innovative progress in ground observation of snow crystals and weather conditions by citizen science

★Invited Papers

*Kentaro Araki[1] (1.Meteorological Research Institute)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MGI37-11] Efforts of landslide susceptibility mapping for slope disaster risk evaluation

*Kazunori Hayashi[1], Akihiko Wakai[2], Go Sato[3], Takashi Kimura[4], Ken T. Murata[5], Akino Watanabe [2] (1.Okuyama Boring Co., Ltd., 2.Gunma University, 3.Teikyo Heisei University, 4.National Research Institute for Earth Science and Disaster, 5.National Institute of Information and Communications Technology)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-AG Applied Geosciences

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 302 3F

[M-AG41] Dynamics of radionuclides emitted from Fukuchima Dai-ichi Nuclear Power Plant in the environment

convener:Yoshio Takahashi(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Kazuyuki Kita(Faculty of Science, Ibaraki University), Yuichi Onda(Center for Research on Isotopes and Environmental Dynamics, University of Tsukuba), Daisuke Tsumune(Central Research Institute of Electric Power Industry), Chairperson:Yoshio Takahashi(東京大学), Yuichi Onda(Center for Research on Isotopes and Environmental Dynamics, University of Tsukuba)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MAG41-01] Investigation on basic physical and chemical properties of radio-Cs micro particles

*Yasuhito Igarashi[1], Kazuyuki Kita[2], Yukihiko Satou[3], Tomoaki Okuda[4], Yoshinari Abe[5], Keisuke Sueki[6], SHINOHARA ATSUSHI[7], Kazuhiko Ninomiya[7], Tsutomu Ohtshuki[1], Koichi Takamiya[1] (1.Institute for Integrated Radiation and Nuclear Science, Kyoto University, 2.Graduate School of Science and Engineering, Ibaraki University, 3.Collaborative Laboratories for Advanced Decommissioning Science, Japan Atomic Energy Agency, 4.Department of Applied Chemistry, Keio University, 5.Faculty of Science,Tokyo University of Science, 6.Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba, 7.Graduate School of Science, Osaka University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MAG41-02] Dynamics of radioactive microparticles released from the Fukushima nuclear plant: heating and dissolution characteristics

★Invited Papers

*Taiga Okumura[1], Noriko Yamaguchi[2], Terumi Dohi[3], Kenso Fujiwara[3], Kazuki Iijima[3], Toshihiro Kogure[1] (1.The University of Tokyo, 2.National Agriculture and Food Research Organization, 3.Japan Atomic Energy Agency)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MAG41-03] Dynamics of atmospheric ^{131}I just after the Fukushima accident related to ^{137}Cs by analysis of published data

*Haruo Tsuruta[1], Yuichi Moriguchi[2], Teruyuki Nakajima[3] (1.Remote Sensing Technology Center of Japan, 2.The University of Tokyo, 3.Japan Aerospace Exploration Agency)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MAG41-04] Distribution of ^{237}Np and Plutonium isotope in terrestrial environment in Fukushima Prefecture

*Miho Fukuda[1], Zheng Jian[1], yamazaki Shinnnosuke[1], Tatsuo Aono[1] (1.National Institute for Quantum and Radiological Science and Technology, National Institute of Radiological Science)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MAG41-05] Study on deposition of ^{134}Cs and ^{137}Cs from atmosphere to freshwater environment using a mountainous lake, Lake Haruna in Gunma Prefecture, Japan

*Seiya Nagao[1], Shouhei Miyasaka[2], Shun Watanabe[3], Kyuma Suzuki[3], Shinya Ochiai[1] (1.Institute of Nature and Environmental Technology, Kanazawa University, 2.Graduate School of Natural Science and Technology, Kanazawa University, 3.Gunma Prefectural Fisheries Experimental Station)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MAG41-06] Spatial variability of radiocesium deposition through the tree canopy via branchflow and stemflow

*Zul Hilmi Saidin[1], Yuichi Onda[2], Hiroaki Kato[2], Momo Kurihara[2], Kazuki Nanko[3], Delphis F. Levia[4] (1.Graduate School of Life and Environmental Sciences, University of Tsukuba, Tsukuba, Ibaraki, Japan, 2.Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba, Tsukuba, Ibaraki, Japan, 3.Department of Disaster Prevention, Meteorology and Hydrology, Forestry and Forest Products Research Institute, Tsukuba, Ibaraki, Japan, 4.Departments of Geography, University of Delaware, Newark, Delaware, USA)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-AG Applied Geosciences

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 302 3F

[M-AG41] Dynamics of radionuclides emitted from Fukuchima Dai-ichi Nuclear Power Plant in the environment

convener:Yoshio Takahashi(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Kazuyuki Kita(Faculty of Science, Ibaraki University), Yuichi Onda(Center for Research on Isotopes and Environmental Dynamics, University of Tsukuba), Daisuke Tsumune(Central Research Institute of Electric Power Industry), Chairperson:Kazuyuki Kita(Ibaraki University), Daisuke Tsumune(Central Research Institute of Electric Power Industry)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MAG41-07] Temporal changes in vertical distributions of radiocesium in forest soils after the FDNPP accident

★Invited Papers

*Junko Takahashi[1], Daichi Hihara[1], Takuya Sasaki[1], Yuichi Onda[1] (1.Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MAG41-08] Change of sediment sources in suspended sediments due to surface decontamination in the Niida river catchment area affected by the Fukushima Daiichi nuclear power plant accident

*Yuichi Onda[1], Yuki Yamanaka[1], Yoshifumi Wakiyama[2], Keisuke Taniguchi[3], Takaaki Kubo[1] (1.Center for Research on Isotopes and Environmental Dynamics, University of Tsukuba, 2.Institute of Environmental Radioactivity, Fukushima University, 3.Fukushima Prefectural Centre for Environmental Creation)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MAG41-09] Neasrshore transport of suspended radiocesium In the Fuksima Coast derived from Niida River induced by Typhoon Wipha

*Natsuki Tokunaga[1], Yusuke Uchiyama[1], Daisuke Tsumune[2], Masatoshi Yamada[5], Yutaka Tateda[2], Yukari Ito[3], Takashi Ishimaru[3], Yutaka Watanabe[7], Ken Ikehara[4], Miho Fukuda[6] (1.Kobe University, 2.Central Research Institute of Electric Power Industry, 3.Tokyo University of Marine Science and Technology, 4.National Institute of Advanced Industrial Science and Technology, 5.Hirosaki University, 6.National Institute of Radiological Sciences, 7.Hokkaido University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MAG41-10] Particle size distribution and radiocesium concentration in suspended particles within the high turbidity layer at near sea bottom off Fukushima prefecture

*Hideki Kaeriyama[1], Naoki Furuichi[2], Kouichi Sugimatsu[3], Yuya Shigenobu[1], Shizuho Miki[1], Takami Morita[1], Daisuke Ambe[1], Tadafumi Ichikawa[1] (1.National Research Institute of Fisheries Science, Japan Fisheries Research and Education Agency, 2.National Research Institute of Fisheries Engineering, Japan Fisheries Research and Education Agency, 3.Seikai National Research Institute, Japan Fisheries Research and Education Agency)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MAG41-11] Fukushima-derived radiocesium in the subarctic region of the North Pacific Ocean in the summer of 2017

★Invited Papers

*Yuichiro Kumamoto[1], Michio Aoyama[2], Yasunori Hamajima[3], Akihiko Murata[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Fukushima University, 3.Kanazawa University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MAG41-12] **Temporal and spatial variations of radiocaesium in the East China Sea and Sea of Japan until 2018**

*Michio Aoyama[1], Yayoi Inomata[2], Yasunori Hamajima[2] (1.Institute of Environmnetal Radioactivity, Fukushima University, 2.Institute of Nature and Environmental Technology, Kanazawa University)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-TT Technology & Techniques

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 201A 2F

[M-TT48] Frontiers in Geochemistry

convener:Hirochika Sumino(Department of Basic Science, Graduate School of Arts and Sciences, The University of Tokyo), Tetsuya Yokoyama(Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology), Hajime Obata(Marine inorganic chemistry division, Atmosphere and Ocean Research Institute, University of Tokyo), Chairperson:Hirochika Sumino, Hajime Obata(Atmosphere and Ocean Research Institute, University of Tokyo), Tetsuya Yokoyama(Tokyo Institute of Technology)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MTT48-01] Data science approaches to geochemical data analysis

★Invited Papers

*Kenta Ueki[1] (1.Japan Agency for Marine-Earth Science and Technology)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MTT48-02] Rapid *in situ* analyses of hydrogen and sulfur isotope ratios in basaltic glass by SIMS and their appilications

*Kenji Shimizu[1], Takayuki Ushikubo[1], Tomokazu Murai[2], Fumihiro Matsuura[2], Yuichiro Ueno[2] (1.Kochi Core Center, Japan Agency for Marine-Earth Science and Technology, 2.Tokyo Institute of Technology)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MTT48-03] Determination of siderophile elements in metallic materials using multiple spot laser ablation-ICP-MS technique

*Yoshiki Makino[1], Yasuo Kuroki[2], Takafumi Hirata[1] (1.Geochemical Research Center, Graduate School of Science, The University of Tokyo, 2.Thermo Fisher Scientific)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MTT48-04] Iron isotopic compositions of Luna 16, 20, 24 soils

★Invited Papers

*Satoki Okabayashi[1], Tetsuya Yokoyama[1], Takafumi Hirata[2], Kazuo Terakado[3], Erick M. Galimov[4] (1.Tokyo Institute of Technology, 2.The University of Tokyo, 3.Japan Space Forum, 4.Russian Academy of Science)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MTT48-05] Synthesis of calcite reference materials for *in situ* U–Pb dating through crystallization from amorphous calcium carbonates

*Yusuke Miyajima[1], Ayaka Saito[1], Hiroyuki Kagi[1], Tatsunori Yokoyama[2], Takafumi Hirata[1] (1.Geochemical Research Center, Graduate School of Science, The University of Tokyo, 2.Tono Geoscience Center, Japan Atomic Energy Agency (JAEA))

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MTT48-06] Magnetic mapping of a speleothem from the southern Pacific with a scanning SQUID microscopy and its magnetic mineralogy

*Naoto Fukuyo[1,2], Hirokuni Oda[3], Yusuke Yokoyama[1,2], Geoffrey Clark[4], Yuhji Yamamoto[5] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Department of Earth and Planetary Science, The University of Tokyo, 3.Institute of Geology and Geoinformation, 4.College of Asia and the Pacific,The Australian National University, 5.Center for Advanced Marine Core Research, Kochi University)

[J] Oral | M (Multidisciplinary and Interdisciplinary) : M-TT Technology & Techniques

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 201A 2F

[M-TT48] Frontiers in Geochemistry

convener:Hirochika Sumino(Department of Basic Science, Graduate School of Arts and Sciences, The University of Tokyo), Tetsuya Yokoyama(Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology), Hajime Obata(Marine inorganic chemistry division, Atmosphere and Ocean Research Institute, University of Tokyo), Chairperson:Hirochika Sumino, Hajime Obata(Atmosphere and Ocean Research Institute, University of Tokyo), Tetsuya Yokoyama(Tokyo Institute of Technology)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MTT48-07] Uptake and accumulation of methylmercury by marine phytoplankton

★Invited Papers

*Yuya Tada[1], Kohji Marumoto[1] (1. National Institute For Minamata Disease)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MTT48-08] A protocol for simultaneous analysis of archaeal core and intact polar lipids using normal-phase HPLC/ESI-MS

*Shunsuke Horai[1], Hiroshi Naraoka[1,2] (1.Kyushu University, 2.Research Center for Planetary Trace Organic Compounds)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MTT48-09] Assessment of Northeastern Japan Tree-Ring Oxygen Isotopes for Reconstructing Early Summer Hydroclimate and Spring Arctic Oscillation

*Wataru Sakashita[1,2,3], Yusuke Yokoyama[3], Hiroko Miyahara[2], Takahiro AZE[3], Stephen Obrochta[4], Motonari Ohyama[5], Hitoshi Yonenobu[6] (1.Forestry and Forest Products Research Institute, 2.Musashino Art University, 3.Atmosphere and Ocean Research Institute, The University of Tokyo, 4.Akita Univeristy, 5.Tohoku University, 6.Naruto University of Education)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MTT48-10] **Development of the rotational diamond anvil cell for high-pressure deformation experiments and its measurement systems**

★Invited Papers

*Shintaro Azuma[1,2], Ryuichi Nomura[3,4], Kentaro Uesugi[5], Yu Nishihara[4], Doi Shunta[4], Takeshi Arimoto[4], Tetsuo Irifune[4] (1.Tokyo Tech., 2.Kyushu Univ., 3.Kyoto Univ., 4.Ehime Univ., 5.JASRI)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MTT48-11] Speciation of metal ions in hydrosphere: Further classification of intermediately hard ligands in HSAB theory

*Makoto Nagasawa[1], Masato Tanaka[1], Asami Miyaji[2], Yoshio Takahashi[1] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2.Hiroshima University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MTT48-12] Difference in the partition behaviors and speciation between scandium and other rare earth elements in nickel laterite ore deposits

Haibo Qin[1], Kenzo Sanematsu[2], Arcilla Carlo[3], *Yoshio Takahashi[1] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2.Institute for Geo-Resources and Environment, National Institute of Advanced Industrial Science and Technology (AIST), 3.National Institute of Geological Sciences, College of Science, University of the Philippines)

Mon. May 27, 2019

[J] Oral | U (Union)：Union

9:30 AM - 10:30 AM JST | 12:30 AM - 1:30 AM UTC | 101 1F

[U-05] Large-scale Research Projects: Master Plan 2020 and its beyond

convener:Eiichi Tajika(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Shigeko Haruyama(Department of Environmental Science, Graduate School of Bioresouces,Mie University), Ryoichi Fujii(Research Organization of Information and Systems), Hodaka Kawahata(Atmosphere Ocean Research Institute, the University of Tokyo), Chairperson:Eiichi Tajika, Shigeko Haruyama

9:45 AM - 10:08 AM JST | 12:45 AM - 1:08 AM UTC

[U05-01] International Astro-Bioscience Research Center

★Invited Papers

*Yukio Isozaki[1] (1.Department of Earth Science and Astronomy, Multi-disciplinary Sciences - General Systems Studies, Graduate School of Arts and Sciences, The University of Tokyo)

10:08 AM - 10:30 AM JST | 1:08 AM - 1:30 AM UTC

[U05-02] Study of coupling processes in the solar-terrestrial system

★Invited Papers

*Mamoru Yamamoto[1], Hiroyuki Hashiguchi[1], Tatsuhiro Yokoyama[1], Hiroshi Miyaoka[2], Yasunobu Ogawa[2], Kazuo Shiokawa[3], Satonori Nozawa[3], Akimasa Yoshikawa[4], Toshitaka Tsuda[5,1] (1.Research Institute for Sustainable Humanosphere, Kyoto University, 2.National Institute of Polar Research, 3.Institute for Space-Earth Environmental Laboratory, Nagoya University, 4.International Center for Space Weather Science and Education, Kyushu University, 5.Research Organization of Information and Systems)

[J] Oral | U (Union)：Union

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 101 1F

[U-05] Large-scale Research Projects: Master Plan 2020 and its beyond

convener:Eiichi Tajika(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Shigeko Haruyama(Department of Environmental Science, Graduate School of Bioresouces,Mie University), Ryoichi Fujii(Research Organization of Information and Systems), Hodaka Kawahata(Atmosphere Ocean Research Institute, the University of Tokyo), Chairperson:Shigeko Haruyama, Hodaka Kawahata

10:45 AM - 11:08 AM JST | 1:45 AM - 2:08 AM UTC

[U05-03] Development of the global earth observation system using satellites

★Invited Papers

*Shinichi Sobue[1], Yoshiaki HONDA[3], Shuichi Rokugawa[2], Akira Iwasaki[2], Nobuhiro Takahashi[4], Yukari Takayabu[2], Riko Oki[1], Toshiyoshi Kimura[1], Teruyuki Nakajima[1], Takeo Tadono[1], Kosuke Yamamoto[1] (1.Japan Aerospace Exploration Agency, 2.University of Tokyo, 3.Chiba University, 4.Nagoya University)

11:08 AM - 11:31 AM JST | 2:08 AM - 2:31 AM UTC

[U05-04] Promotion of Scientific Research on Climate and Earth System Sciences Using Aircrafts

★Invited Papers

*Makoto Koike[1,2] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2.The Meteorological Society of Japan)

11:31 AM - 11:54 AM JST | 2:31 AM - 2:54 AM UTC

[U05-05] Global deployment of Deep Argo floats toward accurate prediction of future climate and ecosystem changes

★Invited Papers

*Toshiyuki Hibiya[1] (1. Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

11:54 AM - 12:15 PM JST | 2:54 AM - 3:15 AM UTC

[U05-06] A new aspect of the polar science: integrated observations of the ice sheet mass loss for better prediction of the sea level rise

★Invited Papers

*Takuji Nakamura[1], Shin Sugiyama[2], Ayako Abe-Ouchi[3], Teruo Aoki[4], Yoshifumi Nogi[1], Takeshi Tamura[1] (1.National Institute of Polar Research, 2.Institute of Low Temperature Science, Hokkaido Univ., 3.Atmosphere and Ocean Research Institute, the University of Tokyo, 4.The Graduate School of Natural Science and Technology, Okayama University)

[J] Oral | U (Union)：Union

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 101 1F

[U-05] Large-scale Research Projects: Master Plan 2020 and its beyond

convener:Eiichi Tajika(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Shigeko Haruyama(Department of Environmental Science, Graduate School of Bioresouces,Mie University), Ryoichi Fujii(Research Organization of Information and Systems), Hodaka Kawahata(Atmosphere Ocean Research Institute, the University of Tokyo), Chairperson:Hodaka Kawahata, Eiichi Tajika

1:45 PM - 2:08 PM JST | 4:45 AM - 5:08 AM UTC

[U05-07] New frontier of Earth, Space and Life Sciences pioneered by the innovative developments of new-generation mass spectrometry

★Invited Papers

*Kentaro Terada[1] (1.Department of Earth and Space Science, Graduate School of Science, Osaka University)

2:08 PM - 2:31 PM JST | 5:08 AM - 5:31 AM UTC

[U05-08] Building of archive and curating system for astrogeoscience materials

★Invited Papers

*Tsuyoshi Komiya[1] (1.Department of Earth Science & Astronomy Graduate School of Arts and Sciences The University of Tokyo)

2:31 PM - 2:54 PM JST | 5:31 AM - 5:54 AM UTC

[U05-09] Innovative 4D imaging of subduction-zones through real-time observatories, ultra-deep drilling and high-pressure experiments

★Invited Papers

*Masataka Kinoshita[1], Naoshi Hirata[1], Masanao Shinohara[1], Tetsuo Irifune[2], Hiroyuki Kagi[7], Teruyuki Kato[3], Shigeaki Ono[4], Katsuyoshi Michibayashi[6], Natsue Abe[4], Fumio Inagaki[4], Kentaro Omura[5], Kazushige Obara[1] (1.Earthquake Research Institute, University of Tokyo, 2.Ehime University, 3.Hot Springs Research Institute, 4.JAMSTEC, 5.NIED, 6.Nagoya Univ., 7.Geochemical Research Center, Univ. Tokyo)

2:54 PM - 3:15 PM JST | 5:54 AM - 6:15 AM UTC

[U05-10] Construction of the Cooperative Research Infrastructure for Intelligent Muography in Earth and Planetary Sciences, Other Sciences, and Society

★Invited Papers

*Hiroyuki Tanaka[1] (1.Earthquake Research Institute, the University of Tokyo)

[J] Oral | U (Union)：Union

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 101 1F

[U-05] Large-scale Research Projects: Master Plan 2020 and its beyond

convener:Eiichi Tajika(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Shigeko Haruyama(Department of Environmental Science, Graduate School of Bioresouces,Mie University), Ryoichi Fujii(Research Organization of Information and Systems), Hodaka Kawahata(Atmosphere Ocean Research Institute, the University of Tokyo), Chairperson:Eiichi Tajika, Shigeko Haruyama

3:30 PM - 3:53 PM JST | 6:30 AM - 6:53 AM UTC

[U05-11] Consortium for Planetary Exploration

★Invited Papers

*Yoshi-Yuki Hayashi[1], Shigeto Watanabe[2,5], Taishi Nakamoto[3,4] (1.Department of Planetology/CPS, Graduate School of Science, Kobe University, 2.SGEPSS, 3.The Japanese Society for Planetary Sciences, 4.Dept. of Earth and Planetary Sciences, Tokyo Institute of Technology, 5.Hokkaido Information University)

3:53 PM - 4:16 PM JST | 6:53 AM - 7:16 AM UTC

[U05-12] Japanese contribution to CAESAR: comet astrobiology exploration sample return

★Invited Papers

*Tomoki Nakamura[1], Kazuhiko Yamada[2], Yoshihiro Furukawa[1], Yuki Kimura[3], Aki Takigawa[4], Tomohiro Usui[2], Hitoshi Kuninaka[2], Team CAESAR SRC team (1.Tohoku University, 2.ISAS/JAXA, 3.Hokkaido University, 4.Kyoto University)

4:16 PM - 4:38 PM JST | 7:16 AM - 7:38 AM UTC

[U05-13] Strategic Mars exploration: Orbiter and EDL demonstration mission for space weather, climate, and aquatic environment

★Invited Papers

*Kanako Seki[1], Shigeto Watanabe[2], Taishi Nakamoto[3], Naoki Terada[4], Atsushi Yamazaki[5], Ayako Matsuoka[5], Tomohiro Usui[5], Yasuhito Sekine[3], Kazuhisa Fujita[5], Shoichiro Yokota[6], Satoshi Kasahara[1], Yoshifumi Saito[5], Hiromu Nakagawa[4], Atsushi Kumamoto[4], Hiroyuki Maezawa[7], Mars Orbiter and EDL Technology Demonstration Mission Planning Team (1.Graduate School of Science, University of Tokyo, 2.Department of Cosmosciences, Hokkaido University, 3.Tokyo Institute of Technology, 4.Graduate School of Science, Tohoku University, 5.ISAS, JAXA, 6.Graduate School of Science, Osaka University, 7.Department of Physical Science, Osaka Prefecture University)

[J] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-PS06] Planetary Sciences

convener:Kenji Kurosaki(Department of Physics, Nagoya University), Yusuke Nakauchi(Japan Aerospace Exploration Agency), Chairperson:Kiyoshi Kuramoto(Hokkaido University), Takanori Sasaki(Department of Astronomy, Kyoto University)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[PPS06-01] Current status of the PLANETS telescope project for planetary and exoplanetary atmospheric monitoring

*Takeshi Sakanoi[1], Masato Kagitani[1], Yasumasa Hirahara[2], Jeffery Kuhn[3], Svetalana Berdyugina[4], Marcelo Emilio[5], Hiromu Nakagawa[6], Mikio Kurita[7], Yasumasa Kasaba[1], Takahiro Obara[1], Shoichi Okano[1] (1.Planetary Plasma and Atmospheric Research Center, Graduate School of Science, Tohoku University, 2.Graduate School of Environmental Studies, Nagoya University, 3.IfA, University of Hawaii, U.S.A., 4.KIS, Germany, 5.Universidade Estadual de Ponta Grossa, Brazil, 6.Graduate School of Science, Tohoku University, 7.Graduate School of Science, Kyoto University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[PPS06-02] Martian Moon eXploration MMX: science objectives and their promotion

*Kiyoshi Kuramoto[1,2], Yasuhiro Kawakatsu[2], Masaki Fujimoto[2], Jean Pierre Bibring[3], David Lawrence[4], Hidenori Genda[5], Naru Hirata[6], Takeshi Imamura[7], Shingo Kameda[8], Koji Matsumoto[9], Hideaki Miyamoto[7], Tomokatsu Morota[10], Hiroshi Nagaoka[2], Hiromu Nakagawa[11], Tomoki Nakamura[11], Kazunori Ogawa[12], Hisashi Otake[2], Masanobu Ozaki[2], Sho Sasaki[13], Hiroki Senshu[14], Shogo Tachibana[7,2], Naoki Terada[11], Tomohiro Usui[2], Koji Wada[14], Sei-ichiro WATANABE[10], MMX study team (1.Hokkaido Univ., 2.JAXA, 3.IAS, 4.APL, 5.ELSI, 6.Aizu Univ., 7.Univ. of Tokyo, 8.Rikkyo Univ., 9.NAOJ, 10.Nagoya Univ., 11.Tohoku Univ., 12.Kobe Univ., 13.Osaka Univ., 14.Chiba Inst. Tech.)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[PPS06-03] Implantation of Martian Materials in the Inner Solar System by a Mega Impact on Mars

*Ryuki Hyodo[1], Hidenori Genda[1] (1.Tokyo Institute of Technology, Earth Life Science Institute)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[PPS06-04] Hydrodynamic escape of a reduced proto-atmosphere on early Mars

*Tatsuya Yoshida[1], Kiyoshi Kuramoto[1] (1.Hokkaido University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[PPS06-05] Orbital evolution of Martian moons by rotating Martian proto-atmosphere with low angular momentum

*Ryo Matsuoka[1], Kiyoshi Kuramoto[1] (1.Department of Cosmosciences, Graduateschool of Science, Hokkaido University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[PPS06-06] N-body simulations of Moon formation with cooling evolution of the protolunar disk

*Takanori Sasaki[1], Natsuki Hosono[2] (1.Department of Astronomy, Kyoto University, 2.Japan Agency for Marine-Earth Science and Technology)

[J] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-PS06] Planetary Sciences

convener:Kenji Kurosaki(Department of Physics, Nagoya University), Yusuke Nakauchi(Japan Aerospace Exploration Agency), Chairperson:Hiroyuki Kurokawa(東京工業大学 地球生命研究所), Yuki Tanaka(Tokyo Institute of Technology)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[PPS06-07] Possibility of giant planet formation by pebble accretion in Class 0/I YSOs

*Yuki Tanaka[1], Yusuke Tsukamoto[2] (1.Tokyo Institute of Technology, 2.Kagoshima University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[PPS06-08] The effect of the three-dimensional gas flow around an embedded planet on pebble accretion

*Ayumu Kuwahara[1], Hiroyuki Kurokawa[2] (1.Tokyo Institute of Technology, 2.Earth-Life Science Institute)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[PPS06-09] Icy pebble accretion onto terrestrial planets: the effect of gas flow

*Hiroyuki Kurokawa[1], Ayumu Kuwahara[2], Satoshi Okuzumi[2] (1.Earth-Life Science Institute, Tokyo Institute of Technology, 2.Tokyo Institute of Technology)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[PPS06-10] Delivery of ammonia ice to Ceres by pebble accretion

*Yuto Nara[1], Satoshi Okuzumi[1], Hiroyuki Kurokawa[2] (1.Tokyo Institute of Technology, 2.Earth-Life Science Institute, Tokyo Institute of Technology)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[PPS06-11] Volatile-driven cryovolcanic eruption on asteroid Ceres as a probe to its interior

*Koki Yumoto[1], Yuichiro Cho[1], Seiji Sugita[1] (1.Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[PPS06-12] Ice sheet formation on synchrnously rotating earth-like planets in M-dwarf abitable zones

Soma Arai[1], Kiyoshi Kuramoto[1], *Masaki Ishiwatari[1], Shunichi Kamata[1] (1.Department of Cosmosciences, Graduate school of Science, Hokkaido University)

[J] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-PS06] Planetary Sciences

convener:Kenji Kurosaki(Department of Physics, Nagoya University), Yusuke Nakauchi(Japan Aerospace Exploration Agency), Chairperson:荻原 正博(国立天文台), Yuri Fujii(Nagoya University)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[PPS06-13] Three-dimensional linear calculation for non-isothermal type 1 planetary migration

*Kohei Okada[1], Hidekazu Tanaka[1] (1.Tohoku University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[PPS06-14] Dependence of Central star mass on Protoplanetary disk evolution

*Ryuunosuke Nakano[1], Takeru Suzuki[1], Masahiro Ogihara[2], Eiichiro Kokubo[2] (1.University of Tokyo, 2.National Astronomical Observatory of Japan)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[PPS06-15] Radiation Hydrodynamic Simulations of the Formation of Circumplanetary Disks

*Yuri Fujii[1], Oliver Gressel[2], Kengo Tomida[3], Udo Zieglar[2] (1.Institute for Advanced Research, Nagoya University, 2.Leibniz Institute for Astrophysics Potsdam, 3.Osaka University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[PPS06-16] Inefficient Magnetic Accretion Heating in Protoplanetary Disks: Evolution of The Snow Line

*Shoji Mori[1], Xuening Bai[2], Satoshi Okuzumi[3] (1.Department of Astronomy, The University of Tokyo, 2.Tsinghua Center for Astrophysics, Tsinghua University, 3.Department of Earth and Planetary Sciences, Tokyo Institute of Technology)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[PPS06-17] Formation of super-Earths and their atmospheres with *N*-body simulations

*Masahiro Ogihara[1], Yasunori Hori[2,1] (1.National Astronomical Observatory of Japan, 2.Astrobiology Center)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[PPS06-18] The orbital stability of planets in resonances: the evolution of mass ratio

*Yuji Matsumoto[1], Masahiro Ogihara[2] (1.Academia Sinica Institute of Astronomy and Astrophysics, 2.National Astronomical Observatory of Japan)

[J] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-PS06] Planetary Sciences

convener:Kenji Kurosaki(Department of Physics, Nagoya University), Yusuke Nakauchi(Japan Aerospace Exploration Agency), Chairperson:Kenji Kurosaki(名古屋大学大学院 理学研究科), Yusuke Nakauchi(JAXA/ISAS)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[PPS06-19] Experimental study on the structure of shock remnant magnetization

*Shota Kato[1], Masahiko Sato[1], Kosuke Kurosawa[2], Masashi Ushioda[3], Sunao Hasegawa[4] (1.The University of Tokyo, 2.Planetary Exploration Research Center, Chiba Institute of Technology, 3.Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology, 4.Japan Aerospace Exploration Agency)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[PPS06-20] Low-dispersion spectra of lunar impact flashes in 2018 Geminids

*Masahisa Yanagisawa[1], Yuki Uchida[1], Seiya Kurihara[1], Shinsuke Abe[2], Ryota Fuse[2], Keisuke Onodera[3,4], Ryuhei Yamada[5] (1.The University of Electro-Communications, 2.Nihon University, 3.SOKENDAI (The Graduate University for Advanced Studies), 4.Institute of Space and Astronautical Science/Japan Aerospace Exploration Agency, 5.The University of Aizu)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[PPS06-21] High velocity cratering experiments on sand-gypsum targets simulating asteroids

*Ryo Sugimura[1], Masahiko Arakawa[1], Minami Yasui[1], Takuya Ishiguro[1] (1.Kobe University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[PPS06-22] Experimental study on collisional processes of highly porous ice balls simulating Saturn's ring particles

*Yukari Toyoda[1], Minami Yasui[1], Masahiko Arakawa[1] (1.Graduate School of Science, Kobe University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[PPS06-23] IN-SITU FORMATION OF THE URANIAN SATELLITES FROM WIDE DEBRIS DISK FORMED BY GIANT IMPACT

*Ishizawa Yuya[1], Takanori Sasaki[1], Natsuki Hosono[2] (1.Department of Astronomy, Kyoto University, 2.JAMSTEC)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[PPS06-24] Effect on the obliquity due to a giant impact on a rotating ice giant

*Kenji Kurosaki[1], Shu-ichiro Inutsuka[1] (1.Department of Physics, Nagoya University)

[J] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[P-PS07] Formation and evolution of planetary materials in the Solar System

convener:Yoko Kebukawa(Faculty of Engineering, Yokohama National University), Wataru Fujiya(Ibaraki University, College of Science), Shin Ozawa(Department of Earth Science, Graduate School of Science, Tohoku University), Megumi Matsumoto(Graduate School of Science, Tohoku University), Chairperson:Wataru Fujiya, Shin Ozawa

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[PPS07-07] **Evaluation of shock metamorphism of eucrites by X-ray diffraction analysis**

*Rei Kanemaru[1], Naoya Imae[2,1], Akira Yamaguchi[2,1], Hirotugu Nishido[3] (1.The Graduate University for Advanced Studyies, 2.National Institute of Polar Research, 3.Okayama University of scienece)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[PPS07-08] Hf-W dating of main-group pallasites

*Yoshitaka Homma[1], Tsuyoshi Iizuka[1], Akira Ishikawa[2] (1.Department of Earth and Planetary Science, The University of Tokyo, 2.Department of Earth and Planetary Sciences, Tokyo Institute of Technology)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[PPS07-09] Mineralogical study of TCIs in CM carbonaceous chondrites

*Akane Iemoto[1], Yusuke Seto[1], Akira Miyake[2] (1.Graduate School of Science, Kobe University, 2.Graduate School of Science, Kyoto University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[PPS07-10] Importance of 10Be as a key indicator of (solar) cosmic ray irradiation in the early solar system

*Hajime Hiyagon[1], Yuuki Tanimura[1], Tomoya Nakamura[1], Kohei Fukuda[3], Wataru Fujiya[4], Naoji Sugiura[1], Takanori Kagoshima[2], Naoto Takahata[2], Yuji Sano[2] (1.Graduate School of Science, The University of Tokyo, 2.Atmosphere and Ocean Research Institute, the University of Tokyo, 3.Department of Geoscience, University of Wisconsin-Madison, 4.College of Science, Ibaraki University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[PPS07-11] **3D microstructure of a cosmic symplectite in primitive carbonaceous chondrite Acfer 094**

*Megumi Matsumoto[1,2], Akira Tsuchiyama[1], Junya Matsuno[1], Aiko Nakato[1,3], Akira Miyake[1], Motoo Ito[4], Naotaka Tomioka[4], Yu Kodama[5], Kentaro Uesugi[6], Akihisa Takeuchi[6], Tsukasa Nakano[7], Epifanio Vaccaro[8] (1.Graduate School of Science, Kyoto Univ., 2.Graduate School of Science, Tohoku Univ., 3.JAXA, ISAS, 4.JAMSTEC, 5.Marine Work Japan LTD., 6.JASRI, 7.AIST, Geological Survey Japan, 8.Natural History Museum, London)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[PPS07-12] Chondrule-like objects and refractory inclusions in GEMS-bearing Antarctic micrometeorites and an interplanetary dust particle.

*Takaaki Noguchi[1], Noriaki Ohashi[2], John P. Bradley[3], Daisuke Nakashima[4], Tomoki Nakamura[4], Makoto Kimura[5], Takayuki Ushikubo[6], Noriko T. Kita[7], Naoya Imae[5] (1.Department of Arts and Science, Kyushu University, 2.NEC Networks and System Integration Co., 3.Univ. of Hawaii at Manoa, 4.Tohoku Univ., 5.National Institute of Polar Research, 6.Kochi Institute for Core Sample Research, JAMSTEC, 7.Univ. of Wisconsin-Madison)

[J] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[P-PS07] Formation and evolution of planetary materials in the Solar System

convener:Yoko Kebukawa(Faculty of Engineering, Yokohama National University), Wataru Fujiya(Ibaraki University, College of Science), Shin Ozawa(Department of Earth Science, Graduate School of Science, Tohoku University), Megumi Matsumoto(Graduate School of Science, Tohoku University), Chairperson:Yoko Kebukawa, Shin Ozawa

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[PPS07-13] Spectral and mineralogical properties of naturally-heated carbonaceous chondrites; implication to heating processes on the surface of hydrous asteroids

★Invited Papers

*Moe Matsuoka[1], Tomoki Nakamura[2], Takahiro Hiroi[3], Nobuyoshi Miyajima[4], Naoya Imae[5,6], Akira Yamaguchi[5], Hideyasu Kojima[5,6] (1.Japan Aerospace Exploration Agency(JAXA), 2.Department of Earth and Planetary Materials Sciences, Faculty of Science, Tohoku University, 3.Department of Earth, Environmental and Planetary Sciences, Brown University, 4.Bayerisches Geoinstitut, University of Bayreuth, 5.National Institute of Polar Research, 6.Department of Polar Science, School of Multidisciplinary Science, SOKENDAI)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[PPS07-14] Heterogeneity of oxygen and carbon isotopic compositions within carbonate grains in the Yamato 791198 CM chondrite and evolution of isotope ratios during aqueous alteration

*Wataru Fujiya[1], YUTO AOKI[1], Takayuki Ushikubo[2], Ko Hashizume[1] (1.Ibaraki University, College of Science, 2.Kochi Institute for Core Sample research, Japan Agency for Marine-Earth Science and Technology)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[PPS07-15] Characteristics of Oxygen isotope ratios of chondrules and isolated olivine grains from Tagish Lake C2 chondrite

*Takayuki Ushikubo[1], Makoto Kimura[2] (1.Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology, 2.National Institute for Polar Research)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[PPS07-16] Extreme ^{16}O-rich CAIs in Isheyevo chondrite

*Naoya Sakamoto[1], Noriyuki Kawasaki[2] (1.Creative Research Institution, Hokkaido University, 2.Natural History Sciences, Hokkaido University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[PPS07-17] Variations in initial ^{26}Al/^{27}Al ratios among fine-grained CAIs in the reduced CV chondrites

*Noriyuki Kawasaki[1], Changkun Park[2], Naoya Sakamoto[1], Hisayoshi Yurimoto[1,3] (1.Hokkaido University, 2.KOPRI, 3.ISAS/JAXA)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[PPS07-18] Petrographic study of compact type A CAIs with partial melting process

*Akimasa Suzumura[1], Yusuke Seto[2], Shoichi Itoh[1] (1.Graduate school of Science, Kyoto University, 2.Graduate school of Science, Kobe University)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 102 1F

[A-OS13] Ocean circulation and material cycle in coastal seas

convener:Kiyoshi Tanaka(University of Tokyo), Akihiko Morimoto(Ehime University), Yuichi Hayami(Saga University), Kazuhiko Ichimi(Seto Inland Sea Regional Research Center, Kagawa University), Chairperson:Kiyoshi Tanaka, Akihiko Morimoto

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[AOS13-01] On-demand development of bay-scale models using the Japanese Coastal Ocean Monitoring and Forecasting System

*Kei Sakamoto[1], Hideyuki Nakano[1], Shogo Urakawa[1], Takahiro Toyoda[1], Hiroyuki Tsujino[1], Goro Yamanaka[1] (1.Meteorological Research Institute)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[AOS13-02] Long term measurement of the current at the bay head in the Suruga Bay, Japan. part 2

*Takaaki Katsumata[1,4], Masato Niki[2], Akihiko Tanaka[1], Hiroyuki Tan[1,3], Kyoko Takashima[2], Takashige Sugimoto (1.Liberal Arts Education Center, Shimizu Campus, Tokai University., 2.School of Marine Science and Technology, Tokai University, 3.Japan Unmanned Vehicle exploration Agency, 4.NPO, the association for the environmental conservation of the ocean)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[AOS13-03] Bottom-water intrusion and subsequent water exchange induced by Yamase around Mutsu Bay

*Satomi Fujisaki[1], Atsuhiko Isobe[1], Izumi Ogida[2], Yuki Kosaka[2] (1.Kyushu university, 2.Aomori Prefectural Fisheries Research Institute)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[AOS13-04] The Generation Process of the Bottom Intrusion in the Bungo Channel

*Kana Maetani[1], Akihiko Morimoto[2], Xinyu Guo[2], Toru Miyama[3] (1.Graduate School of Science and Engineering, Ehime University, 2.Center for Marine Environmental Studies, Ehime University, 3.Japan Agency for Marine-Earth Science and Technology)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[AOS13-05] Characteristics of bottom intrusion in the Bungo Channel

*Akihiko Morimoto[1], Shuya Fujita[1], Hidetaka Takeoka[1], Xinyu Guo[1] (1.Ehime University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[AOS13-06] Role of Kuroshio Current in fish resource variability off southwest Japan

*Yushi Morioka[1], Sergey Varlamov[1], Yasumasa Miyazawa[1] (1.Japan Agency for Marine-Earth Science and Technology)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 102 1F

[A-OS13] Ocean circulation and material cycle in coastal seas

convener:Kiyoshi Tanaka(University of Tokyo), Akihiko Morimoto(Ehime University), Yuichi Hayami(Saga University), Kazuhiko Ichimi(Seto Inland Sea Regional Research Center, Kagawa University), Chairperson:Akihiko Morimoto, Yuichi Hayami

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[AOS13-07] Variation in hypoxic water mass in Ariake Sea -what consumed the dissolved oxygen?-

*Yuichi Hayami[1], Naoki Fujii[1], Hiroyuki Takasu[2], Yu Umezawa[3], Minoru Wada[2] (1.Saga University, 2.Nagasaki University, 3.Tokyo University of Agriculture and Technology)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[AOS13-08] Influence of Nori aquaculture-induced change in light environment on phytoplankton dynamics

*Naoya Minamiura[1], Soichi Yamaguchi[1] (1.Kyushu University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[AOS13-09] **Enhanced West Philippine Sea intrusion diminishes hypoxia conditions in the Pearl River estuary**

*Hon-Kit Lui[1,2], Chen-Tung Arthur Chen[1], Wei-Ping Hou[2], Jian-Ming Liau[2] (1.Department of Oceanography, National Sun Yat-sen University, 2.Taiwan Ocean Research Institute, National Applied Research Laboratories)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[AOS13-10] North Pacific seawater radiocarbon recorded in abalone shells obtained from Otsuchi Bay, Japan

*Ota Kosuke[1], Yusuke Yokoyama[1,2], Yosuke Miyairi[2], Jun Hayakawa[2], Naomi Sato[2], Hideki Fukuda[2], Kiyoshi Tanaka[2] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2.Atmosphere and Ocean Research Institute, The University of Tokyo)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[AOS13-11] Spreading of Radioactive Cesium off Joban coast through Large River Discharge

*Kiyoshi Tanaka[1], Seiya Nagao[2], Yujiro Kitade[3], Masato Niki[4], Takaaki Katsumata[4], Toru Miyama[5] (1.University of Tokyo, 2.Kanazawa University, 3.Tokyo University of Marine Science and Technology, 4.Tokai University, 5.Japan Agency for Marine-Earth Science and Technology)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[AOS13-12] Development of a river-ocean seamless model for simulating river discharges around Kyushu

*Takahiro Tsutsumi[1], Shinichiro Kida[2], Ryusuke Kuroki[3], Yosuke Alexandre Yamashiki[3] (1.Interdisciplinary Graduate School of Engineering Science, Kyushu University, 2.Research Institute for Applied Mechanics, Kyushu University, 3.Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 102 1F

[A-OS15] Freshwater discharge through rivers and estuaries to the ocean

convener:Shinichiro Kida(Research Institute for Applied Mechanics, Kyushu University), Dai Yamazaki(Institute of Industrial Sciences, The University of Tokyo), Yosuke Alexandre Yamashiki(Earth & Planetary Water Resources Assessment Laboratory Graduate School of Advanced Integrated Studies in Human Survivability Kyoto University), Humio Mitsudera(Institute of Low Temperature Science, Hokkaido University), Chairperson:Shinichiro Kida(RIAM, Kyushu University), Humio Mitsudera(Hokkaido University, Institute of Low Temperature Science), Yosuke Yamashiki(GSAIS Kyoto University)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[AOS15-01] The forefront research for flow and water quality estimations in coastal area using geo-stationary and polar orbital satellites data

★Invited Papers

*Yuji Sakuno[1] (1.Graduate School of Engineering, Hiroshima University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[AOS15-02] Rainfall-Runoff-Inundation Processes and Modeling in a Humid Tropical River Basin

★Invited Papers

*Takahiro Sayama[1], Kodai Yamamoto[2], Ryoko Araki[2], Apip Apip[3], Eva Mia Siska[1], Kaoru Takara[4] (1.Disaster Prevention Research Institute, Kyoto University, 2.Graduate School of Engineering, Kyoto University, 3.LIPI, Indonesia, 4.Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[AOS15-03] Role of river inflows from Kamchatka Peninsula in the Okhotsk Sea

*Toru Miyama[1], Humio Mitsudera[2] (1.Application Laboratory, Japan Agency for Marine-Earth Science and Technology, , 2.Institute of Low Temperature Science, Hokkaido University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[AOS15-04] CHLOROPHYLL ESTIMATION OF LAKE AND COASTAL WATER USING REMOTE SENSING APPROACH

*Shweta Yadav[1], Yamashiki Yosuke[1], Junichi Susaki[1], Kanako Ishikawa[2], Yoh Yamashita[1] (1.Kyoto University, 2.LBERI)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[AOS15-05] Maritime-continent coastal region as land-sea-air triple boundary layer and bio-anthroposphere

*Manabu D. Yamanaka[1] (1.Research Institute for Humanity and Nature / Professor Emeritus of Kobe University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[AOS15-06] River-ocean interaction at the Ganges-Brahmaputra river mouth

*Shinichiro Kida[1], Dai Yamazaki[2] (1.Research Institute for Applied Mechanics, Kyushu University, 2.Institute of Industrial Sciences, The University of Tokyo)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 303 3F

[A-OS16] Chemical and Biological Oceanography

convener:Namiha Yamada(National Institute of Advanced Industrial Science and Technology), Sayaka Yasunaka(Japan Agency for Marine-Earth Science and Technology), Hiroaki Saito(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Tsuneo Ono(Japan Fisheries Research and Education Agency), Naohiro Kosugi(気象研究所)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[AOS16-01] Variability of the growth rate for dissolved inorganic carbon in surface seawater along the 165°E line

*Chiho Tanizaki[1], Hisashi Ono[2], Masao Ishii[2], Atsushi Kojima[1], Shinji Masuda[1], Kazutaka Enyo[1], Daisuke Sasano[1], Toshiya NAKANO[1] (1.Japan Meteorological Agency, 2.Meteorological Research Institute, Japan Meteorological Agency)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[AOS16-02] Seasonal variations of oceanic CO_2 disequilibrium and anthropogenic CO_2 in the subarctic North Pacific

*Bofeng Li[1], Shukuta Satori[1], Kasai Hiromi[2], Hiroshi Kuroda[2], Taniuchi Yukiko[2], Daisuke Hasegawa[3], Yutaka Watanabe[1] (1.Hokkaido University, 2.Hokkaido National Fisheries Research Institute, Japan Fisheries and Education Research , 3.Tohoku National Fisheries Research Institute, Japan Fisheries and Education Research)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[AOS16-03] An evaluation of current and future ocean acidification based on pCO_2 database around Okinawa Island

*Naohiro Kosugi[1], Hiroyuki Tsujino[1], Masao Ishii[1] (1.Meteorological Research Institute)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[AOS16-04] Reconstruction of spatiotemporal change of anthropogenic fixed nitrogen in the western North Pacific

*Yutaka Watanabe[1], Kouichi Fujita[1], BOFENG LI[1] (1.Hokkaido University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[AOS16-05] On the mechanism of significant increasing trend of silicate in intermediate layer of Oyashio region

*Tsuneo Ono[1] (1.Fisheries Research and Education Agency)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[AOS16-06] Systematics of aluminum, manganese, iron, cobalt, and lead in the North Pacific Ocean observed during ocean-section study of GEOTRACES Japan

*Yoshiki Sohrin[1], Linjie Zheng[1] (1.Institute for Chemical Research, Kyoto University)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 301A 3F

[A-OS19] Dynamics of oceanic and atmospheric waves, vortices, and circulations

convener:Yuki Tanaka(Graduate School of Science, The University of Tokyo), Ryo Furue(APL/JAMSTEC), Yukiharu Hisaki(University of the Ryukyus), Norihiko Sugimoto(Keio University, Department of Physics), Chairperson:Norihiko Sugimoto, Ryo Furue

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[AOS19-01] Instability of Ekman pumping

★Invited Papers

*Yoshiaki Miyamoto[1], Daivd S Nolan[2], Norihiko Sugimoto[3] (1.Faculty of Environment and Information Studies, Keio University, 2.Rosenstiel School of Marine and Atmospheric Science, University of Miami, 3.Keio University, Department of Physics)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[AOS19-02] Extratropical Cyclone Structures around Japan -Comparison between Extratropical Cyclones Developing around Japan and those in Northwestern Atlantic Ocean-

*Eigo Tochimoto[1], Hiroshi Niino[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[AOS19-03] Application of a new wave energy flux formulation to assessment of tropical wave propagation dynamics: Diagnostics for the tropical synoptic-scale wave disturbances in the Maritime Continent-northern Australian region

*Fukutomi Yoshiki[1], Hidenori Aiki[1] (1.Institute for Space-Earth Environmental Reasearch, Nagoya University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[AOS19-04] Direct measurement of turbulent fluxes at sea-air interface by micrometeorological technique

★Invited Papers

*Fumiyoshi Kondo[1], Shujiro Komiya[2], Kosuke Noborio[3], Hidenori Aiki[4], Kunio Kutsuwada[5], Mitsuo Uematsu[6], Osamu Tsukamoto[7] (1.Japan Coast Guard Academy, 2.Max Planck Institute for Biogeochemistry, 3.Meiji University, 4.Nagoya University , 5.Tokai University, 6.The University of Tokyo, 7.Okayama University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[AOS19-05] Swell-Dominant Surface Waves Inherent in the Shape of the Rias Coast facing the western North Pacific

*Kosei Komatsu[1,2], Takaki Fujii[1,2], Kiyoshi Tanaka[2] (1.Graduate School of Frontier Sciences, The University of Tokyo, 2.Atmosphere and Ocean Research Institute, The University of Tokyo)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[AOS19-06] **Variabilities of the Sea Surface Height in the Kuril Basin of the Okhotsk Sea: Coherent shelf-trapped mode and Rossby wave-like mode**

*Vigan Mensah[1], Kay I. Ohshima[1] (1.Institute of Low Temperature Science)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 301A 3F

[A-OS19] Dynamics of oceanic and atmospheric waves, vortices, and circulations

convener:Yuki Tanaka(Graduate School of Science, The University of Tokyo), Ryo Furue(APL/JAMSTEC), Yukiharu Hisaki(University of the Ryukyus), Norihiko Sugimoto(Keio University, Department of Physics), Chairperson:Yukiharu Hisaki(琉球大学理学部), Hidenori AIKI

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[AOS19-07] Dynamics of water exchange processes at a deep submarine canyon off the western coast of the Sakhaline which causes the origin of the cold water belt along the Soya Warm Current

★Invited Papers

*Humio Mitsudera[1], Hiroyuki Iida[2] (1.Institute of Low Temperature Science, Hokkaido University, 2.Graduate School of Environmental Science)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[AOS19-08] Generation Mechanism of Tropical Instability Waves in the Equatorial Pacific Ocean

*Yuki Tanaka[1], Toshiyuki Hibiya[1] (1.Graduate School of Science, The University of Tokyo)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[AOS19-09] Annual Rossby waves below the pycnocline in the Indian Ocean

*Motoki Nagura[1] (1.Japan Agency for Marine-Earth Science and Technology)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[AOS19-10] Eddies observed by Argo floats

★Invited Papers

*Katsuro Katsumata[1] (1.JAMSTEC)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[AOS19-11] Rhythmic Phenomena in Nonlinear Systems and Oceanic General Circulation

*Shinya Shimokawa[1], Tomonori Matsuura[2] (1.National Research Institute for Earth Science and Disaster Prevention, 2.University of Toyama)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[AOS19-12] Control of the ocean circulation by bottom topography and generation of mesoscale disturbances

*Yuri Kase[1], Tomonori Matsuura[1] (1.National university corporation University of Toyama)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-HW Hydrology & Water Environment

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 105 1F

[A-HW24] Isotope Hydrology 2019

convener:Masaya Yasuhara(Rissho Univ.), Kohei Kazahaya(Geological Survey of Japan, AIST), Shinji Ohsawa(Institute for Geothermal Sciences, Graduate School of Science, Kyoto University), Kazuyoshi Asai(Geo Science Laboratory), Chairperson:Masaya Yasuhara(Rissho Univ.), Noritoshi Morikawa(産業技術総合研究所活断層・火山研究部門)

9:00 AM - 9:30 AM JST | 12:00 AM - 12:30 AM UTC

[AHW24-01] The use of natural abundances of stable isotopes to elucidate the nitrogen dynamics in plant-soil systems

★Invited Papers

*Keisuke Koba[1] (1.Center for Ecological Research, Kyoto University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[AHW24-02] Reconstruction of local temporal variation on atmospheric sulfur hexafluoride concentration in the Kyoto Basin by multiple environmental tracer and mass transport analyses

*Koki Kashiwaya[1], Taishi Hori[1], Ryuta Hazama[2], Yoichi Sakuma[3], Katsuaki Koike[1] (1.Kyoto University, 2.Osaka Sangyo University, 3.Tokyo Institute of Technology)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[AHW24-03] Quantitative reconstruction of the humidity in the moisture source region based on the ^{17}O-excess in precipitation on a subtropical island

Yuina Uechi[1], *Ryu Uemura[1] (1.University of the Ryukyus)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[AHW24-04] Identification of deep groundwater recharge system in an intermontane basin

*Takashi Nakamura[1], Kei Nishida[1], Naim Mohamad[2], Bijay Man Shakya[1], Kazuyoshi Asai[4], Sresh Das Shrestha[3] (1.ICRE, University of YAMANASHI, 2.University of Yamanashi, 3.CDG, Tribhuvan University, 4.Geo-Science Laboratory)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-HW Hydrology & Water Environment

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 105 1F

[A-HW24] Isotope Hydrology 2019

convener:Masaya Yasuhara(Rissho Univ.), Kohei Kazahaya(Geological Survey of Japan, AIST), Shinji Ohsawa(Institute for Geothermal Sciences, Graduate School of Science, Kyoto University), Kazuyoshi Asai(Geo Science Laboratory), Chairperson:Noritoshi Morikawa(産業技術総合研究所活断層・火山研究部門), Kazuyoshi Asai(Geo-Science Laboratory), Kohei Kazahaya(Geological Survey of Japan, AIST)

10:45 AM - 11:15 AM JST | 1:45 AM - 2:15 AM UTC

[AHW24-05] The discharge rate of the Arima-type deep brine discharge in Ooshika-mura, Nagano Prefecture

★Invited Papers

*Fumitake Kusuhara[1] (1.Central Research Institute of Electric Power Industry)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[AHW24-06] Sublacustrine hydrothermal system of the active crater lake, Yudamari of Aso Volcano inferred from Mg budget of the lake

*Shinji Ohsawa[1], Takeshi Saito[2], Kazuhiro Amita[3] (1.Institute for Geothermal Sciences, Graduate School of Science, Kyoto University, 2.Academic Assembly School of Science and Technology, Shinshu University, 3.Graduate School of Engineering Science, Akita University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[AHW24-07] Spatial distribution of chemical compositions, hydrogen and oxygen isotopic ratios of stream water of the Shimanto River area, southwestern Japan

*Masaaki Takahashi[1], Hinako Shimizu[1], Kohei Kazahaya[1], Masaya Yasuhara[2,1] (1.The National Institute of Advanced Industrial Science and Technology, 2.Rissho University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[AHW24-08] An isotopic study on shallow groundwater origins in a densely-populated area in Shinagawa, central Tokyo, Japan

*Masaya Yasuhara[1], Akihiko Inamura[2], Takashi Nakamura[3], Kazuyoshi Asai[4] (1.Rissho Univ., 2.Geological Survey of Japan, AIST, 3.Yamanashi Univ., 4.Geo Science Laboratory)

[J] Oral | H (Human Geosciences)：H-DS Disaster geosciences

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 106 1F

[H-DS14] Geohazards in humid, tectonically active countries and their precursors

convener:Masahiro Chigira(Disaster Prevention Research Institute, Kyoto University), Hiroshi YAGI(Faculty of Art, Science and Education, Yamagata University), Satoru Kojima(Department of Civil Engineering, Gifu University), Taro Uchida(National Institute for Land and Infrastructure Management), Chairperson:Satoshi Ishimaru

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[HDS14-01] The sources of landslides occurred by the 2018 Hokkaido Eastern Iburi Earthquake

*Satoshi Ishimaru[1], Wataru Hirose[1], Gentaro Kawakami[1], Ryo Takahashi[1], Yoshihiro Kase[1], Ken'ichi Koshimizu[1], Hiromichi Koyasu[1], Masahiro Chigira[2], Jun Tajika[3] (1.Geological Survey of Hokkaido, 2.Kyoto University, 3.Docon Co., Ltd.)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[HDS14-02] Feature of landslide of pyroclastic fall deposits induced by 2018 Hokkaido Eastern Iburi Earthquake, and its relation with damage

*Jun Tajika[1], Kazuo Amemiya[2], Masahiro Chigira[3], Satoshi Ishimaru[4], Akio Koike[1], Hidetoshi Kon[1], Kenji Kizaki[5], Nobuo Yamane[6] (1.Docon Co.,Ltd., 2.Bousai Chishitsu Kogyo Co.,Ltd., 3.Kyoto University, 4.Geological Survey of Hokkaido, HRO, 5.Kizaki PE Office, 6.Terre Research Co.)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[HDS14-03] Influence of slope cutting on failures induced by the July heavy rain, and the Iburi-tobu earthquake, 2018.

*Hidehisa Nagata[1] (1.Fu-Sui-Do Company Limited)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[HDS14-04] Slope failures occurred in the southwest part of the Izu-oshima Island in geological time, NE Japan

*Takehiko Suzuki[1], Masahiro Chigira[2] (1.Faculty of Urban Environmental Sciences, Tokyo Metropolitan University, 2.Disaster Prevention Research Institute, Kyoto University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[HDS14-05] The strain rate observation by the borehole inclinometer on the bedrock creep slopes in Akadani-west area

*Atsuhiko Kinoshita[1,2], Yasutaka Tanaka[2], Wataru Sakurai[1], Taro Uchida[1], Koichiro Hayashi[3], Yasuuchi Kubota[3], Katsushi Kawato[4] (1.National Institute for Land and Infrastructure Management, 2.Sediment Disaster Prevention Technology Center, Kinki Developing Regional Bureau, Ministry of Land, Infrastructure, Transport and Tourism , 3.OYO Corporation, 4.NIPPON ENGINEERING CONSULTANTS CO., LTD.)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[HDS14-06] Assessing Potential Landslide Areas Due to Earthquake Using Three-Dimensional Resistivity Datasets from Across a Wide Area

*Yusuke Sakai[1], Taro Uchida[1], YASUMASA FUJIWARA[2] (1.National Institute for Land and Infrastructure Management , 2.Eight-Japan Engineering Consultants)

[J] Oral | H (Human Geosciences)：H-DS Disaster geosciences

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 106 1F

[H-DS14] Geohazards in humid, tectonically active countries and their precursors

convener:Masahiro Chigira(Disaster Prevention Research Institute, Kyoto University), Hiroshi YAGI(Faculty of Art, Science and Education, Yamagata University), Satoru Kojima(Department of Civil Engineering, Gifu University), Taro Uchida(National Institute for Land and Infrastructure Management), Chairperson:Chigira Masahiro, Taro Uchida

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[HDS14-07] Prediction of shallow landslides and debris flow by rainstorm: dynamic hazard mapping toward disaster mitigation

*Yuki Matsushi[1] (1.Disaster Prevention Research Institute, Kyoto University)

2:00 PM - 2:30 PM JST | 5:00 AM - 5:30 AM UTC

[HDS14-08] Land slide warning judgment mesh information of the Meteorological Agency using the Soil Water Index

★Invited Papers

*KENJI OKADA[1] (1.Japan Meteorological Agency)

2:30 PM - 3:00 PM JST | 5:30 AM - 6:00 AM UTC

[HDS14-09] A future direction of remedial measures for sediment disaster reduction from the viewpoint of enhancing a workable early warning system

★Invited Papers

*Masaru Kunitomo[1,2,3,4], Shigetaka Takiguchi[1,2,3,4], Fumiaki Akazawa[1,2,3,4], Kazuyuki Imai[1,2,3,4] (1.Ministry of Land, Infrastructure, Transport and Tourism, 2.Water and Disaster Management Bureau, 3.Sediment and Erosion Control Department, 4.Sediment and Erosion Control Planning Division)

[J] Oral | S (Solid Earth Sciences)：S-GD Geodesy

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 304 3F

[S-GD03] Geodesy General Contributions/Global Geodetic Observing System

convener:Koji Matsuo(Geospatial Information Authority of Japan), Yusuke Yokota(Institute of Industrial Science, The University of Tokyo), Takahiro Wakasugi(Geospatial Information Authority of Japan), Chairperson:Kensuke Kokado(GSI of Japan), Yusuke Yokota

1:50 PM - 2:05 PM JST | 4:50 AM - 5:05 AM UTC

[SGD03-01] Activities and future perspective of GGOS Working Group Japan

*Basara Miyahara[1] (1.GSI of Japan)

2:05 PM - 2:20 PM JST | 5:05 AM - 5:20 AM UTC

[SGD03-02] Discussion

*Koji Matsuo[1] (1.Geospatial Information Authority of Japan)

2:20 PM - 2:35 PM JST | 5:20 AM - 5:35 AM UTC

[SGD03-03] VLBI-GNSS Co-location Survey at the Ishioka Geodetic Observing Station

*Saho Matsumoto[1], Michiko Umei[1], Haruka Ueshiba[1], Shinobu Kurihara[1], Tadao Kikkawa[1], Takahiro Wakasugi[1] (1.GSI of Japan)

2:35 PM - 2:50 PM JST | 5:35 AM - 5:50 AM UTC

[SGD03-04] Research of Crustal Deformation Model for Next Version of Japanese Geodetic Datum

*Kensuke Kokado[1] (1.GSI of Japan)

2:50 PM - 3:05 PM JST | 5:50 AM - 6:05 AM UTC

[SGD03-05] Construction of a laser-strainmeter network for accurate seismic and geodetic observations

*Akito Araya[1], Akiteru Takamori[1], Wataru Morii[2], Akio Katsumata[3], Akio Kobayashi[3], Takeo Ito[4], Takashi Okuda[4], Makoto Okubo[5] (1.Earthquake Research Institute, University of Tokyo, 2.Disaster Prevention Research Institute, Kyoto University, 3.Meteorological Research Institute, Japan Meteorological Agency, 4.Graduate School of Environmental Studies, Nagoya University, 5.Natural Science Cluster, Kochi University)

[J] Oral | S (Solid Earth Sciences)：S-GD Geodesy

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 304 3F

[S-GD03] Geodesy General Contributions/Global Geodetic Observing System

convener:Koji Matsuo(Geospatial Information Authority of Japan), Yusuke Yokota(Institute of Industrial Science, The University of Tokyo), Takahiro Wakasugi(Geospatial Information Authority of Japan), Chairperson:Yuji Harada(Macau University of Science and Technology), Koji Matsuo

3:35 PM - 3:50 PM JST | 6:35 AM - 6:50 AM UTC

[SGD03-06] UNAVCO GNSS Data: Real-time High-rate Streams, Geodetic Earthquake Magnitudes, Cloud Computing and Future Machine Learning Frameworks

*David A Phillips[1], Kathleen Hodgkinson[1], David Mencin[1], Charles Meertens[1], Thomas Herring[2], Walter Szeliga[3], Timothy Melbourne[3], Mark Murray[4], Glen Mattioli[1], Christine Puskas[1] (1.UNAVCO, Inc. Boulder, 2.Massachusetts Institute of Technology, 3.Central Washington University, 4.USGS)

3:50 PM - 4:05 PM JST | 6:50 AM - 7:05 AM UTC

[SGD03-07] **On application of GNSS-techniques for early tsunami warning in the Sea of Japan**

*Grigorii Viktorovich Nechaev[1,2,3], Nikolai Shestakov[2,3], Hiroaki Takahashi[1], Mako Ohzono[1] (1.Institute of Seismology and Volcanology, Graduate Schooll of Science, Hokkaido University, 2.Far Eastern Federal University, 3.Institute for Applied Mathematics FEB RAS)

4:05 PM - 4:20 PM JST | 7:05 AM - 7:20 AM UTC

[SGD03-08] Measurements of occurrence of solar conjunction with the orbits of Asian QZSS/IGSO satellites

Cancelled

*Fujinobu Takahashi[1] (1.Yokohama National University)

4:20 PM - 4:35 PM JST | 7:20 AM - 7:35 AM UTC

[SGD03-09] Sea level evaluation in northern Australian coast

*Yuta Tokui[1], Kosuke Heki[1] (1.Hokkaido University)

4:35 PM - 4:50 PM JST | 7:35 AM - 7:50 AM UTC

[SGD03-10] Implications from geomagnetic observation for the interannual fluctuations of Earth rotation

*Seiki Asari[1], Masanori Kurihara[1], Kenji Morinaga[1], Shingo Nagamachi[1] (1.Kakioka Magnetic Observatory, Japan Meteorological Agency)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-SS11] Seismic wave propagation: Theory and Application

convener:Kiwamu Nishida(Earthquake Research Institute, University of Tokyo), Kazuya Shiraishi(Japan Agency for Marine-Earth Science and Technology), Takao Nibe(JAPEX), Kaoru Sawazaki(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Tsutomu Takahashi(JAMSTEC)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SSS11-01] Power Spectrum of Random Heterogeneity of the Solid Earth

*Haruo Sato[1] (1.Tohoku Unvieristy)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SSS11-02] Estimation of spatio-temporal changes of seismic scattering property associated with the 2008 Iwate-Miyagi Nairiku earthquake from sparse modeling of seismic ambient noise CCFs

*Takashi Hirose[1], Hisashi Nakahara[1], Takeshi Nishimura[1], Michel Campillo[2] (1.Graduate School of Science, Tohoku University, 2.University Grenoble Alpes, CNRS, ISTerre)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SSS11-03] Surface roughness of the Philippine Sea plate at Nankai subduction zone

*Tsutomu Takahashi[1], Ayako Nakanishi[1], Shuichi Kodaira[1], Yoshiyuki Kaneda[2] (1.JAMSTEC, 2.Kagawa University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SSS11-04] Source location of volcanic earthquakes and tremors at Sakurajima volcano based on seismic correlation

*Theodorus Permana[1], Takeshi Nishimura[1], Hisashi Nakahara[1] (1.Solid Earth Physics Laboratory, Department of Geophysics, Graduate School of Science, Tohoku University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SSS11-05] **Crustal Structure Investigation in Northern Taiwan - Localized Wavefield Inversion of TAIGER T6 Wide Angle Refraction/Reflection Data**

*Fandy Adji Fachtony[1], How-wei Chen[1] (1.Institute of Geophysics, National Central University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SSS11-06] Self-organized criticality induced by randomness in block-spring models and the Gutenberg=Richter law

*Hidetsugu Sakaguchi [1] (1.Kyushi University)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-SS11] Seismic wave propagation: Theory and Application

convener:Kiwamu Nishida(Earthquake Research Institute, University of Tokyo), Kazuya Shiraishi(Japan Agency for Marine-Earth Science and Technology), Takao Nibe(JAPEX), Kaoru Sawazaki(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Kiwamu Nishida(東京大学地震研究所)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SSS11-07] Land-Atmosphere Interaction in the low-frequency seismic band and inversion for shallow elasticity structure

*Toshiro Tanimoto[1], Jiong Wang[1] (1.Department of Earth Science, University of California, Santa Barbara, CA93106, USA)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SSS11-08] Noise correlation analysis of S-net records

*Ryota Takagi[1], Genti Toyokuni[1], Mare Yamamoto[1] (1.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SSS11-09] Atmospheric waves from the gas explosion in Sapporo on December 16, 2018, recorded by seismometers

*Kazunori Yoshizawa[1] (1.Faculty of Science, Hokkaido University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SSS11-10] Time-lapse monitoring of seismic velocity associated with the 2011 Shinmoedake eruption using seismic interferometry

*Kiwamu Nishida[1], Yuta Mizutani[1] (1.Earthquake Research Institute, University of Tokyo)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SSS11-11] Temporal variations of seismic velocity and azimuthal anisotropy in near-surface rock and soil at KiK-net downhole array sites

*Taka'aki Taira[1], Li-Wei Chen[1], Hiroe Miyake[2] (1.Berkeley Seismological Laboratory, University of California, Berkeley, 2.The University of Tokyo)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SSS11-12] Denoising Ambient Seismic Field Correlation Functions with Deep Autoencoders

*Loic Viens[1], Chris Van Houtte[2] (1.Disaster Prevention Research Institute, Kyoto University, 2.GNS Science)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Convention Hall A 2F

[S-SS13] Strong Ground Motion and Earthquake Disaster

convener:Masayuki Kuriyama(Central Research Institute of Electric Power Industry), Kazuhiro Somei(Geo-Research Institute), Chairperson:Nobuyuki Morikawa(National Research Institute for Earth Science and Disaster Resilience), Ryoichi Nakamura(Earthquake Research Institute, The University of Tokyo)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SSS13-25] **Determination of dynamic characteristics of existing buildings at various site conditions in Eskisehir, Turkey**

*Onur Kaplan[1], Seiji Tsuno[2], Hiroaki Yamanaka[3], Mehmet Safa Arslan[4], Oguz Ozel[4] (1.Eskisehir Technical University, 2.Railway Technical Research Institute , 3.Tokyo Institute of Technology , 4.Istanbul University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SSS13-26] **ICDP DSeis 10: Near-field Observations for the M5.5 Orkney, South Africa Earthquake**

Tatsunari Yasutomi[1], *James Mori[1], Hiroshi Ogasawara[2] (1.Earthquake Hazards Division, Disaster Prevention Research Institute, Kyoto University, 2.Ritsumeikan University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SSS13-27] Number of earthquakes from seismic activity model of the national seismic hazard maps for Japan

*Nobuyuki Morikawa[1], Junichi Miyakoshi[2], Hiroyuki Fujiwara[1] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Ohsaki Research Institute, Inc.)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SSS13-28] Comparative examination of the Probabilistic Seismic Hazard Maps in Japan with observed maximum seismic intensities for various periods

*Takamoto Muneta[1], Kazuki Koketsu[1] (1.Earthquake Research Institute, The University of Tokyo)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SSS13-29] A Study on the Ground Motion Characteristics close to the Basin Edge

Ryota Hamabe[2], *Shinichi Matsushima[1], Takashi Azuma[3], Florent De Martin[4] (1.Disaster Prevention Research Institute, Kyoto University, 2.Graduate School of Engineering, Kyoto University, 3.National Institute of Advanced Industrial Science and Technology, 4.French Geological Survey)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SSS13-30] Spectrum Characteristics of MeSO-net seismograms – Effect of Underground Installation -

*Ryoichi Nakamura[1], Hiroshi Tsuruoka[1], Aitaro Kato[1], Shin'ichi Sakai[1], Naoshi Hirata[1], Takahiro Shiina[1] (1.Earthquake Research Institute, The University of Tokyo)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Convention Hall A 2F

[S-SS13] Strong Ground Motion and Earthquake Disaster

convener:Masayuki Kuriyama(Central Research Institute of Electric Power Industry), Kazuhiro Somei(Geo-Research Institute), Chairperson:Yasumaro Kakehi(Department of Planetology, Graduate School of Science, Kobe University), Hisashi Nakahara(Solid Earth Physics Laboratory, Department of Geophysics, Graduate School of Science, Tohoku University)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SSS13-31] Interpretation of attenuation of high-frequency waves from the intraslab, interplate, and outer-rise earthqukakes of Northeastern Japan

*Yasumaro Kakehi[1], Yu Ogasawara[1] (1.Graduate School of Science, Kobe University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SSS13-32] **Effect analysis of soil interlayer on seismic dynamic response and failure mode of metro station structure**

*Shuai Huang[1], Yuejun Lyu[1], Yanju Peng[1] (1.Institute of Crustal Dynamics,China Earthquake Administration)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SSS13-33] **Investigation on the Applicability of V_{S30} Estimation Models for the Beijing Plain Area**

*Yi Fang, Yanju Peng, Zhijie Jiang

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SSS13-34] Early prediction of PGA and Sa using ANN

*Ting Yu Hsu[1] (1.Taiwan Tech)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SSS13-35] Analysis of strong-motion acceleration records based on the Generalized Pareto distribution

*Hisashi Nakahara[1] (1.Solid Earth Physics Laboratory, Department of Geophysics, Graduate School of Science, Tohoku University)

[J] Oral | S (Solid Earth Sciences)：S-EM Earth's Electromagnetism

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 304 3F

[S-EM19] Electromagnetic Induction in the Earth and Planetary Interiors, and Tectono-Electromagnetism

convener:Koki Aizawa(Institute of Seismology and Volcanology, Faculty of Sciences, Kyushu University), Tetsuo Matsuno(Kobe Ocean Bottom Exploration Center, Kobe University), Chairperson:Tetsuo Matsuno, Koki Aizawa

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SEM19-01] Repeated measurements of the Self-Potential at Akita-Yakeyama, Iwate and Kurikoma volcanoes

*Shin'ya Sakanaka[1], Yasiaki Sawada[3], Kenta Kato[2], Inoue Yusuke[1], Kobayashi Takuya[1], Ryuichi Takei[1], YUYA TADA[2], Muhammad Faizul Nizam Bin Zainudin[2], Tomoya Moriwaki[2] (1.Graduate school of International Resource Sciences, Akita University, 2.Faculty of International Resource Sciences, Akita University, 3.Faculty of International Resource Sciences, Akita University (gradusted in 2018))

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SEM19-02] Evaluation of surface conductivity of unsaturated Berea sandstone and porous glasses

*Ryosuke Umezawa[1], Makoto Katsura[1], Satoru Nakashima[1] (1.Department of Earth and Space Science, Graduate School of Science, Osaka University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SEM19-03] Observational and theoretical waveforms of electromagnetic signals generated by the motional induction effect before the arrival of seismic waves

*Ken'ichi Yamazaki[1] (1.Disaster Prevention Research Institute, Kyoto University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SEM19-04] Effect of reference data on geomagnetic transfer functions

*Shinya Sato[1], Tada-nori Goto[1] (1.Kyoto Univesity, Graduate School of Engineering)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SEM19-05] Reliability estimation of magnetotelluric inversion result based on the Principle Component Analysis and Markov Chain Monte-Carlo method

Hisatoshi Koji[1], *Tada-nori Goto[1] (1.Graduate School of Engineering, Kyoto University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SEM19-06] Probing one-dimensional electrical anisotropy in the oceanic upper mantle from seafloor magnetotelluric array data

*Tetsuo Matsuno[1], Kiyoshi Baba[2], Hisashi Utada[2] (1.Kobe Ocean Bottom Exploration Center, Kobe University, 2.Earthquake Research Institute, The University of Tokyo)

[J] Oral | S (Solid Earth Sciences)：S-EM Earth's Electromagnetism

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 304 3F

[S-EM19] Electromagnetic Induction in the Earth and Planetary Interiors, and Tectono-Electromagnetism

convener:Koki Aizawa(Institute of Seismology and Volcanology, Faculty of Sciences, Kyushu University), Tetsuo Matsuno(Kobe Ocean Bottom Exploration Center, Kobe University), Chairperson:Koki Aizawa, Tetsuo Matsuno

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SEM19-07] The Analysis of magnetotelluric sounding data on Kikai submarine caldera.

*Toki Hirose[1], Tetsuo Matsuno[2,1], Nobukazu Seama[1,2], Yuki Okizono[4], Hiroshi Ichihara[3], Hiroko Sugioka[1,2], Yoshiyuki Tatsumi[2,1] (1.Department of Planetology, Graduate School of Science, Kobe University, 2.Kobe ocean Bottom Exploration Center, Kobe University, 3.Graduate school of environmental studies, Nagoya University, 4.Department of Planetology, Faculty of Science, Kobe University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SEM19-08] Role of Fluids in the earthquake generation: The Nagamachi-Rifu reverse fault, NE Honshu, Japan

*Sabri Bulent Tank[1], Yasuo Ogawa[2] (1.Bogazici University, 2.Tokyo Institute of Technology)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SEM19-09] Audio-frequency Magnetotelluric Survey of the Tsuyama-hoppou Fault, Yamasaki Fault Zone, southwest Japan.

*Satoru Yamaguchi[1], Daisuke Takakuwa[2], Akira Mimura[1], Kazuki Fkue[1], Shigehiro Katoh[3], Hideki Murakami[4], Shinichi Takakura[5] (1.Department of Geosciences, Graduate School of Science, Osaka City University, 2.Faculty of Science, Osaka City University, 3.The Museum of Nature and Human Activities, 4.Science and Technology Unit, Research and Education Faculty, Kochi University, 5.Geological Survey of Japan, Institute of Advanced Industrial Science and Technology)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SEM19-10] Three dimensional resistivity structure around the focal region of the 2016 Kumamoto earthquakes

*Koki Aizawa[1], Hisashi Asaue[2], Katsuaki Koike[3], Shinichi Takakura[4], Toru Yoshinaga[10], Makoto Uyeshima[5], Takao Koyama[5], Ryokei Yoshimura[7], Ken'ichi Yamazaki[7], Shintaro Komatsu[7], Yusuke Yamashita[7], Hiroshi Ichihara[9], Mitsuru Utsugi[8], Kaori Tsukamoto[12], Dan Muramatsu[12], Yoshiko Teguri[1,11], Kazunari Uchida[1], Hideaki Hase[6], Azusa Shito[1], Satoshi Matsumoto[1], Takeshi Matsushima[1], Hiroshi Shimizu[1] (1.Institute of Seismology and Volcanology, Faculty of Sciences, Kyushu University, 2.Laboratory on Innovative Techniques for Infrastructures, Kyoto University, 3.Environmental Geosphere Engineering, Department of Urban Management, Graduate School of Engineering, Kyoto University, 4.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 5.Earthquake Research Institute, University of Tokyo, 6.GERD, 7.Disaster Prevention Research Institute, Kyoto University, 8.Aso Volcanological Laboratory, Institute for Geothermal Sciences, Graduate School of Science, Kyoto University, 9.Earthquake and Volcano Research Center, Graduate School of Environmental Studies, Nagoya University, 10.Kumamoto University, 11.Japan Meteorological Agency, 12.Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SEM19-11] **A research report on the fundamental investigations of an electrical resistivity structure beneath Chugoku and Shikoku regions, southwestern Japan(2018)**

*Ichiro Shiozaki[1], Tomofumi Uto[1], Makoto Uyeshima[2], Hiroshi Hataoka[3], Yasuo Ikezoe[3], Shinji Yamamoto[3], Tatsuya Noguchi[1], Daiki Furuichi[4], Yuki Murayama[4], Kohei Matsushita[4], Hideki Murakami[5], Naoto Oshiman[6], Yoshihisa Iio[6], Kazuya Ando[7] (1.Graduate School of Engineering, Tottori University, 2.Earthquake Research Institute, The University of Tokyo, 3.Technical Department, Tottori University, 4.Faculty of Engineering, Tottori University, 5.Research and Education Faculty , Kochi University, 6.Disaster Prevention Research Institute, Kyoto University, 7.San'in Kaigan Geopark Museum of the Earth and Sea)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SEM19-12] Fluid distribution beneath central and southern Kyushu imaged by 3-D electrical resistivity model

*Maki Hata[1], Hiroshi Munekane[2], Hisashi Utada[1], Tsuneomi Kagiyama[3] (1.Earthquake Research Institute, the University of Tokyo , 2.Geospatial Information Aurhotiry of Japan, 3.Aso Geopark Promotion Council)

[J] Oral | S (Solid Earth Sciences)：S-GL Geology

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-GL28] Regional geology and tectonics

convener:Makoto Otsubo(Geological Survey of Japan, Research Institute of Earthquake and Volcano Geology), Jun Hosoi(Geological Survey of Japan, Institute of Geology and Geoinformation, AIST), Chairperson:Makoto Otsubo(Research Institute of Earthquake and Volcano Geology, Geological Survey of Japan)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SGL28-01] Lithology and zircon U-Pb geochronology of Paleoproterozoic and Paleozoic granitic complex in Maizuru Terrane from Tsuwano area, Shimane Prefecture, SW Japan

*Kosuke Kimura[1], Yasutaka Hayasaka[1], Tomoyuki Shibata[1], Kenta Kawaguchi[1], Hiroshi Fujiwara[1] (1.Hiroshima University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SGL28-02] Tectonic significance of new Zircon U-Pb ages of sedimentary complexes in the northern Hidaka Belt, central Hokkaido, northern Japan

*Futoshi Nanayama[1,5], Toru Yamasaki[1], Jun Tajika[2], Hideki Iwano[3], Tohru Danhara[3], Takafumi Hirata[4] (1.Geological Survey of Japan, AIST, 2.Docon Co. Ltd, 3.Kyoto Fission-Track Co.Ltd, 4.Tokyo Univ., 5.CWMD, Kumamoto Univ.)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SGL28-03] New age constraints and tectonic significance of Late Oligocene marine biosiliceous deposits in the Hidaka Belt, northeastern Hokkaido, northern Japan

*Futoshi Nanayama[1,6], Hiroshi Kurita[2], Toru Yamasaki[1], Jun Tajika[3], Hideki Iwano[4], Tohru Danhara[4], Takafumi Hirata[5] (1.Geological Survey of Japan, AIST, 2.Niigata Univ., 3.Docon Co. Ltd, 4.Kyoto Fission-Track Co. Ltd, 5.Tokyo Univ., 6.CWMD, Kumamoto Univ.)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SGL28-04] Late Cretaceous sea-level changes and tectonic history recorded in the forearc sedimentary successions of the Northeast Japan

*Jun Arimoto[1], Reishi Takashima[2], Hiroshi Nishi[2], Yuji Orihashi[3], Toshiro Yamanaka[4] (1.Department of Earth Science, Graduate School of Science, Tohoku University, 2.The Center for Academic Resources and Archives, Tohoku University, 3.Department of Earth and Environmental Sciences, Graduate School of Hirosaki University, 4.Tokyo University of Marine Science and Technology)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SGL28-05] Paleo-stress analysis in coherent zone, an exhumed Cretacesou accretionary complex, Shimanto Belt, in Konan city and Geisei villege, Kochi prefecture, SW Japan

*Makoto Hashiguchi[1], Yoshitaka Hashimoto[1] (1.Kochi University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SGL28-06] Relationship between accretion of limestone blocks and subduction tectonics in Japan

*Koji Wakita[1] (1.Yamaguchi University)

[J] Oral | S (Solid Earth Sciences)：S-GL Geology

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-GL28] Regional geology and tectonics

convener:Makoto Otsubo(Geological Survey of Japan, Research Institute of Earthquake and Volcano Geology), Jun Hosoi(Geological Survey of Japan, Institute of Geology and Geoinformation, AIST), Chairperson:Jun Hosoi(Geological Survey of Japan)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SGL28-07] Discovery of faulted basin margin from the middle Miocene Tottori Grope, Tottori Prefecture, Southwest Japan and its significance

*Yuta Maruyma[1] (1.Shimane Umiversity)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SGL28-08] Fault activity during Quaternary Period off the Shimane Peninsula based on the profiles acquired by the high-resolution seismic survey

*Masaaki Tanaka[1], Norihiro Matsuda[1], Masaru Nakamura[1], Yuichi Shimizu[1], Masanori Shimazaki[2], Kazuhito Hatakeyama[2] (1.The Chugoku Electric Power Co., Inc., 2.Sogo Geophysical Exploration Co., Ltd.)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SGL28-09] Paleomagnetic directions of early Miocene sediments in central Japan and tectonic implications

*Hiroyuki Hoshi[1], Takuro Matsuo[2] (1.Department of Earth Sciences, Aichi University of Education, 2.Aichi Prefectural Kariya High School)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SGL28-10] Revised Cenozoic chronostratigraphy and tectonics in the Yatsuo Area, Toyama Prefecture, central Japan

*Takeshi Nakajima[1], Hideki Iwano[2], Tohru Danhara[2], Tohru Yamashita[2], Yukio Yanagisawa[1], Yoshihiro Tanimura[3], Mahito Watanabe[1], Takayuki Sawaki[1], Satoshi Nakanishi[4], Hiroyuki Mitsuishi[4], Okiyuki Yamashina[4], Seiichi Imahori[5] (1.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2.Kyoto Fission-Track Co., Ltd., 3.National Museum of Nature and Science, 4.JX Nippon Oil & Gas Exploration Corporation, 5.JX Nippon Oil & Gas Exploration Technical Services Corporation)

[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 105 1F

[S-VC35] Mitigation of volcanic disasters - basic and applied researches

convener:Shinji Takarada(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Mitsuhiro Yoshimoto(Mount Fuji Research Institute, Yamanashi Prefectural Government), Yasuhiro Ishimine(Research and Education Center for Natural Hazards, Kagoshima University), Tomohiro Kubo(National Research Institute for Earth Science and Disaster Prevention), Chairperson:Tomohiro Kubo(防災科学技術研究所), Shinji Takarada(Geological Survey of Japan/AIST)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SVC35-01] A working hypothesis for source craters and sequence of the 1707 Hoei eruption of Fuji Volcano, Japan

*Masato Koyama[1] (1.Shizuoka Univ.)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SVC35-02] Consideration of the formation process of Mt.Hoei, Fuji volcano

*Akira Baba[1], Toshitsugu Fujii[1], Tatsuro Chiba[2], Mitsuhiro Yoshimoto[1], Fumikatsu NISHIZAWA[1], Hidetoshi Shibuya[3] (1.Mount Fuji Research Institute, 2.Asia Air Survey Co., Ltd., 3.Department of Earth and Environmental Sciences, Faculty of Advanced Science and Technology, Kumamoto University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SVC35-03] Airborne LiDAR Bathymetry reveals underwater topography of Lake Motosu - The level of water raised by lava inflow -

*Tatsuro Chiba[1], Sin-ichi kaneta[1], Makoto Ohashi[1] (1.Asia Air Survey Co., Ltd.)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SVC35-04] Volcano monitoring using satellite thermal infrared imagery of CIRC (Compact Infrared Camera)

*Yuki Takakura[1], Koji Nakau[1], Junichiro Ishizawa[1] (1.Japan Aerospace Exploration Agency)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SVC35-05] Impact absorption properties of wooden buildings roof subjected to ballistic block collision

*Kohei Tateyama[1], Hiroyuki Yamada[2], Mitsuhiro Yoshimoto[3], Ryo Honda[3], Toshitsugu Fujii[3] (1.Ritsumeikan University, 2.National defense academy, 3.Mount Fuji Research Institute, Yamanashi Prefectural Government)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SVC35-06] Distribution of ballistic ejecta of the phreatic eruption at Kusatsu-Shirane volcano, on 23 Jan, 2018, part 2

*Mitsuhiro Yoshimoto[1], Ryuta FURUKAWA[2,3], Yoshihiro Ishizuka[2], Yusuke Minami[2], Masashi NAGAI[4], Shuichi Hosokawa[3], Ryo Honda[1], Taisuke Yasuda[1], Akihiko Terada[5], Tatsuji Nishizawa[5], Yasuhiro Ishimine[6], Kenichi Arai[7], Hisashi Sasaki[7], Shino Naruke[7], Yuko Sekiguchi[3], Takahiro Yanada[3], Yasuo Ishizaki[8], Nobuko Kametani[8], Fukashi Maeno[9] (1.Mount Fuji Research Institute, Yamanashi Prefectural Government, 2.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 3.Japan Meteorological Agency, 4.Volcano Research Department, National Research Institute for Earth Science and Disaster Resilience, 5.Volcanic Fluid Research Center, Tokyo Institute of Technology, 6.Research and Education Center for Natural Hazards, Kagoshima University, 7.Asia Air Survey Co., Ltd., 8. Graduate School of Science and Engineering, University of Toyama, 9.Earthquake Research Institute, University of Tokyo)

[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 105 1F

[S-VC35] Mitigation of volcanic disasters - basic and applied researches

convener:Shinji Takarada(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Mitsuhiro Yoshimoto(Mount Fuji Research Institute, Yamanashi Prefectural Government), Yasuhiro Ishimine(Research and Education Center for Natural Hazards, Kagoshima University), Tomohiro Kubo(National Research Institute for Earth Science and Disaster Prevention), Chairperson:Mitsuhiro Yoshimoto(山梨県富士山科学研究所), Yasuhiro Ishimine(鹿児島大学地域防災教育研究センター)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SVC35-07] Developing Ash-fall impact forecasting content.

*Tomohiro Kubo[1], Yosuke Miyagi[1], Setsuya Nakada[1], Eisuke Fujita[1], Masamitsu Miyamura[1] (1.National Research Institute for Earth Science and Disaster Prevention)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SVC35-08] New Websites and a Pamphlet of IVHHN

*Yasuhiro Ishimine[1] (1.Research and Education Center for Natural Hazards, Kagoshima University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SVC35-09] State of river water pollution derived from the recent volcanic activity of Mt Iwo-Yama, Kirishima volcanoes

*Yoshikazu Kikawada[1], Haruka Yamamoto[2], Wei Deng, Megumi Fukai (1.Faculty of Science and Technology, Sophia University, 2.Graduate School of Science and Technology, Sophia University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SVC35-10] Development of information tools for evacuation and rescue in the event of volcanic disaster

*Yosuke Miyagi[1], Setsuya Nakada[1], Tomohiro Kubo[1], Mitsuhiro Yoshimoto[2], Ryo Honda[2] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Mount Fuji Research Institute, Yamanashi Prefectural Government)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SVC35-11] **Ignimbrite, tephra-fall, caldera and fatalities of major volcanoes in the East and Southeast Asia**

*Shinji Takarada[1], Joel Calupas Bandibas[1] (1.Geological Survey of Japan, AIST)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SVC35-12] On the climber’s attitudes to the Volcanic mitigation for active volcanoes.

*Hideyuki Itoh[1], Chizuru Totani[2], Mizuho Arai[2] (1.Faculty of policy studies, Iwate prefectural University, 2.Asia air Survey, Co.Ltd.)

[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | IC 2F

[S-VC38] Active Volcanism

convener:Yuta Maeda(Nagoya University), Takahiro Miwa(National research institute for earth science and disaster prevention), Takeshi Nishimura(Department of Geophysics, Graduate School of Science, Tohoku University), Chairperson:Takehiko Suzuki, Maya Yasui

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SVC38-01] Tephrochoronology in the southwest part of basaltic Izu-oshima volcanic island during last 20,000 years, off Tokyo, Pacific Ocean

*Takehiko Suzuki[1], Satoshi Terayama[1], Jun Matsukaze[1], Yuichi Kato[1] (1.Faculty of Urban Environmental Sciences, Tokyo Metropolitan University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SVC38-02] **Tephrostratigraphy at Daisan-yama and Jinai-jima, and correlation with eruption deposits from Mamashitaura Volcanoes in Niijima Volcano, Izu-islands**

*Makoto Kobayashi[1], Masanori Murata[1], Kaori Aoki[1], Daisuke Ishimura[1,2], Takehiko Suzuki[1,2] (1.Research Center for Volcanic Hazards and Their Mitigations, Tokyo Metropolitan Univ., 2.Department of Geography, Tokyo Metropolitan Univ.)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SVC38-03] Constration of pre-eruptive process using crystal clot: A case study of Unzen 1991-95 eruption

*Kurumi Iwahashi[1], ATSUSHI YASUDA[1] (1.Earthquake Research Institute,The University of Tokyo)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SVC38-04] Petrological study of Pinatubo 1991 eruption ~ Discussions of magma plumbing model~

*Tomohisa Tamura[1,2], Mitsuhiro Nakagawa[2] (1.West Japan Engineering Consultants, Inc., 2.Earth and Planetary System Science, Hokkaido University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SVC38-05] Rediscovery of the Higuruma Debris Avalanche Deposit in Asama-Kurofu Volcano

*Maya Yasui[1], Masaki Takahashi[1], Tatsuo Kanamaru[1] (1.College of Humanities and Sciences, Nihon University)

[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | IC 2F

[S-VC39] Hydrothermal systems of volcanoes

convener:Yasuhiro Fujimitsu(Department of Earth Resources Engineering, Faculty of Engineering, Kyushu University), Wataru Kanda(Volcanic Fluid Research Center, School of Science, Tokyo Institute of Technology), Takeshi Ohba(Department of chemistry, School of Science, Tokia University), Chairperson:Yasuhiro Fujimitsu(Faculty of Engineering, Kyushu University), Takeshi Ohba, Wataru Kanda

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SVC39-01] Hydrothermal system of Tokachidake volcano, Japan: Examination from multi-disciplinary surveys

*Ryo Takahashi[1], Noritoshi Okazaki[1], Makoto Tamura[1] (1.Geological Survey of Hokkaido, Hokkaido Research Organization)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SVC39-02] Fumarole and hot spring activities after the 2015 eruption of Hakone Volcano and their relationships with the seismicity and crustal deformation

*Kazutaka Mannen[1], Masatake Harada[1], Yohei Yukutake[1], George Kikugawa[1] (1.Hot Springs Research Institute of Kanagawa Prefecture)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SVC39-03] A possible geothermal source at around 4 km depth estimated by the seismic observation in Ibusuki geothermal area

*Junzo Kasahara[1,3], Yoko Hasada[2,1], Hiroyasu Kuzume[1] (1.ENAA, 2.Daiwa Exploration and Consulting Co., 3.Shizuoka Univ.)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SVC39-04] Time variation in the chemical and isotopic composition of fumarolic gases at Kusatsu-Shirane volcano Japan

*Takeshi Ohba[1], Muga Yaguchi[2], Nozomi Numanami[1], Kotaro Toyama[3], Hirochika Sumino[3], Urumu Tsunogai[4], Masanori Ito[4], Ryo Shingubara[4] (1.Department of chemistry, School of Science, Tokia University, 2.Meteorological Research Institute, JMA, 3.The University of Tokyo Graduate School of Arts and Sciences Department of Basic Science, 4.Nagoya University Graduate School of Environmental Studies)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SVC39-05] Behavior of Arsenic and Mercury related to hydrothermal activities in Kirishima, Satsuma Iwojima, and Yamagawa, Kyushu Japan

*Motoya Habuchi[1], Harue Masuda[1], Tsuyoshi Shintani[1], Shuzo Furuya[1], Keigo Mori[1], Jun-ichiro Ishibashi[2], Takeshi Matsushima[2], Akinori Takeuchi[3], Syogo Oshima[4], Reo Ikawa[5] (1.Osaka City University, 2.Kyushu University, 3.National Institute for Environmental Studies, 4.West Japan Engineering Consultants, Inc., 5.National Institute of Advanced Industrial Science and Technology)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SVC39-06] The chemical composition of thermal waters from spring and hot pool at Mt. Iwoyama of Kirishima volcano

*Muga Yaguchi[1], Takeshi Ohba[2], Kotaro Toyama[3], Fukuoka Regional Headquarters JMA[4], Kagoshima Meteorological Office JMA[4] (1.Meteorological Research Institute, 2.Tokai University, 3.Graduate School of the University of Tokyo, 4.Japan Meteorological Agency)

[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | IC 2F

[S-VC39] Hydrothermal systems of volcanoes

convener:Yasuhiro Fujimitsu(Department of Earth Resources Engineering, Faculty of Engineering, Kyushu University), Wataru Kanda(Volcanic Fluid Research Center, School of Science, Tokyo Institute of Technology), Takeshi Ohba(Department of chemistry, School of Science, Tokia University), Chairperson:Yasuhiro Fujimitsu(Faculty of Engineering, Kyushu University), Takeshi Ohba, Wataru Kanda

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SVC39-07] Re-examination of origin of the variety in magmatic-hydrothermal fluids

*Hiroshi Shinohara[1] (1.Geological Survey of Japan, AIST)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SVC39-08] **Constraining electrical resistivity structure of volcanoes using multiphase flow modelling: an example of Miyake-jima**

*Marceau Gresse[1], Makoto Uyeshima[1], Takao Koyama[1], Maki Hata[1], Hideaki Hase[2], Koki Aizawa[3], Yusuke Yamaya[4], Yoichi Sasai[5], Jacques Zlotnicki[6], Tawat Rung-Arunwan[1], Hideki Ueda[7] (1.Earthquake Research Institute, The University of Tokyo, Tokyo, Japan, 2.Geothermal Energy Research & Development Co., Ltd., Tokyo, Japan, 3.Institute of Seismology and Volcanology, Faculty of Science, Kyushu University, Fukuoka, Japan., 4.Planning Division, National Institute of Advanced Industrial Science and Technology, Tokyo, Japan, 5.Earthquake Prediction Research Centre, Tokai University, Shizuoka, Japan, 6.CNRS, OPGC-UMR6524, Aubière, France, 7.National Research Institute for Earth Science and Disaster Resilience, Tsukuba, Japan)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SVC39-09] MT survey and 3-D resistivity structure in the Niseko area, southwestern Hokkaido

*Makoto Tamura[1], Toru Mogi[2], Junna Kanahiro[2], Daisuke Oka[1], Junya Maruyama[1], Takahiro Suzuki[1], Noritoshi Okazaki[1] (1.Geological Survey of Hokkaido, Hokkaido Research Organization, 2.Division of Sustainable Resource Engineering, Fucluty of Engineering, Hokkaido University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SVC39-10] **Hydrothermal fluid activity of the Tatun Volcano Group, Taiwan, revealed by self-potentials and seismicity**

*Hong-Jia Chen[1], Zhi-Xian Yang[1], Chien-Chih Chen[1,2], Cheng-Horng Lin[3,4] (1.Department of Earth Sciences, National Central University, Taiwan., 2.Earthquake-Disaster & Risk Evaluation and Management, National Central University, Taoyuan, Taiwan., 3.Institute of Earth Sciences, Academia Sinica, Taipei, Taiwan., 4.Taiwan Volcano Observatory at Tatun, Taipei, Taiwan.)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SVC39-11] Utilizing the electrical conductivity distribution to unravel the hydrothermal system beneath Mt.Hasan composite volcano and its vicinity, southwest Cappodocia, Turkey

*Sabri Bulent Tank[1], Mustafa Karas[1] (1.Bogazici University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SVC39-12] Three-dimensional Magnetotelluric Inversion to map geothermal structures in Eburru Geothermal field, Kenya.

*JUSTUS MAITHYA[1], Yasuhiro FUJIMITSU[2] (1.Graduate School of Engineering, Department of Earth Resources Engineering, Kyushu University, 2.Faculty of Engineering, Department of Earth Resources Engineering, Kyushu University)

[J] Oral | S (Solid Earth Sciences)：S-TT Technology & Techniques

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 303 3F

[S-TT45] Synthetic Aperture Radar

convener:Youhei Kinoshita(University of Tsukuba), Yu Morishita(Geospatial Information Authority of Japan), Shoko Kobayashi(Tamagawa University), Takahiro Abe(Earth Observation Research Center, Japan Aerospace Exploration Agency), Chairperson:Shoko Kobayashi(Tamagawa University), Kazuya Ishitsuka(Kyoto University)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[STT45-01] Extraction of ground changes near the crater by the eruption of Kilauea volcano.

*Fujiyama Kaho[1], Masanobu Shimada[1], Yuki Kimoto[1], Kenta Yoshioka[1] (1.TokyoDenki University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[STT45-02] ALOS-2 observation of the 2017 Sefidsang earthquake, northeastern Iran: a blind shallow-dipping thrust event near the Eastern Kopeh Dagh

*Nematollah Ghayournajarkar[1], Yo Fukushima[2] (1.Graduate School of Science, Tohoku University, 2.International Research Institute of Disaster Science, Tohoku University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[STT45-03] **InSAR ground displacements and slip distribution associated with secondary fault slips of the 2016 Kumamoto earthquake**

*Yo Fukushima[1], Daisuke Ishimura[2] (1.International Research Institute of Disaster Science, Tohoku University, 2.Department of Geology, Tokyo Metropolitan University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[STT45-04] Surface displacements at the Kumamoto plain using persistent scatterer interferometry and comparison with groundwater levels

*Kazuya Ishitsuka[1], Takeshi Tsuji[2] (1.Kyoto Univ., 2.Kyushu Univ.)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[STT45-05] Forest fire detection in the low biomass dry forest with JICA-JAXA Forest Early Warning System in the Tropics (JJ-FAST).

*Manabu Watanabe[1], Christian Naohide koyama[1], Masato Hayashi[2], Izumi Nagatani[2], Takeo Tadono[2], Masanobu Shimada[1,2] (1.School of Science and Engineering, Tokyo denki university, 2.JAXA/EORC)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[STT45-06] Nominal operation results of Japanese ALOS-2

★Invited Papers

*Shinichi Sobue[1] (1.Japan Aerospace Exploration Agency)

[J] Oral | S (Solid Earth Sciences)：S-TT Technology & Techniques

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 303 3F

[S-TT45] Synthetic Aperture Radar

convener:Youhei Kinoshita(University of Tsukuba), Yu Morishita(Geospatial Information Authority of Japan), Shoko Kobayashi(Tamagawa University), Takahiro Abe(Earth Observation Research Center, Japan Aerospace Exploration Agency), Chairperson:Yohei Kinoshita(RESTEC), Takahiro Abe(JAXA)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[STT45-07] Estimation of velocity distribution of Shirase Glacier derived from SAR data obtained by ERS-1/2 tandem mission

*Koichiro Doi[1,2], Yuichi Aoyama[1,2], Kazuki Nakamura[3], Tsutomu Yamanokuchi[4], Kazuo Shibuya[1] (1.National Institute of Polar Research, 2.SOKENDAI, 3.College of Engineering, Nihon University, 4.RESTEC)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[STT45-08] Heavy rainfall-induced displacement of more than 2.5m in the Kushiro Marsh in 2016, detected by ALOS-2 SAR

*Satoshi Fujiwara[1], Yu Morishita[1], Takayuki Nakano[1], Yuji Miura[1], Yasuaki Kakiage[1], MURAMATSU Hiroki[1], Hiroshi Une[1] (1.GSI of Japan)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[STT45-09] Surface deformation of Asama Volcano, Japan, detected by time-series InSAR combining persistent and distributed scatterers, 2014-2018

*Yosuke Aoki[1], Xiaowen Wang[1] (1.Earthquake Research Institute, University of Tokyo)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[STT45-10] Improvement of Airborne L-band-SAR (Pi-SAR-L2) Coherence by Pixel by Pixel Resampling

*Makoto Murakami[1], Masato Furuya[1], Taku Ozawa[4], Youichiro Takada[1], Yosuke Aoki[3], Masanobu Shimada[2], Shohei Narita[1] (1.Hokkaido University, 2.Tokyo Denki University, School of Science and engineerring, 3.Earthquake Research Institute, The University of Tokyo, 4. National Research Institute for Earth Science and Disaster Resilience)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[STT45-11] Ionospheric delay estimation in SAR interferometry: Significance of the method using the split-spectrum double-difference interferogram

*Taku Ozawa[1] (1.National Research Institute for Earth Science and Disaster Resilience)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[STT45-12] Detecting surface displacement accosiated with the 2018 slow slip event around Boso peninsla by use of Sentinel-1 InSAR with atmospheric correction

*Youhei Kinoshita[1], Tadahiro Nimura[1], Ryoichi Furuta[1] (1.RESTEC, Remote Sensing Technology Center of Japan)

[J] Oral | S (Solid Earth Sciences)：S-TT Technology & Techniques

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[S-TT46] Seismic Big Data Analysis Based on the State-of-the-Art of Bayesian Statistics

convener:Hiromichi Nagao(Earthquake Research Institute, The University of Tokyo), Aitaro Kato(Earthquake Research Institute, the University of Tokyo), Takuto Maeda(Graduate School of Science and Technology, Hirosaki University), Keisuke Yano(The university of Tokyo), Chairperson:Nana Yoshimitsu(Earthquake Research Institute, The University of Tokyo), Takeru Matsuda(Graduate School of Information Science and Technology, The University of Tokyo)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[STT46-01] A bad inversion result suggests bad modeling

★Invited Papers

*Yukitoshi Fukahata[1], Yuji Yagi[2] (1.Disaster Prevention Research Institute, Kyoto University, 2.Graduate School of Life and Environmental Sciences, University of Tsukuba)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[STT46-02] A seismic wavefield estimation in a dense seismograph network: An optimization for the MeSO-net

*Takahiro Shiina[1], Takuto Maeda[2], Masayuki Kano[3], Aitaro Kato[1], Naoshi Hirata[1] (1.Earthquake Research Institute, The University of Tokyo, 2.Graduate School of Science and Technology, Hirosaki University, 3.Graduate school of science, Tohoku University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[STT46-03] Uncertainty quantification based on 4DVar data assimilation for massive simulation models

*Shin-ichi Ito[1], Masayuki Kano[2], Hiromichi Nagao[1] (1.The University of Tokyo, 2.Tohoku University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[STT46-04] Bayesian approach for statistical modeling and forecasting of aftershock activities

★Invited Papers

*Takahiro Omi[1] (1.Institue of Industrial Science, the University of Tokyo)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[STT46-05] **Bias Correction for the Distribution of Aftershocks Within Short-Term Period Immediately After Large Main Shock**

*Kosuke Morikawa[1], Hiromichi Nagao[2], Shin-ichi Ito[2], Shin'ichi Sakai[2], Naoshi Hirata[2] (1.Osaka University, 2.Earthquake Research Institute, The University of Tokyo)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[STT46-06] Deep-learning-based Earthquake Detection for Continuous Seismic Network Records

*Keisuke Yano[1], Takahiro Shiina[2], Sumito Kurata[1], Aitaro Kato[2], Fumiyasu Komaki[1], Shin'ichi Sakai[2], Naoshi Hirata[2] (1.Graduate School of Information Science and Technology, The University of Tokyo, , 2.Earthquake Research Institute, The University of Tokyo)

[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-CG56] Ocean Floor Geosciences

convener:Kyoko Okino(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Arata Kioka, Atsushi Noda

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SCG56-25] Observational plans of the South Sandwich Arc by R/V Hakuho Maru: Toward understanding formation and evolution of the world southernmost arc-trench system

*Asuka Yamaguchi[1], Kenichiro Tani[2], Minoru Ikehara[3] (1.Atomosphere and Ocean Research Institute, The University of Tokyo, 2.National Museum of Nature and Science, 3.Center for Advanced Marine Core Research, Kochi University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SCG56-26] Seismic imaging of the source zone of the 2011 Tohoku-oki earthquake

*Dapeng Zhao[1], Xin Liu[1] (1.Department of Geophysics, Tohoku University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SCG56-27] Drastic export of organic carbon to hadal trench driven by megathrust earthquake

*A. Kioka[1], T. Schwestermann[1], J. Moernaut[1], K. Ikehara[2], T. Kanamatsu[3], C. M. McHugh[4], C. dos Santos Ferreira[5], G. Wiemer[5], N. Haghipour[6], A. J. Kopf[5], T. I. Eglinton[6], M. Strasser[1,5] (1.Universität Innsbruck, Austria, 2.GSJ-AIST, Japan, 3.JAMSTEC, Japan, 4.Queens-CUNY, USA, 5.MARUM-U. Bremen, Germany, 6.ETH Zürich, Switzerland)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SCG56-28] How do trench-fill sediments subduct under the accretionary wedge?

*Atsushi Noda[1], Hiroaki Koge[2], Yasuhiro Yamada[3], Ayumu Miyakawa[1], Juichiro Ashi[2] (1.National Institute of Advanced Industrial Science and Technology, 2.Atomosphere and Ocean Research Institute, The University of Tokyo, 3.Japan Agency for Marine-Earth Science and Technology)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SCG56-29] Formation process of a slope basin in the Nankai Accretionary prism reconstructed from high-resolution SBP integrated with core data of ODP Site 1175 and Site 1176

*Yuichi Okuma[1], Asuka Yamaguchi[1], Hiroaki Koge[1], Rina Fukuchi[1], Juichiro Ashi[1] (1.Atmosphere and Ocean Research Institute, the University of Tokyo)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SCG56-30] About the turbidity current considered that it occurred in the northern Suruga Bay, Central Japan by the typhoon No.24. -The traces of the accidents and the phenomenon at the sea floor detected the OBSs Array-

*Nakao Nagisa[1], Hisatoshi Baba[2], Hiroshi Sato[3], Kayoko Tsuruga[4], Izumi Sakamoto[2], Takahito Nishimiya[5], Masanao Shinohara[3], Shintaro Abe[6] (1.Tokai University, 2.Department of Marine and Earth Science, Tokai University, 3.Earthquake Research Institute, University of Tokyo, 4.Tokyo University of Marine Science and Technology, 5.Meteorological Research Institute, Japan Meteorological Agency, 6.Association for the Development of Earthquake Prediction)

[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-CG60] Investigation of inputs to subduction zones: Influence of tectonic processes on the incoming plate

convener:Makoto Yamano(Earthquake Research Institute, the University of Tokyo), Tomoaki Morishita(School of Geoscience and Civil Engineering, College of Science and Technology, Kanazawa University), Gou Fujie(Japan Agency for Marine-Earth Science and Technology), Chairperson:Shigeaki Ono(Japan Agency for Marine-Earth Science and Technology)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SCG60-01] Geophysical-petrological studies of the Chile triple junction and their significance: MIRAI research cruise MR-1806Leg2

*Masataka Kinoshita[1,5], Hikaru Iwamori[1,5], Tomoaki Nishikawa[2], Ryo Anma[3], Sofia Lagarrigue[4], Natsue Abe[5], Yuka Yokoyama[6], Andres Veloso Espinosa[4], Alessandra Isabella Rivero Cortes[7], Gabriela Pia Lazcano Prado[7], Ivan Andres Arriagada Bascuñan[7], Satoru Haraguchi[5], Kosuke Ota[9], Yuji Orihashi[8], Kaishi Nakao[8], Shogo Numata[8], Hajime Shiobara[1], Hiroko Sugioka[10], Aki Ito[5], Nicolás Pérez-Estay[11] (1.Earthquake Research Institute, University of Tokyo, 2.DPRI, Kyoto Univ., 3.Tokushima Univ., 4.Pontificia Universidad Catolica de Chile, 5.JAMSTEC, 6.Tokai Univ., 7.Andres Bello University, 8.Hirosaki Univ., 9.AORI, Univ. Tokyo, 10.Graduate School of Science, Kobe Univ., 11.Ministerio de relaciones exteriores, Chile)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SCG60-02] Heat flow measurement on the seaward side of the Kuril Trench off Hokkaido

*Kouta Sasaki[1], Makoto Yamano[1], Yoshifumi Kawada[2], Masataka Kinoshita[1], Kiichiro Kawamura[3] (1.Earthquake Research Institute, the University of Tokyo, 2.International Research Institute of Disaster Science, Tohoku University, 3.Yamaguchi University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SCG60-03] Comparison of experimental and intermediate-depth earthquake b-value: difference in hydration degree of the oceanic mantle between Tohoku and Hokkaido

★Invited Papers

*Saeko Kita[1], Thomas P. Ferrand[2] (1.International Institute of Seismology and Earthquake Engineering, BRI, 2.ERI, University of Tokyo)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SCG60-04] Variations in bend faulting and the nature of the incoming oceanic plate off northeast Japan arc

*Gou Fujie[1], Koichiro Obana[1], Yojiro Yamamoto[1], Tomoaki Yamada[2], Takehi Isse[2], Shuichi Kodaira[1], Seiichi Miura[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Earthquake Research Institute, Univ. of Tokyo)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SCG60-05] Seismicity in the trench-outer rise region off Fukushima and Ibaraki, southern Japan Trench

*Koichiro Obana[1], Gou Fujie[1], Yojiro Yamamoto[1], Yuka Kaiho[1], Yasuyuki Nakamura[1], Seiichi Miura[1], Tsutomu Takahashi[1], Shuichi Kodaira[1] (1.Research and Development Center for Earthquake and Tsunami, Japan Agency for Marine-Earth Science and Technology)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SCG60-06] Influence of water–rock interactions on the strength of outer-rise faults

★Invited Papers

*Ken-ichi Hirauchi[1] (1.Department of Geosciences, Faculty of Science, Shizuoka University)

[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-CG60] Investigation of inputs to subduction zones: Influence of tectonic processes on the incoming plate

convener:Makoto Yamano(Earthquake Research Institute, the University of Tokyo), Tomoaki Morishita(School of Geoscience and Civil Engineering, College of Science and Technology, Kanazawa University), Gou Fujie(Japan Agency for Marine-Earth Science and Technology), Chairperson:Makoto Yamano(Earthquake Research Institute, University of Tokyo)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SCG60-07] Seismic image of the incoming oceanic crust entering the central part of the Japan Trench: structural variation caused by petite-spot, bend fault and seamount

*Shuichi Kodaira[1,2], Akane Ohira[1,2], Gou Fujie[1], Tetsuo No[1], Yasuyuki Nakamura[1], Yuka Kaiho[1], Seiichi Miura[1] (1.R&D Center for Earthquake and Tsunami Japan Agency for Marine-Earth Science and Technology, 2.Graduate School of Environment and Information Sciences, Yokohama National University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SCG60-08] Dependence of calculation parameters on tsunami height from the outer-rise earthquakes

*Toshitaka Baba[1], Naotaka YAMAMOTO CHIKASADA[2], Yasuyuki Nakamura[3], Gou Fujie[3], Koichiro Obana[3], Seiichi Miura[3], Shuichi Kodaira[3] (1.Graduate School of Science and Technology, Tokushima University, 2.National Research Institute for Earth Science and Disaster Resilience, 3.Japan Agency for Marine-Earth Science and Technology)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SCG60-09] Bathymetry data analysis and multi-channel seismic reflection survey in the 1933 Sanriku earthquake (Mw 8.4) rupture region

*Tomoko Hanyu[1], Jin-Oh Park[1], Yukari Kido[2] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SCG60-10] Sedimentation process and deformation process before sinking of sediment on oceanic plate: examples in northwest Pacific Ocean and Sumatra

★Invited Papers

*Kiichiro Kawamura[1] (1.Yamaguchi University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SCG60-11] Exploring more asthenospheric melt: the preliminary report of KS-18-9 cruise, R/V Shinseimaru

*Naoto Hirano[1], Taku Yutani[2,1], Yuki Katsuragi[1], Jeffrey Anthony Oalmann[3], Fidel Costa Rodriguez[3], KS-18-9 Onboard Scientific Party (1.Tohoku University, 2.University of Bayreuth, 3.Nanyang Technological University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SCG60-12] Inputs of Argon on oceanic plate at subduction zones

*Shigeaki Ono[1] (1.Japan Agency for Marine-Earth Science and Technology)

[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Convention Hall A 2F

[S-CG61] Dynamics in mobile belts

convener:Yukitoshi Fukahata(Disaster Prevention Research Institute, Kyoto University), Toru Takeshita(Department of Natural History Sciences, Graduate School of Science, Hokkaido University), Hikaru Iwamori(Geochemical Evolution Research Program, Japan Agency for Marine-Earth Science and Technology), Chairperson:Toru Takeshita, Kenta Kobayashi

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SCG61-01] Fault zone development in the West Tottori area, Japan

*Kenta Kobayashi[1] (1.Department of Geology, Faculty of Science, Niigata University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SCG61-02] **Inerastic deformation around focal area of the 2000 Western Tottori EQ (M7.3) detected by "0.1 manten" Hyper Dense Seismic Observation (2)**

★Invited Papers

*Satoshi Matsumoto[1], Yoshihisa Iio[2], Shin'ichi Sakai[3], Aitaro Kato[3], Takuo Shibutani[2], Yuto Hayashida[4], Group for 0.1 manten Hyper dense seismic observation (1.Institute of Seismology and Volcanology, Faculty of Sciences, Kyushu University, 2.Disaster Prevention Reasearch Institute, Kyoto University, 3.Earthquake Research Institute, University of Tokyo, 4.Graduate School of Science, Kyushu University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SCG61-03] Non-double couple micro-earthquakes in the focal area of the 2000 Western Tottori earthquake (M7.3) by "0.1 manten" hyper dense seismic observation

*Yuto Hayashida[1], Satoshi Matsumoto[2], Yoshihisa Iio[3], Shin'ichi Sakai[4], Aitaro Kato[4], Group for "0.1 Manten" hyper dense seismic observation Group registration (1.Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2.Institute of Seismology and Volcanology, Faculty of Sciences, Kyushu University, 3.Disater Prevention Research Institute, Kyoto University, 4.Earthquake Research Institute, the University of Tokyo)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SCG61-04] Stress field in the Western Tottori and Western Shimane regions deduced by the dense seismic observations

*Yoshihisa Iio[1], Manten seicmic observation group, Manten seismic observation group in the Western Tottori region (1.Disater Prevention Research Institute, Kyoto University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SCG61-05] Modeling the spatiotemporal change in stress field around Hinagu fault zone through the 2016 Kumamoto earthquake sequence, in central Kyushu, Japan

*Ayaho Mitsuoka[1], Satoshi Matsumoto[2], Azusa Shito[2], Yusuke Yamashita[3], Manami Nakamoto[4], Masahiro Miyazaki[3], Shin'ichi Sakai[5], Yoshihisa Iio[3], Group for urgent joint seismic observation of the 2016 Kumamoto earthquake (1.Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2.Institute of Seismology and Volcanology, Faculty of Sciences, Kyushu University, 3.Disaster Prevention Research Institute, Kyoto University, 4.Association for the Development of Earthquake Prediction, 5.Earthquake Research Institute, The University of Tokyo)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SCG61-06] **Development of the Median Tectonic Line Fault zone in Mie Prefecture, Southwest Japan : A Possible Interpretation for Strain Localization and Softening**

*Toru Takeshita[1], Dong Van Bui[1], Thomas Anthony Czertowicz[1], Shun Arai[2], Takafumi Yamamoto[3], Jun-ichi Ando[3], Norio Shigematsu[4], Koichiro Fujimoto[5] (1.Department of Natural History Sciences, Graduate School of Science, Hokkaido University, 2.Department of Earth Science, Graduate School of Science, Tohoku University, 3.Department of Earth and Planetary Systems Science, Hiroshima University, 4.AIST, 5.Tokyo Gakugei University)

[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Convention Hall A 2F

[S-CG61] Dynamics in mobile belts

convener:Yukitoshi Fukahata(Disaster Prevention Research Institute, Kyoto University), Toru Takeshita(Department of Natural History Sciences, Graduate School of Science, Hokkaido University), Hikaru Iwamori(Geochemical Evolution Research Program, Japan Agency for Marine-Earth Science and Technology), Chairperson:Tomomi Okada, Ryosuke Ando(Graduate School of Science, University of Tokyo)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SCG61-07] **What caused the Main Himalayan Thrust (MHT) to ramp? Insights from analogue and numerical models**

*Subhajit Ghosh[1,2], Arijit Laik[2], Santanu Bose[2,3], Nibir Mandal[4] (1.Earthquake Research Institute, The University of Tokyo, 1-1-1 Yayoi, Bunkyo-Ku, Tokyo 113-0032, 2.Department of Geology, University of Calcutta, 35, Ballygunge Circular Road, Kolkata 700019, India, 3.Department of Geology, Presidency University, 86/1 College Street, Kolkata 700073, India, 4.Department of Geological Sciences, Jadavpur University, Kolkata 700032, India)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SCG61-08] Control of fault weakening on the structural styles of underthrusting-dominated non-cohesive tectonic wedges

*Arthur Bauville[1], Mikito Furuichi[1] (1.Department of Mathematical Science and Advanced Techology, JAMSTEC)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SCG61-09] **Complexity of the 2016 *M* 7.8 Kaikoura, New Zealand, earthquake from seismic observation: inferences of overpressured fluid involvement**

*Tomomi Okada[1], Satoshi Matsumoto[2], Yoshihisa Iio[3], Federica Lanza[4], Clifford H Thurber[4], Miu Matsuno[1], Yuta Kawamura[2], Tadashi Sato[1], Stephen C Bannister[5], John Ristau[5], Martha K Savage[6], John Townend[6], Jarg Petttinga[7], Francesca Ghisetti[8], Richard H Sibson[9] (1.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University, 2. Institute of Seismology and Volcanology, Faculty of Sciences, Kyushu University, 3. Disater Prevention Research Institute, Kyoto University, 4.University of Wisconsin-Madison, U.S.A., 5.GNS Science, New Zealand, 6.Victoria University of Wellington, New Zealand, 7.University of Canterbury, New Zealand, 8.TerraGeoLogica, New Zealand, 9.University of Otago, New Zealand)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SCG61-10] Dynamic Rupture Simulation Reproduces Spontaneous Multifault Rupture and Arrest During the 2016 Mw 7.9 Kaikoura Earthquake

*Ryosuke Ando[1], Yoshihiro Kaneko[2] (1.Graduate School of Science, University of Tokyo, 2.GNS science)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SCG61-11] Ductile deformation explains the physics of friction and genesis of earthquakes

*James Daniel Paul Moore[1], Stefan Nielsen[2], Lars N Hansen[3] (1.Earth Observatory of Singapore, 2.University of Durham, 3.University of Oxford)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SCG61-12] The seismic moment, stress drop, and strain energy release for the rupture of asperities

*Mitsuhiro Matsu'ura[1] (1.Institute of Statistical Mathematics)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 103 1F

[M-IS08] Geopark

convener:Takayuki Ogata(Disaster Prevention Research Center for Island Regions, University of the Ryukyus), Tatsuto Aoki(School of Regional Development Studies, Kanazawa University), Noritaka Matsubara(Graduate School of Regional Resource Management, University of Hyogo), Keiichi Tadokoro(Research Center for Seismology, Volcanology and Earthquake and Volcano Research Center, Nagoya University), Chairperson:Takeyuki Ueki(Faculty of Risk and Crisis Management, Chiba Institute of Science), Marekazu OHNO(Unzen Volcanic Area Geopark promotion office), Takayuki Arima(Department of Tourism Management, Faculty of Economics, Teikyo University)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MIS08-01] Normal faults observed in the Yonaguni-jima Island, Okinawa Prefecture, southwestern Japan

*Makoto Otsubo[1], Kiyokazu Oohashi[2], Takayuki Ogata[3], Tadahiro Shibata[4] (1.Geological Survey of Japan, 2.Yamaguchi University, 3.University of the Ryukyus, 4.Agency for Cultural Affairs)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MIS08-02] Example of Study of the Itoigawa-Shizuoka Tectonic Line using “NIED Quake map!”

*Ko Takenouchi[1], Yousuke Ibaraki[1], Takahiko Ogawara[1], Hiroshi Miyajima[1], Makoto Matsubara[2], Azusa Nishizawa[2], Shin Aoi[2], Yoshihiro Hiramatsu[3], Kazuyuki Nakagawa[4] (1.Fossa Magna Museum, 2.National Research Institute for earth Science and Disaster Resilience, 3.Kanazawa University, 4.Jiji Press)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MIS08-03] The Opening of ‘NIED Quake map!’ and result of questionnaire survey about interest of local seismicity

*Makoto MATSUBARA[1], Azusa Nishizawa[1], Shin Aoi[1], Ko Takenouchi[2], Yoshihiro Hiramatsu[3], Kazuyuki Nakagawa[4] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Fossa Magna Museum, Itoigawa City, 3.School of Geosciences and Civil Engineering, College of Science and Engineering, Kanazawa University, 4.Jiji Press)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MIS08-04] Bandaisan Geopark's traveling exhibitions and lectures on "Debris avalanche in the world"

*Hiroshi Sato[1], Tadahide UI[2] (1.Mt.Bandai Museum, 2.CeMI)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MIS08-05] PLANETARY SCIENCE Education in Geoparks-Science Festival for Youth Formation experiment of Izumo Plain in Shimane convention

*Kunihiro Abe[1] (1.Shimane Penunsula Shinjiko Narumi, Kuibiki Geopark Promotion Committee)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MIS08-06] ESD in Geopark: Systems thinking and Systems competence for renovating the school curriculum of local area study.

*Ryuta YAMAMOTO[1] (1.Center for professional development of teachers Shizuoka University)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[M-IS11] Aqua planetology

convener:Yasuhito Sekine(Earth-Life Science Insitute, Tokyo Institute of Technology), Tomohiro Usui(Earth-Life Science Institute, Tokyo Institute of Technology), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Takazo Shibuya(Japan Agency for Marine-Earth Science and Technology), Chairperson:Yasuhito Sekine(Dept. Earth & Planetary Sci., University of Tokyo), Tomohiro Usui, Takazo Shibuya(JAMSTEC)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MIS11-01] An interior structure model of Pluto resolving its mysteries

*Shunichi Kamata[1], Francis Nimmo[2], Yasuhito Sekine[3], Kiyoshi Kuramoto[1], Naoki Noguchi[4], Jun Kimura[5], Atsushi Tani[6] (1.Hokkaido University, 2.University of California, Santa Cruz, 3.Tokyo Institute of Technology, 4.Tokushima University, 5.Osaka University, 6.Kobe University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MIS11-02] Isotopic measurement of gas hydrate sample simulating environment of icy satellite and icy planet: Equipment development and consideration for observation method

*Kushi Kudo[1], Atsushi Tani[1], Naohiro Yoshida[2,3] (1.Graduate School of Human Development and Environment, Kobe University, 2.Department of Chemical Science and Engineering, School of Materials and Chemical Technology, Tokyo Institute of Technology, 3.Earth–Life Science Institute)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MIS11-03] Dynamics of icy crust of the Enceladus with tidal heating and asymmetric distribution of heat generation in the rocky core

*Kaho Harada[1,2], Takashi Nakagawa[3], Manabu Morishige[2], Shigenobu Hirose[2] (1.Keio University, 2.JAMSTEC, 3.University of Hong Kong)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MIS11-04] Chlorine-bearing aqueous fluid at crust/mantle boundary in mid-ocean ridge hydrothermal system: a case study of crustal diopsidite from Oman ophiolite

★Invited Papers

*Norikatsu Akizawa[1], Akira Miyake[2], Akira Tsuchiyama[2] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Graduate School of Science, Kyoto University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MIS11-05] Phase relation of the $MgSO_4$-H_2O system under high pressure

*Tadashi Kondo[1], Keita Harada[1], Miki Sirata[1], Takumi Kikegawa[2] (1.Department of Earth and Space Science, Graduate School of Science Osaka University, 2.Institute for Material Structure Science, KEK)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MIS11-06] The Origin of Earth's Volatile Composition: Effects of Impact-induced Atmospheric Erosion and Core Formation

*Sakuraba Haruka[1], Hiroyuki Kurokawa[2], Hidenori Genda[2], Kenji Ohta[1] (1.Tokyo Institute of Technology, 2.Earth-Life Science Institute)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[M-IS11] Aqua planetology

convener:Yasuhito Sekine(Earth-Life Science Insitute, Tokyo Institute of Technology), Tomohiro Usui(Earth-Life Science Institute, Tokyo Institute of Technology), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Takazo Shibuya(Japan Agency for Marine-Earth Science and Technology), Chairperson:Yasuhito Sekine(Dept. Earth & Planetary Sci., University of Tokyo), Keisuke Fukushi, Tomohiro Usui

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MIS11-07] Finding of oxidized sulfur species in carbonates from a Martian meteorite Allan Hills 84001 using μ-XANES

*Kajitani Iori[1], Gaku Tanabe[1], Ryoichi Nakada[2], Tomohiro Usui[3], Mizuho Koike[3], Fumihiro Matsuura[4], Tetsuya Yokoyama[1] (1.Tokyo Institute of Technology, 2.Japan Agency for Marine-Earth Science and Technology, 3.Institute of Space and Astronautical Science, 4.Earth-Life Science Institute)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MIS11-08] A study on Martian water environment based on the μ-XRF-XANES analysis for the secondary minerals formed in a nakhlite meteorite (Y 000593) vein

*Keika Suzuki[1], Hiroki Suga[1], Akira Yamaguchi[2], Tomohiro Usui[3], Oki Sekizawa[4], Kiyofumi Nitta[4], Yoshio Takahashi[1] (1.University of Tokyo, 2.National Institute of Polar Research, 3.JAXA, ISAS, 4.JASRI/SPring-8)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MIS11-09] Influence of water and clay minerals for slope angles on Mars

*Yuhki Matsuoka[1], Ikuo Katayama[1], Rina Noguchi[2], Tomohiro Usui[2] (1.Department of Earth and Planetary Systems Science, Hiroshima University, 2.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MIS11-10] **Dark Streak Features in Mongolia: Implications for Formation Mechanisms of Recurring Slope Lineae on Mars**

*Maya Nakamura[1,2], Yasuhito Sekine[1], Keisuke Fukushi[3], Noriko Hasebe[3], Davaadorj Davaasuren[4], Yoshio Takahashi[2], Hitoshi Hasegawa[5], Takuro Ogura[6], Koki Morida[3], Tuvshin Gerelmaa[4] (1.Earth-Life Science Institute, Tokyo Institute of Technology, 2.Department of Earth and Planetary Science, The University of Tokyo, 3.Institute of Nature & Environmental Technology, Kanazawa University, 4.Department of Geography, National University of Mongolia, 5.Department of Global Environment and Disaster Prevention, Kochi University, 6.Department of Socio-Cultural Environmental Science, The University of Tokyo)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MIS11-11] The occurrence of perchlorate salt in and around the Taklimakan Desert, China

*Haibo Qin[1,2], Shitong Yang[1], Qing Chang[3], Chihiro Miyamoto[1], Yoshio Takahashi[1] (1.Department of Earth and Planetary Science, Graduate School of Science, 2.State Key Laboratory of Environmental Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences, 3.Japan Agency for Marine-Earth Science and Technology)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MIS11-12] Measurement technique to quantify OH radicals photochemically generated on the ice surface

*Akihiro Yabushita[1], Hiroaki Nishimoto[1], Akira Harata[1] (1.Interdisciplinary Graduate School of Engineering Sciences, Kyushu University)

[J] Oral | M (Multidisciplinary and Interdisciplinary) : M-IS Intersection

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 201A 2F

[M-IS13] Biogeochemistry

convener:Keisuke Koba(Center for Ecological Research, Kyoto University), Hideaki Shibata(Field Science Center fot Northern Biosphere, Hokkaido University), Naohiko Ohkouchi(Japan Agency for Marine-Earth Science and Technology), Youhei Yamashita(Faculty of Environmental Earth Science, Hokkaido University), Chairperson:Keisuke Koba(Kyoto University), Yoshiyuki Inagaki, Kazumichi Fujii

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MIS13-01] **Root meets clays: Tree root plasticity in podzolized soil**

*Kazumichi Fujii[1], Naoki Makita[2], Martin Küttim[3], Shinya sugita[3] (1.Forestry and Forest Products Research Institute, 2.Shinshu University, 3.Tallinn University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MIS13-02] Nitrogen transformation process in newly created salt marsh in the aftermath of the 2011 Great East Japan Earthquake

*Keitaro Fukushima[1], Kazuma Hashimoto[2], Megumi Kuroiwa[3], Katsuhide Yokoyama[2], Yuichi Suwa[3] (1.Center for Ecological Research, Kyoto University, 2.Graduate School of Urban Environmental Sciences, Tokyo Metropolitan University, 3.Faculty of Science and Engineering, Chuo University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MIS13-03] Succession of soil nitrification potential at a glacier foreland in Svalbard

*Kentaro Hayashi[1], Yukiko Tanabe[2,3], Keisuke Ono[1], Maki Asano[4], Shohei Hattori[5], Masaki Uchida[2,3], Masahito Hayatsu[1] (1.Institute for Agro-Environmental Sciences, NARO, 2.National Institute of Polar Research, 3.SOKENDAI, 4.University of Tsukuba, 5.Tokyo Institute of Technology)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MIS13-04] **Transition of soil organic carbon in a volcanic ash soil derived from Towada volcano, Japan**

*JITHYA NAWODI WIJESINGHE[1], Jun Koarashi[2], Mariko Atarashi Andoh[2], Yoko Saito Kokubu[3], Noriko Yamaguchi[4], Takashi Sase[5], Mamoru Hosono[6], Yudzuru Inoue[7], Yuki Mori[1], Syuntaro Hiradate[1] (1.Soil Science Laboratory, Faculty of Agriculture, Kyushu University, Fukuoka 819-0395, Japan, 2.Nuclear Science and Engineering Center, Japan Atomic Energy Agency, Ibaraki 319-1195, Japan, 3.Tono Geoscience Center, Japan Atomic Energy Agency,Gifu 509-5102, Japan, 4.National Agriculture and Food Research Organization, Institute for Agro-environmental Sciences, 3-1-3 Kan-nondai, Tsukuba, Ibaraki 305-8604, Japan, 5.Boreal Laboratory for Phytolith Research, Iwate 028-7302,Japan, 6.Tokyo Natural History Research Structure,Tokyo 162-0052, Japan, 7.Faculty of Applied Information Technology, Nagasaki Institute of Applied Science,Nagasaki 851-0193, Japan)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MIS13-05] General pattern of carbon and nitrogen isotopic variation across a wide range of soils and its controlling factors

*Rota Wagai[1], Masako Kajiura[1], Yudzuru Inoue[2], Maki Asano[3], Chie Hayakawa[4] (1.NARO, Institute for Agro-Environmental Sciences, 2.Nagasaki Institute of Applied Science, 3.University of Tsukuba, 4.University of Tokyo)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[MIS13-06] Nutrient sources in some Japanese forest ecosystems: the contribution of precipitation, weathering and litter fall

*Yoshiyuki Inagaki[1], Kazumichi Fujii[1] (1.Forestry and Forest Products Research Institute)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 201A 2F

[M-IS13] Biogeochemistry

convener:Keisuke Koba(Center for Ecological Research, Kyoto University), Hideaki Shibata(Field Science Center fot Northern Biosphere, Hokkaido University), Naohiko Ohkouchi(Japan Agency for Marine-Earth Science and Technology), Youhei Yamashita(Faculty of Environmental Earth Science, Hokkaido University), Chairperson:Keisuke Koba(Kyoto University), Yohei Yamashita, Kazuya Nishina, Kazumichi Fujii

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MIS13-07] Ultrahigh-resolution mass spectral analysis of dissolved organic matter in rainfall, throughfall and soil water in temperate forest stands, western Japan

*Junichiro Ide[1], Keitaro Yamase[2], Seonghun Jeong[3], Noki Makita[4], Hiroshi Nishimura[5], Keitaro Fukushima[6], Kyoichi Otsuki[7], Mizue Ohashi[8] (1.Institute of Decision Science for a Sustainable Society, Kyushu University, 2.Forestry and Forest Products Research Institute, Hyogo Prefectural Technology Center for Agriculture, Forestry and Fisheries, 3.Graduate School of Bioresources and Bioenvironmental Sciences, Kyushu University, 4.Faculty of Science, Shinshu University, 5.Research Institute for Sustainable Humanosphere, Kyoto University, 6.The Center for Ecological Research, Kyoto University, 7.Faculty of Agriculture, Kyushu University, 8.School of Human Science and Environment, University of Hyogo)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MIS13-08] Basin-scale transport of allochthonous humic-like fluorescent dissolved organic matter by the North Pacific Intermediate water

*Youhei Yamashita[1], Jun Nishioka[2], Hajime Obata[3], Hiroshi Ogawa[3] (1.Faculty of Environmental and Earth Science, 2.Institute of Low Temperature Science, Hokkaido University, 3.Atmosphere and Ocean Research Institute, The University of Tokyo)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MIS13-09] Bacterial contribution to dissolved organic matter in a large monomictic lake (Lake Biwa) indicated by amino acids enantiomers

*Yasuhiko T. Yamaguchi[1], Chikage Yoshimizu[2], Ichiro Tayasu[2], Keisuke Koba[3], Kazuhide Hayakawa[1] (1.Lake Biwa Environmental Research Institute, 2.Research Institute for Humanity and Nature, 3.Center for Ecological Research, Kyoto University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MIS13-10] High-sensitivity tracer assay for oxygen consumption rate in ocean and lakes using ^{17}O as a tracer

*Urumu Tsunogai[1], Shogo Kashiwagi[1], Masanori Ito[1], Fumiko Nakagawa[1], Chiho Sukigara[1] (1.Graduate School of Environmental Studies, Nagoya University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MIS13-11] Ecology of bacterioplankton inhabiting oxygenated hypolimnia of deep freshwater lakes

*Yusuke Okazaki[1] (1.National Institute of Advanced Industrial Science and Technology)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MIS13-12] Nitrous oxide emission from the drainage and the production processes in oil palm plantation on peatland

*Kazuya Nishina[1], Lulie Melling[2], Ryuichi Hirata[1], Yoshiyuki Takahashi[1], Sakae Toyoda[3], Kotaro Terajima[3], Masayuki Itoh[4] (1.NIES National Institute of Environmental Studies, 2.SARAWAK Tropical Peat Research Institute, 3.Tokyo Institute of Technology, 4.University of Hyogo)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Convention Hall B 2F

[M-IS14] Global climate change driven by the Southern Ocean and the Antarctic Ice Sheet

convener:Osamu Seki(Institute of Low Temperature Science, Hokkaido University), Akira Oka(Atmosphere and Ocean Research Institute, The University of Tokyo), Ryu Uemura(University of the Ryukyus), Ryosuke Makabe(National Institute of Polar Research), Chairperson:Yuji Kato(Kochi University)

9:00 AM - 9:25 AM JST | 12:00 AM - 12:25 AM UTC

[MIS14-01] Mass loss of the Antarctic ice sheet under the influence of ice-ocean interaction

★Invited Papers

*Shin Sugiyama[1] (1.Institute of Low Temperature Science, Hokkaido University)

9:25 AM - 9:40 AM JST | 12:25 AM - 12:40 AM UTC

[MIS14-02] Accurate chronology and climatic reconstruction around MIS 11 (interglacial period ~400,000 years ago) from Dome Fuji ice core, Antarctica

*Kenji Kawamura[1,2,3], Ikumi Oyabu[1], Shuji Aoki[4], Takakiyo Nakazawa[4], Ayako Abe-Ouchi[5,3], Fuyuki SAITO[3] (1.National Institute of Polar Research, Research Organization of Information and Systems, 2.SOKENDAI (The Graduate University of Advanced Studies), 3.JAMSTEC, 4.Tohoku University, 5.University of Tokyo)

9:40 AM - 9:55 AM JST | 12:40 AM - 12:55 AM UTC

[MIS14-03] Study on physics and layers of ice cores containing information of climate change over the past 720 k-years, and study on the "oldest ice"

*Shuji Fujita[1,2], Motohiro Hirabayashi[1], Iizuka Yoshinori[3], Hiroshi Ohno[4] (1.National Institute of Polar Research, Research Organization of Information and Systems(ROIS), 2.Department of Polar Science, The Graduate University for Advanced Studies (SOKENDAI), Japan, 3. Institute of Low Temperature Science, Hokkaido University, Japan, 4.Kitami Institute of Technology, Japan)

9:55 AM - 10:15 AM JST | 12:55 AM - 1:15 AM UTC

[MIS14-04] Reconstructions of the Antarctic Polar Front through the glacial/interglacials

★Invited Papers

*Hiroki Matsui[1], Yuji Kato[1,2], Itsuki Suto[3], Minoru Ikehara[1] (1.Center for Advanced Marine Core Research, Kochi University, 2.JSPS PD, 3.Graduate School of Environmental Studies, Nagoya University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[MIS14-05] **Integrated observations for marine earth science in the Indian sector of the Southern Ocean: Preliminary results of R/V Hakuho-maru KH-19-1 cruise**

*Minoru Ikehara[1], Kay I. Ohshima[2], Takuya Itaki[3], Hiroshi Sato[4], Masakazu Fujii[5], Michiyo Yamamoto-Kawai[6], Hiroki Matsui[1], Takahito Ikenoue[7], . Scientific Party of R/V Hakuho-maru KH-19-1 cruise (1.Center for Advanced Marine Core Research, Kochi University, 2.ILTS, Hokkaido University, 3.GSJ, AIST, 4.Senshu University, 5.National Institute of Polar Research, 6.Tokyo University of Marine Science and Technology, 7.Marine Ecology Research Institute)

[J] Oral | M (Multidisciplinary and Interdisciplinary) : M-IS Intersection

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Convention Hall B 2F

[M-IS14] Global climate change driven by the Southern Ocean and the Antarctic Ice Sheet

convener:Osamu Seki(Institute of Low Temperature Science, Hokkaido University), Akira Oka(Atmosphere and Ocean Research Institute, The University of Tokyo), Ryu Uemura(University of the Ryukyus), Ryosuke Makabe(National Institute of Polar Research), Chairperson:Sam Sherriff-Tadano(University of Tokyo)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MIS14-06] **High resolution ocean temperatures reconstructions over the last glacial-interglacial in the Kerguelen region, Southern Ocean.**

*Matthieu Civel[1,2], Xavier Crosta[3], Giuseppe Cortese[4], Elisabeth Michel[5], Alain Mazaud[5], Samuel Jaccard[6], Lena Thöle[6], Minoru Ikehara[1], Takuya Itaki[2] (1.Center for Advanced Marine Core Research, Kochi University, Japan, 2.Geological Survey of Japan, AIST, Tsukuba, Japan, 3.UMR 5805 CNRS EPOC, Université de Bordeaux, France, 4.GNS Science, Lower Hutt, New Zealand, 5.LSCE-IPSL, CEA-CNRS-UVSQ, 91198 Gif-sur-Yvette, France, 6.Institute of Geological Sciences & Oeschger Centre for Climate Change Research, University of Bern, Switzerland)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MIS14-07] Present-day crustal motion and gravity change in East Antarctica: implications for the mantle viscosity and Holocene Antarctic Ice Sheet change inferred from GIA modeling

*Jun'ichi Okuno[1,2], Koichiro Doi[1,2], Yuichi Aoyama[1,2], Takeshige Ishiwa[1], Akihisa Hattori[2], Yoichi Fukuda[3] (1.National Institute of Polar Research, 2.SOKENDAI, 3.Kyoto University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MIS14-08] **Reconstruction of the East Antarctic ice sheet variability during the last 3 myrs in the central & eastern Droning Maud Land, East Antarctica**

*Yusuke Suganuma[1,2], Moto Kawamata[2], Kota Katsuki[3], Tatsuo Kanamaru[4], Heitaro Kaneda[5], Takushi Koyama[6], Tanabe Yukiko[1,2], Daisuke Shibata[7], Takeshige Ishiwa[1], Takuya Itaki[8], Jun'ichi Okuno[1,2], Osamu Seki[9], Itsuki Suto[10], Masakazu Fujii[1,2], Hideki Miura[1,2] (1.National institute of Polar Research, 2.SOKENDAI, 3.Shimane University, 4.Nihon University, 5.Chiba University, 6.Oita University, 7.Tsukuba University, 8.GSJ, AIST, 9.Hokkaido University, 10.Nagoya University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MIS14-09] Vertical ice flow motions obtained from year-round GNSS observations on Shirase Glacier, Antarctica

*Yuichi Aoyama[1,2], Koichiro Doi[1,2], Daisuke Hirano[3], Takeshi Tamura[1,2], Shigeru Aoki[3], Kazuo Shibuya[1] (1.National Institute of Polar Research, 2.SOKENDAI, 3.Institute of Low Temperature Science, Hokkaido University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MIS14-10] **Operation plan and design of the Antarctic exploration AUV "MONACA"**

*Hirokazu Yamagata[1], Toshihiro Maki[1], Hiroshi Yoshida[2], Yoshifumi Nogi[3] (1.Institute of Industrial Science, The University of Tokyo, 2.Japan Marine Science and Technology Center, 3.National Institute of Polar Research)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[MIS14-11] Geophysical insights into tectonic, volcanic, sedimentation, and glacial processes in Indian and Southern Oceans: Preliminary geophysical results of R/V *Hakuho-maru* KH-19-1 cruise

*Masakazu Fujii[1], Hiroshi Sato[2], Minoru Ikehara[3], Yoshifumi Nogi[1], Taichi Sato[4], Yasuyuki Nakamura[5], Eri Helen Amsler[6], Sam Sherriff-Tadano[7] (1.National Institute of Polar Research and SOKENDAI, 2.Senshu University, 3.Kochi University, 4.AIST, 5.JAMSTEC, 6.University of Bern, 7.AORI, UTokyo)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Convention Hall B 2F

[M-IS14] Global climate change driven by the Southern Ocean and the Antarctic Ice Sheet

convener:Osamu Seki(Institute of Low Temperature Science, Hokkaido University), Akira Oka(Atmosphere and Ocean Research Institute, The University of Tokyo), Ryu Uemura(University of the Ryukyus), Ryosuke Makabe(National Institute of Polar Research), Chairperson:Takeshige Ishiwa(National institute of Polar Research)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MIS14-12] Simulations of glacial ocean carbon cycle with a parameterization of stratification dependence of vertical diffusivity

*Hidetaka Kobayashi[1], Akira Oka[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MIS14-13] Impacts of precession on the periodicity of climate and AMOC variabilities

*Sam Sherriff-Tadano[1] (1.Atmosphere and Ocean Research Institute, the University of Tokyo)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MIS14-14] Warming and climate feedbacks in the southern high latitude driven by obliquity, precession-eccentricity, and atmospheric CO2

*Kanon Kino[1], Ayako Abe-Ouchi[1,2], Ryouta O'ishi[1], Fuyuki SAITO[2], Masakazu Yoshimori[1] (1.Atmosphere and Ocean Research Institute, the University of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MIS14-15] Origin of Circumpolar Deep Water intruding onto the Amundsen and Bellingshausen Sea continental shelves

*Yoshihiro Nakayama[1,2], Menemenlis Dimitris[2], Hong Zhang[2], Michael Schodlok[2], Eric Rignot[2,3] (1.Institute of Low Temperature Science, Hokkaido University, 2.NASA's Jet Propulsion Laboratory, 3.Uniersity of California, Irvine)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MIS14-16] Ocean and material circulation in the southern part of the Australian Antarctic Basin in 2018/2019 summer - preliminary results from Kaiyomaru KY18-04 cruise

*Katsuro Katsumata[1], Daisuke Hirano[2], Daiki Nomura[2], Kaihe Yamazaki[2], Yoichiro Koh[2], Masaaki Kiuchi[2], Shigeru Aoki[2], Hiroto Murase[3] (1.JAMSTEC, 2.Hokkaido Univ., 3.NRI-FSF)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MIS14-17] Mooring observation aiming direct current measurement and quantitative evaluation of Meridional Circulation of Southern Ocean

*Kitade Yujiro[1], Kohei Mizobata[1], Kazuho Watanabe[1], Linquiao Chen[3], Gaopin Guo[3], Shigeru Aoki[2], Shyuki Ushio[4], Keishi Shimada[1], Kay I. Ohshima[2] (1.Tokyo University of Marine Science and Technology, 2.Hokkaido University, 3.Shanghi Ocean University, 4.National Institute of Polar Research)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 302 3F

[M-IS15] Evolution of Pelagic Realm

convener:Atsushi Matsuoka(Department of Geology, Faculty of Science, Niigata University), Katsunori Kimoto(Japan Agency for Marine-Earth Science and Technology), Toshiyuki Kurihara(Graduate School of Science and Technology, Niigata University), Tetsuji Onoue(Earth and Environmental Sciences, Graduate School of Science and Technology, Kumamoto University), Chairperson:Atsushi Matsuoka, Toshiyuki Kurihara

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MIS15-01] **Environmental changes of the North Pacific Ocean through the Cenozoic era recorded in DSDP/ODP pelagic clay cores**

*Kazuhide Mimura[1], Katsushi Yamamoto[1], Kentaro Nakamura[1], Kazutaka Yasukawa[1,2], Junichiro Ohta[2], Koichiro Fujinaga[2,1], Shiki Machida[2], Yoichi Usui[3], Yasuhiro Kato[1,2] (1.Department of Systems Innovation, School of Engineering, the University of Tokyo, 2.ORCeNG, Chiba Institute of Technology, 3.JAMSTEC)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MIS15-02] Reconstruction of oceanic redox conditions in the Lower Jurassic (Pliensbachian–Toarcian) pelagic deep-sea bedded chert sequence of the Mino Belt, central Japan

*Katsuhito Soda[1] (1.Department of Earth and Environmental Sciences, Faculty of Science, Kumamoto University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MIS15-03] Conodont biostratigraphy of Anisian pelagic deep-sea sedimentary rocks deposited in the pelagic Panthalassa—Integration with radiolarian biozones—

*Shun Muto[1], Satoshi Takahashi[1], Satoshi Yamakita[2], Katsuhito Soda[3], Tetsuji Onoue[3] (1.Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo, 2.Faculty of Education, University of Miyazaki, 3.Faculty of Advanced Science and Technology)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MIS15-04] Triassic marine Os isotope record reconstructed from a pelagic chert succession, Sakahogi section, Mino Belt, southwest Japan

★Invited Papers

*Tatsuo Nozaki[1,2,3,4], Takashi Nikaido[5], Tetsuji Onoue[6], Yutaro Takaya[7,1,2,4], Keiko Sato[1], Jun-Ichi Kimura[8], Qing Chang[8], Daisuke Yamashita[6], Honami Sato[4,1], Katsuhiko Suzuki[1], Yasuhiro Kato[2,4], Atsushi Matsuoka[5] (1.JAMSTEC/R&D CSR, 2.Univ. of Tokyo, 3.Kobe Univ., 4.ChibaTech, 5.Niigata Univ., 6.Kumamoto Univ., 7.Waseda Univ., 8.JAMSTEC/D-SEG)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MIS15-05] **The preservation of radiolarians across the Jurassic-Cretaceous (J/K) boundary in the Bosso Valley section, Central Italy**

*XIN LI[1], Atsushi Matsuoka[2], Angela Bertinelli[3], Marco Chiari[4] (1.State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, 2.Niigata University, 3.Università degli Studi di Perugia, 4. Istituto di Geoscienze e Georisorse)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MIS15-06] Radiolarian faunas around the Jurassic-Cretaceous boundary in the Bosso Valley section, central Italy

*Atsushi Matsuoka[1], XIN LI[2], Marco Chiari[3], Angela Bertinelli[4] (1.Department of Geology, Faculty of Science, Niigata University, 2.Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciense, 3.C.N.R., Istituto di Geoscienze e Georisorse, sede secondaria di Firenze, 4. Dipartimento di Fisica e Geologia, Università degli Studi di Perugia)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 201B 2F

[M-IS17] History X Earth and Planetary Science

convener:Yasuyuki Kano(Earthquake Research Institute, The University of Tokyo), Kei Yoshimura(Institute of Industrial Science, The University of Tokyo), Hiroaki Isobe(Faculty of Fine Arts, Kyoto City University of Arts), kiyomi iwahashi(National Institute of Japanese Literature), Chairperson:Yasuyuki Kano(東京大学 地震研究所), Kiyomi Iwahashi, Hiroaki Isobe, Kei Yoshimura, Harufumi Tamazawa

9:05 AM - 9:30 AM JST | 12:05 AM - 12:30 AM UTC

[MIS17-01] Document based reconstruction of environment of forests in the Edo period

★Invited Papers

*SATOSHI SHIROUZU[1] (1.Chuogakuin University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[MIS17-02] Studies of Babylonian Astronomical Diaries: Today and the Future

*Yasuyuki Mitsuma[1] (1.The University of Tokyo)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[MIS17-03] Characteristics of the Sunspots that Produce Large Solar Flares and the Possibility to Investigate these Events Utilizing Historical Observational Records

*Shin Toriumi[1] (1.National Astronomical Observatory of Japan)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[MIS17-04] An Approach of Environmental History to the "14th Century Crisis"

*Isahaya Yoichi[1] (1.Slavic-Eurasian Research Center, Hokkaido University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[MIS17-05] Recovery of the Asian monsoon variations since the late 19th century by the data rescue activities in ACRE-Japan

*Jun Matsumoto[1,2], Tomoshige Inoue[1], Fumiaki Fujibe[1], Jun-Ichi Hamada[1], Taiichi Hayashi[3], Toru Terao[4], Fumie Murata[5], Hisayuki Kubota[6], Ikumi Akasaka[7], Hirotaka Kamahori[8], Nobuhiko Endo[9], Haruhiko Yamamoto[10], Shigeru Kobayashi[11], Yoshitaka Muraji[12] (1.Deaprtment of Geography, Tokyo Metropolitan University, 2.Department of Coupled Ocean-Atmosphere-Land Processes Research, 3.Kyoto University, 4.Kagawa University, 5.Kochi University, 6.Hokkaido University, 7.Senshu University, 8.Meteorological Research Institute, 9.NARO/NIAES, 10.Yamaguchi University, 11.Osaka University, 12.EScoT)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 201B 2F

[M-IS17] History X Earth and Planetary Science

convener:Yasuyuki Kano(Earthquake Research Institute, The University of Tokyo), Kei Yoshimura(Institute of Industrial Science, The University of Tokyo), Hiroaki Isobe(Faculty of Fine Arts, Kyoto City University of Arts), kiyomi iwahashi(National Institute of Japanese Literature), Chairperson:Hiroaki Isobe, Kei Yoshimura, Kiyomi Iwahashi, Yasuyuki Kano(東京大学 地震研究所), Harufumi Tamazawa

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MIS17-06] Historical big data: integrated analysis of the past world by the workflow that bridges data structuring gaps

*Asanobu Kitamoto[1,2,3], Mika Ichino[1,2] (1.National Institute of Informatics, 2.ROIS-DS Center for Open Data in the Humanities, 3.SOKENDAI)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MIS17-07] Felt earthquakes in Tokyo (Edo) based on historical daily records and seismic intensity data

*Kenji Satake[1] (1.Earthquake Research Institute, University of Tokyo)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MIS17-08] Climate and social changes in ancient Japan construed by use of high resolution reconstruction of the Climate in Historical Time

*Katsunori IMAZU[1], Takeshi Nakatsuka[2] (1.OKAYAMA University Graduate School of Humanities and Social Sciences, 2.Research Institute for Humanity and Nature)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MIS17-09] Absolute ages for huge eruptions of Towada Caldera and Baitoushan volcano in the 10th century as seen from dendrochronological studies and historical documents

*Masataka Hakozaki[1], Fusa Miyake[2], Masaki Sano[3], Katsuhiko Kimura[4], Toshio Nakamura[2], Mitsuru Okuno[5], Minoru Sakamoto[1], Takeshi Nakatsuka[6,2] (1.National Museum of Japanese History, 2.Nagoya University, 3.Waseda University, 4.Fukushima University, 5.Fukuoka University, 6.Research Institute for Humanity and Nature)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MIS17-10] How can we activate collaborations with history and archaeology? – Lesson from Historical Climate Adaptation project

★Invited Papers

*Takeshi Nakatsuka[1,2] (1.Research Institute for Humanity and Nature, 2.Graduate School of Environmental Studies, Nagoya University)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 301A 3F

[M-IS18] Geophysical fluid dynamics-Transfield approach to geoscience

convener:Keita Iga(Atmosphere and Ocean Research Institute, The University of Tokyo), Shigeo Yoshida(Department of Earth and Planetary Sciences, Faculty of Sciences, Kyushu University), Takatoshi Yanagisawa(Department of Deep Earth Structure and Dynamics Research, Japan Agency for Marine-Earth Science and Technology), Hidenori AIKI(Nagoya University), Chairperson:Kensuke Nakajima

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MIS18-01] Axisymmetric disturbance on an axisymmetric shallow water vortex

*Toshihisa Itano[1] (1.National Defense Academy)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MIS18-02] Numerical studies on the classification of flow regimes of the 3-D thermal convection of rotating fluids

*Masanori Kameyama[1,2] (1.Geodynamics Research Center, Ehime University, 2.Japan Agency for Marine-Earth Science and Technology)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MIS18-03] Diffusive behavior of columnar vortices in rotating thermal convection

*Daisuke Noto[1], Yuji Tasaka[2], Takatoshi Yanagisawa[3], Yuichi Murai[2] (1.Graduate School of Engineering, Hokkaido University, 2.Faculty of Engineering, Hokkaido University, 3.Japan Agency for Marine-Earth Science and Technology)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MIS18-04] Liquid metal flows driven by a rotating magnetic field

*Koki Sawada[1], Vladimir Galindo[2], Tobias Vogt[2], Sven Eckert[2], Yuji Tasaka[3], Yuichi Murai[3] (1.Graduate School of Engineering, Hokkaido University , 2.Helmholtz-Zentrum Dresden-Rossendorf, 3.Faculty of Engineering, Hokkaido University,)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MIS18-05] A symmetry-breaking self-regulating dynamo generating Mercury’s anomalous magnetic field

*Futoshi Takahashi[1], Hisayoshi Shimizu[2], Hideo Tsunakawa[3] (1.Faculty of Sciences, Kyushu University, 2.Earthquake Research Institute, University of Tokyo , 3.Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 103 1F

[M-IS20] Mountain Science

convener:Keisuke Suzuki(Department of Environmental Sciences, Faculty of Science, Shinshu University), Yoshihiko Kariya(Department of Environmental Geography, Senshu University), Akihiko SASAKI(Department of Geography and Environmental Studies, Kokushikan University), Chiyuki Narama(Niigata University, Department of Science), Chairperson:Yoshihiko Kariya(専修大学)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[MIS20-01] Early Holocene landslide deposits found from Mount Honita, the upper Tama River basin, west of Tokyo

*Yoshihiko Kariya[1], Koichiro Sawabe[2] (1.Department of Environmental Geography, Senshu University, 2.Japan Conservation Engineers)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[MIS20-02] The effect of understanding of mountainous terrain using 3D maps and solid model

*Jiro Komori[1] (1.Teikyo Heisei University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[MIS20-03] Development process of Lake Naganuma in a large-scale landslide on Hachimantai Volcano

*Natsuki Sasaki[1], Toshihiko Sugai[1] (1.Graduate School of Frontier Science, the University of Tokyo)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[MIS20-04] Air and ground temperature conditions on alpine and sub-apline zone of Norikura Volcano, Northern Japanese Alps

*Akihiko SASAKI[1], Motoshi NISHIMURA[2], Keisuke Suzuki[3] (1.Department of Geography and Environmental Studies, Kokushikan University, 2.Interdisciplinary Graduate school of Science and Technology, Shinshu University, 3.Faculty of Science, Shinshu University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[MIS20-05] Initiation and flow characteristics of debris flows on a sediment deposition zone in a mountain area

★Invited Papers

*Fumitoshi Imaizumi[1], Yuichi S. Hayakawa[2], Haruka Tsunetaka[3], Norifumi Hotta[4] (1.Faculty of Agriculture, Shizuoka University, 2.Faculty of Environmental Earth Sciences, 3.Forestry and Forest Products Research Institute, 4.Graduate School of Agricultural and Life Sciences)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[MIS20-06] Relationships between annual landform changes of the riverbed and vegetation dynamics during recent 10 years in the upper Asusa River in Kamikochi valley in the Japan Alps

★Invited Papers

*Hiroshi Shimazu[1] (1.Department of Geography, Faculty of Geo-Environmental Science, Rissho University)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 103 1F

[M-IS20] Mountain Science

convener:Keisuke Suzuki(Department of Environmental Sciences, Faculty of Science, Shinshu University), Yoshihiko Kariya(Department of Environmental Geography, Senshu University), Akihiko SASAKI(Department of Geography and Environmental Studies, Kokushikan University), Chiyuki Narama(Niigata University, Department of Science), Chairperson:Akihiko SASAKI

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MIS20-07] Age dating of groundwater using tritium and CFCs in headwater catchments, Fukushima after the Fukushima Dai-ichi Nuclear Power Plant accident

*Koichi Sakakibara[1], Sho Iwagami[2], Maki Tsujimura[3], Yutaka Abe[4], Manami Hada[5], Ishwar Pun[6], Yuichi Onda[3,7] (1.Faculty of Science, Shinshu University, 2.Department of Disaster Prevention, Meteorology and Hydrology, Forestry and Forest Products Research Institute, 3.Faculty of Life and Environmental Sciences, University of Tsukuba, 4.Natural Environment Conservation Center, Kanagawa, 5.Graduate School of Life and Environmental Sciences, University of Tsukuba, 6.Organization for the Strategic Coordination of Research and Intellectual Property, Meiji University, 7.Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MIS20-08] Hydraulic adaptation for tree height growth in tall tree species

★Invited Papers

*Wakana Azuma[1] (1.Kyoto University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MIS20-09] **The molecular phylogenetic structure and biogeographic history of a alpine gravel environment specific plant *Dicentra peregrina* (Papaveraceae) in Japan**

*Takahisa Ozaki[1], Hirokazu Matsuda, Koji Tojo[2] (1.Graduate School of Science and Technology, Shinshu University, 2.Biology Department, Faculty of Science, Shinshu University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MIS20-10] Formation process of small stands of *Abies mariesii* forest in pseudo-alpine zone on Mt. Akita-komagatake, northern Japan

*Asaka Konno[1] (1.International Research Institute of Disaster Science, Tohoku University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MIS20-11] Distribution of the pinas forests including a Cryptomeria japonica and its environmental factors in Echigo mountain range.

*Masatsugu YASUDA[1] (1.Asia Air Survey Co., Ltd.)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[MIS20-12] Roles of glacier microbes in alpine ecosystems of Asian high mountains: effect of cryoconite outflow on soil development in glacier forefields

★Invited Papers

*Nozomu Takeuchi[1], Masato Shiomuki[1] (1.Chiba University)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 103 1F

[M-IS20] Mountain Science

convener:Keisuke Suzuki(Department of Environmental Sciences, Faculty of Science, Shinshu University), Yoshihiko Kariya(Department of Environmental Geography, Senshu University), Akihiko SASAKI(Department of Geography and Environmental Studies, Kokushikan University), Chiyuki Narama(Niigata University, Department of Science), Chairperson:Chiyuki Narama(新潟大学)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MIS20-13] Comparison of surface energy balance of seasonal snowcover for three sites in Japanese alpine region

*Motoshi NISHIMURA[1], Akihiko SASAKI[2], Keisuke Suzuki[3] (1.Interdisciplinary Graduate school of Science and Technology, Shinshu University, 2.Department of Geography and environmental Studies, Kokushikan University, 3.Faculty of Science, Shinshu University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MIS20-14] The influence of snow for the local wind system on the east slope of Mt.Norikura

*Genki Uehara[1], Keisuke Suzuki[2] (1.Graduate School of Science and Technology, Shinshu University, 2.Department of Environmental Science, Faculty of Science, Shinshu University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MIS20-15] Mass balance of "Avalanche-accumulation type"glaciers and perennial snow patches in Hida mountain range.

*Kenshiro Arie[1], Chiyuki Narama[2], Kotaro FUKUI[3], Hajime IIDA[3] (1.Graduate School of Science and Technology, Niigata University, 2.Faculty of Science, Niigata University, 3.Tateyama Caldera Sabo Museum)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MIS20-16] Pattern of occurrence of sea of clouds and waterfall cloud near Mt.Nishihotakadake

★Invited Papers

*Toru Awazawa[1] (1.Faculty of Science, Shinshu University National University, Shinshu University Faculty of Science)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MIS20-17] Review and prospect of strong local wind “Matsubori-kaze” blowing at the western foot of Mt. Aso.

★Invited Papers

*Hiroshi Matsuyama[1] (1.Graduate School of Urban Environmental Sciences, Tokyo Metropolitan University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MIS20-18] **Two decades of mountain climate monitoring and research: lessons learned and future challenges.**

*Luis Duran[1,2,3], Irene Rodríguez-Muñoz[1] (1.interMET Sistemas y Redes S.L.U. Madrid. Spain, 2.Centro de Investigación, Seguimiento y Evaluación del Parque Nacional Sierra de Guadarrama. Madrid. Spain, 3.Departamento de Física de la Tierra y Astrofísica. Facultad de Ciencias Físicas. Universidad Complutense de Madrid. Spain)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 106 1F

[M-IS23] Planetary Volcanology

convener:Rina Noguchi(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Tomokatsu Morota(Graduate School of Environmental Studies, Nagoya University), Kyoko S. Kataoka(Research Institute for Natural Hazards and Disaster Recovery, Niigata University), Shizuka Otsuki(Research Institute of Earthquake and Volcano Geology, Geological Survey of Japan, Advanced Industrial Science and Technology), Chairperson:Rina Noguchi(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Nobuo Geshi(GSJ/AIST)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[MIS23-01] Growth and evolution of isolated volcanic island, Nishinoshima, Ogasawara

★Invited Papers

*Fukashi Maeno[1] (1.Earthquake Research Institute, University of Tokyo)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[MIS23-02] The style of magmatism on terrestrial planets of various sizes predicted from numerical models of mantle dynamics

*Masaki Ogawa[1] (1.Division of General Systems Studies, Graduate School of Arts and Sciences, University of Tokyo)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[MIS23-03] Lunar and Matian lava tubes and explorations to them through their skylight holes

*Junichi Haruyama[1], Takahiro Iwata[1], Yukio Yamamoto[1], Tetsuya Kaku[2,1], Wataru Miyake[2], Atsushi Kumamoto[3], Ken Ishiyama[1], yokota yasuhiro[4], Takumi Ono[2,1] (1.Japan Aerospace Exploration Agency, 2.Tokai University, 3.Tohoku University, 4.Kochi University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[MIS23-04] Volcanic activity on Io, formation of the atmosphere, and escape of atmosphere to the magnetosphere

*Fuminori Tsuchiya[1], Ryoichi Koga[1], Mizuki Yoneda[2], Masato Kagitani[1], Kazuo Yoshioka[4], Reina Hikida[4], Go Murakami[3], Tomoki Kimura[1], Atsushi Yamazaki[3], Hajime Kita[3], Ichiro Yoshikawa[4] (1.Tohoku University, 2.Tadano, 3.ISAS/JAXA, 4.The University of Tokyo)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[MIS23-05] Cryovolcanism, a critical review

*Kei Kurita[1] (1.Earthquake Research Inst.,The University of Tokyo)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[MIS23-06] Cryovolcanisms on Solar System bodies: Observations, importance, and future perspectives

★Invited Papers

*Yasuhito Sekine[1] (1.Earth-Life Science Insitute, Tokyo Institute of Technology)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 201B 2F

[M-IS28] Fluid-sediment migration and geo-bio interaction

convener:Robert Jenkins(School of Geosciences and Civil Engineering, College of Science and Engineering, Kanazawa University), Tomohiro Toki(Faculty of Science, University of the Ryukyus), Akira Ijiri(Japan Agency for Marine-Earth Science and Technology), Takami Nobuhara(Science Education (Geology), Faculty of Education, Shizuoka University), Hiromi Kayama WATANABE(Japan Agency for Marine-Earth Science and Technology), Miho Asada(Japan Agency for Marine-Earth Science and Technology), Chairperson:Tomohiro Toki, Robert Jenkins(Kanazawa University)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MIS28-01] Upper Pliocene large lucinid communities with cold-seep carbonates from the Shimajiri Group in the Miyagi-jima Island off the central part of Okinawa-jima Island, Japan

*Takami Nobuhara[1], Robert Jenkins[2], Shin-ichi Nomura[3] (1.Science Education (Geology), Faculty of Education, Shizuoka University, 2.School of Natural System, College of Science and Engineering, Kanazawa University, 3.Chiba Prefectural Kisarazu High School)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MIS28-02] Chemosynthetic fossil community in Early Cretaceous methane seep from Yubari City, Hokkaido

*Nanami Shimazu[1], Robert Jenkins[1] (1.Kanazawa University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MIS28-03] Marine Snow Hypothesis: What is controling faunal composition of the methane-seep since Mesozoic?

*Robert Jenkins[1] (1.School of Geosciences and Civil Engineering, College of Science and Engineering, Kanazawa University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MIS28-04] *In situ* Sr isotope analysis of methane-seep carbonates: insight into ancient subseafloor fluid circulation

★Invited Papers

*Yusuke Miyajima[1], Michał Jakubowicz[2,3], Takafumi Hirata[1] (1.Geochemical Research Center, Graduate School of Science, The University of Tokyo, 2.Institute of Geoecology and Geoinformation, Adam Mickiewicz University, Poland, 3.Isotope Laboratory, Adam Mickiewicz University, Poland)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MIS28-05] Monitoring CH_4 amounts deep inside deep-water mud volcanoes

★Invited Papers

*A. Kioka[1], T. Tsuji[2], H. Otsuka[3], J. Ashi[3] (1.Universität Innsbruck, Austria, 2.Kyushu University, Japan, 3.The University of Tokyo, Japan)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MIS28-06] Discussion

*Robert Jenkins[1] (1.School of Natural System, College of Science and Engineering, Kanazawa University)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[M-GI33] Data-driven geosciences

convener:Tatsu Kuwatani(Japan Agency for Marine-Earth Science and Technology), Hiromichi Nagao(Earthquake Research Institute, The University of Tokyo), Kenta Ueki(Japan Agency for Marine-Earth Science and Technology), Masayuki Kano(Graduate school of science, Tohoku University), Chairperson:Kenta Ueki, Masayuki Kano(東北大学大学院理学研究科 地球物理学専攻)

10:45 AM - 11:15 AM JST | 1:45 AM - 2:15 AM UTC

[MGI33-01] Forecasting volcanic eruption sequence based on field data and physical models

★Invited Papers

*Takehiro Koyaguchi[1], Kensuke Ishii[2], Kyle R. Anderson[3], Tomofumi Kozono[4] (1.Earthquake Research Institute, University of Tokyo, 2.Meteorological Research Institute, 3.US Geological Survey, 4.Graduate School of Science, Tohoku University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MGI33-02] Sparse modeling based feature selection of magmatic tectonic settings

*Kenta Ueki[1], Hideitsu Hino[2], Tatsu Kuwatani[1,3] (1.Japan Agency for Marine-Earth Science and Technology, 2.The Institute of Statistical Mathematics, 3.Japan Science and Technology Agency)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MGI33-03] Automatic Detection of Stationary Gravity Waves in the Venus' Atmosphere Using Deep Generative Models

*Minori Narita[1], Daiki Kimura[2], Atsushi Yamazaki[3], Takeshi Imamura[1] (1.The University of Tokyo, 2.IBM Research AI, 3.ISAS/JAXA)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MGI33-04] Fracture and mineral distribution analysis using hyper-resolution DEM and hyperspectral satellite imagery for detecting geothermal fluids paths

*Taiki Kubo[1], Hiroaki Gonnokami[1], Arie Naftali Hawu Hede[2], Mohamad Nur Heriawan[2], Irwan Iskandar[2], Katsuaki Koike[1], Sudarto Notosiswoyo[2] (1.Graduate School of Engineering, Kyoto University, 2.Bandung Institute of Technology)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[MGI33-05] **Geochemical characterization of deep-sea sediments in the western North Pacific Ocean by an integrated multivariate statistical technique**

*Kazutaka Yasukawa[1,2], Kentaro Nakamura[1], Koichiro Fujinaga[2,1], Hikaru Iwamori[3,4], Yasuhiro Kato[1,2] (1.School of Engineering, The University of Tokyo, 2.Ocean Resources Research Center for Next Generation, Chiba Institute of Technology, 3.Earthquake Research Institute, The University of Tokyo, 4.Department of Earth and Planetary Sciences, Tokyo Institute of Technology)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[M-GI33] Data-driven geosciences

convener:Tatsu Kuwatani(Japan Agency for Marine-Earth Science and Technology), Hiromichi Nagao(Earthquake Research Institute, The University of Tokyo), Kenta Ueki(Japan Agency for Marine-Earth Science and Technology), Masayuki Kano(Graduate school of science, Tohoku University), Chairperson:Tatsu Kuwatani(JAMSTEC), Suguru Yabe(JAMSTEC)

3:30 PM - 4:00 PM JST | 6:30 AM - 7:00 AM UTC

[MGI33-06] Markov Chain Monte Carlo: algorithms for multimodal distribution and their applications

★Invited Papers

*Yukito iba[1] (1.The Institute of Statistical Mathematics)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MGI33-07] **Specifying rate constants and reaction path on the water-rock chemical reaction based on exchange Monte Carlo method and sparse modeling**

*Ryosuke Oyanagi[1], Tatsu Kuwatani[1], Omori Toshiaki[2] (1.Japan Agency for Marine-Earth Science and Technology, 2.Kobe University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MGI33-08] Superresolution of X-ray CT images of core samples for understanding the multi-scale structures of water-rock interaction

*Toshiaki Omori[1], Atsushi Okamoto[2], Katsuyoshi Michibayashi[3], Oman Drilling Project Phase 2 Science Party (1.Kobe Univ., 2.Tohoku Univ., 3.Nagoya Univ.)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MGI33-09] 3-dimensional Fracture Network Analysis by Persistent Homology

*Miyuki Miyazawa[1], Anna Suzuki[2], Atsushi Okamoto[1], Hiroyuki Shimizu[3], Ippei Obayashi[4], Yasuaki Hiraoka[4,5], Takatoshi Ito[2] (1.Graduate School of Environmental Studies, Tohoku University, 2.Institute of Fluid Science, Tohoku University, 3.Kajima Corporation, 4.The Advanced Institute for Materials Research, Tohoku University, 5.Kyoto University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MGI33-10] Characteristic patterns and minimal dynamics of correlated seismicity in Japanese island region

*mitsuhiro toriumi[1] (1.Japan agency of marine science and technology)

Tue. May 28, 2019

[J] Oral | U (Union)：Union

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 101 1F

[U-03] Future of Scientific Publishing in Geosciences

convener:Hodaka Kawahata(Atmosphere Ocean Research Institute, the University of Tokyo), Hirokuni Oda(Institute of Geology and Geoinformation, Geological Survey of Japan, AIST), Chairperson:Hirokuni Oda, Hodaka Kawahata

9:00 AM - 9:30 AM JST | 12:00 AM - 12:30 AM UTC

[U03-01] Game-change of scholarly communication based on papers and the role of learned society and peer-review

★Invited Papers

*Kazuhiro Hayashi[1] (1.National Institute of Science and Technology Policy)

9:30 AM - 10:00 AM JST | 12:30 AM - 1:00 AM UTC

[U03-02] The future of the journal metrics and new trend of the scholarly publishing

★Invited Papers

*Yoshiko Tanahashi[1] (1.Clarivate Analytics)

10:00 AM - 10:30 AM JST | 1:00 AM - 1:30 AM UTC

[U03-03] Underlying Issues and Problems in Publishing International Scientific Journals in Japan. “DNA Research” As A Case Study.

★Invited Papers

*Michio Oishi[1] (1.Kazusa DNA Research Institute)

[J] Oral | U (Union)：Union

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 101 1F

[U-03] Future of Scientific Publishing in Geosciences

convener:Hodaka Kawahata(Atmosphere Ocean Research Institute, the University of Tokyo), Hirokuni Oda(Institute of Geology and Geoinformation, Geological Survey of Japan, AIST), Chairperson:Hirokuni Oda, Hodaka Kawahata

10:45 AM - 11:05 AM JST | 1:45 AM - 2:05 AM UTC

[U03-04] Review of editorial work for PEPS in 2018-2019 and new strategy for 2019–2020

★Invited Papers

*Yasufumi Iryu[1] (1.Institute of Geology and Paleontology Graduate School of Science Tohoku University)

11:05 AM - 11:25 AM JST | 2:05 AM - 2:25 AM UTC

[U03-05] "Earth, Planets and Space" An Open Access Journal: Past, Present and and Future

★Invited Papers

*Yasuo Ogawa[1], Kiyoshi Baba[2] (1.Volcanic Fluid Research Center, School of Science, Tokyo Institute of Technology, 2.Earthquake Research Institute, University of Tokyo)

11:25 AM - 11:55 AM JST | 2:25 AM - 2:55 AM UTC

[U03-06] Scientific Research Output and Publication: research article, data, and digital transformation

★Invited Papers

*Yasuhiro Murayama[1] (1.Strategic Program Produce Office, National Institute of Information and Communications Technology)

11:55 AM - 12:15 PM JST | 2:55 AM - 3:15 AM UTC

[U03-07] **Enhancing dissemination of research activities to international communities by Japanese Geoscience Union**

★Invited Papers

*Hodaka Kawahata[1] (1.Atmosphere Ocean Research Institute, the University of Tokyo)

[J] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-PS06] Planetary Sciences

convener:Kenji Kurosaki(Department of Physics, Nagoya University), Yusuke Nakauchi(Japan Aerospace Exploration Agency), Chairperson:Ryo Suetsugu(University of Occupational and Environmental Health, Japan), Keisuke Sugiura(Nagoya University)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[PPS06-25] Tensile Strength of Porous Dust Aggregates Measured with Dust N-body Simulations

*Misako Tatsuuma[1,2], Akimasa Kataoka[2], Hidekazu Tanaka[3] (1.The University of Tokyo, 2.National Astronomical Observatory of Japan, 3.Tohoku University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[PPS06-26] **Filling factor dependence of the thermal conductivity understood from the graph structure of dust aggregates**

*Sota ARAKAWA[1], Masaki TAKEMOTO[1], Taishi NAKAMOTO[1] (1.Tokyo Institute of Technology)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[PPS06-27] Collisional disruption of planetesimals: dependence of material strength

*Ryo Suetsugu[1], Hidekazu Tanaka[2], Hiroshi Kobayashi[3], Hidenori Genda[4] (1.University of Occupational and Environmental Health, 2.Tohoku University, 3.Nagoya University, 4.Tokyo Institute of Technology)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[PPS06-28] Size and cooling rate of chondrules formed thorough collision between planetesimals containing volatile materials

*Sin-iti Sirono[1] (1.Department of Earth and Planetary Sciences, Nagoya University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[PPS06-29] From Dust to Planet via collisional growth

*Hiroshi Kobayashi[1], Hidekazu Tanaka[2] (1.Department of Physics, Nagoya University, 2.Tohoku University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[PPS06-30] Impact Conditions for the Formation of the Extremely Elongated Shape of 1I/'Oumuamua

*Keisuke Sugiura[1], Hiroshi Kobayashi[1], Shu-ichiro Inutsuka[1] (1.NAGOYA UNIVERSITY Graduate School of Science)

[J] Oral | P (Space and Planetary Sciences)：P-CG Complex & General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[P-CG25] Planetary Magnetosphere, Ionosphere, and Atmosphere

convener:Kanako Seki(Graduate School of Science, University of Tokyo), Takeshi Imamura(Graduate School of Frontier Sciences, The University of Tokyo), Hiroyuki Maezawa(Department of Physical Science Osaka Prefecture University), Naoki Terada(Graduate School of Science, Tohoku University), Chairperson:Masaki Nishino(名古屋大学宇宙地球環境研究所), Hiroyuki Maezawa(大阪府立大学大学院理学系研究科)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[PCG25-01] On the observational constraint on time and spatial variation of Titan's atmospheric trace gases driven with the ALMA solar system big-data

*Takahiro IINO[1,2], Hideo Sagawa[3], Takashi Tsukagoshi[4] (1.The University of Tokyo, 2.Tokyo Univ. of Agr. and Tech., 3.Kyoto Sangyo University, 4.NAOJ)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[PCG25-02] Transport and energization of planetary ions in the magnetospheric flanks of Mercury

*Sae Aizawa[1], Dominique Delcourt[2], Naoki Terada[1] (1.Graduate School of Science,Tohoku University, 2.LPC2E, CNRS)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[PCG25-03] Exploring the real-time prediction of Mercury's magnetosphere

*Manabu Yagi[1], Kanako Seki[2], Yosuke Matsumoto[3], Dominique C. Delcourt[4], Francois Leblanc[4] (1.RIKEN Center for Computational Science, 2.Graduate School of Science, University of Tokyo, 3.Graduate School of Science, Chiba University, 4.The National Center for Scientific Research)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[PCG25-04] Model study on the contribution of various physical processes for generation and dissipation of Mercury's exosphere

*Yudai Suzuki[1], Kazuo Yoshioka[1] (1.University of Tokyo)

[J] Oral | P (Space and Planetary Sciences)：P-CG Complex & General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[P-CG25] Planetary Magnetosphere, Ionosphere, and Atmosphere

convener:Kanako Seki(Graduate School of Science, University of Tokyo), Takeshi Imamura(Graduate School of Frontier Sciences, The University of Tokyo), Hiroyuki Maezawa(Department of Physical Science Osaka Prefecture University), Naoki Terada(Graduate School of Science, Tohoku University), Chairperson:Hiromu Nakagawa(Planetary Atmosphere Physics Laboratory, Department of Geophysics, Graduate School of Science, Tohoku University), Kanako Seki(Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo,)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[PCG25-05] Updated status and science goals of the BepiColombo mission

*Go Murakami[1], Hajime Hayakawa[1], Masaki Fujimoto[1], BepiColombo Project Team (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[PCG25-06] A Novel High-Moment Multifluid Model for Mercury: From the Planetary Conducting Core to the Dynamic Magnetosphere

*Chuanfei Dong[1], Liang Wang[1], Ammar Hakim[1], Amitava Bhattacharjee[1], James A Slavin[2], Gina A DiBraccio[3], Kai Germaschewski[4] (1.Princeton University, 2.University of Michigan, Ann Arbor, 3.NASA Goddard Space Flight Center, 4.University of New Hampshire)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[PCG25-07] DSMC simulation of slow hydrodynamic escape from terrestrial planets

Kaori Terada[1], *Naoki Terada[1], Hitoshi Fujiwara[2] (1.Graduate School of Science, Tohoku University, 2.Faculty of Science and Technology, Seikei University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[PCG25-08] The influence of Martian crustal magnetic fields on atmospheric escape

*Dave A Brain[1,2], Robin Ramstad[1], Yaxue Dong[1], Tristan Weber[1], Shogo Inui[2], Kanako Seki[2], Andrew Poppe[3], Riku Jarvinen[4], Jim McFadden[3], Jasper Halekas[5], Jared Espley[6], David Mitchell[3], Laila Andersson[1], Bruce Jakosky[1] (1.University of Colorado, 2.University of Tokyo, 3.University of California Berkeley, 4.Finnish Meteorological Institute, 5.University of Iowa, 6.NASA Goddard Space Flight Center)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[PCG25-09] Effects of the IMF direction on atmospheric escape under a weak intrinsic magnetic field at Mars

*Shotaro Sakai[1], Kanako Seki[1], Naoki Terada[2], Hiroyuki Shinagawa[3], Ryoya Sakata[1], Takashi Tanaka[3,4], Yusuke Ebihara[5] (1.Graduate School of Science, The University of Tokyo, 2.Graduate School of Science, Tohoku University, 3.National Institute of Information and Communications Technology, 4.International Center for Space Weather Science and Education, Kyushu University, 5.Research Institute for Sustainable Humanosphere, Kyoto University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[PCG25-10] Simulating solar energetic electron precipitation and drift at Mars

*Rebecca Jolitz[1], Chuanfei Dong[2], Dave A Brain[1], Steve Bougher[3], Christina Lee[4], Rob Lillis[4], Shannon Curry[4], Bruce Jakosky[1] (1.Univ. of Colorado Boulder, 2.Princeton Univ., 3.Univ. of Michigan, 4.Univ. of California Berkeley)

[J] Oral | P (Space and Planetary Sciences)：P-CG Complex & General

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[P-CG25] Planetary Magnetosphere, Ionosphere, and Atmosphere

convener:Kanako Seki(Graduate School of Science, University of Tokyo), Takeshi Imamura(Graduate School of Frontier Sciences, The University of Tokyo), Hiroyuki Maezawa(Department of Physical Science Osaka Prefecture University), Naoki Terada(Graduate School of Science, Tohoku University), Chairperson:Takeshi Imamura(Graduate School of Frontier Sciences, University of Tokyo), Naoki Terada(School of Science, Tohoku University)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[PCG25-11] Effects of the intrinsic magnetic field on the ion loss from ancient Mars

*Ryoya Sakata[1], Kanako Seki[1], Shotaro Sakai[1], Naoki Terada[2], Hiroyuki Shinagawa[3], Takashi Tanaka[3,4] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2.Graduate School of Science, Tohoku University, 3.National Institute of Information and Communications Technology, 4.International Center for Space Weather Science and Education, Kyushu University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[PCG25-12] Global characterization of wave perturbations in the middle atmosphere on Mars

*Hiromu Nakagawa[1], Naoki Terada[1], Hannes Groller[7], Roger Yelle[7], Montmessin Franck[8], Schneider M Nicholas[4], England Scott[5], Kanako Seki[6], Takeshi Kuroda[3], Hitoshi Fujiwara[2], Takeshi Imamura[6], Kaori Terada[1], Nao Yoshida[1], Justin I Deighan[4], Sonal K Jain[4], Bruce M Jakosky[4] (1.Planetary Atmosphere Physics Laboratory, Department of Geophysics, Graduate School of Science, Tohoku University, 2.Seikei University, 3.National Institute of Information and Communications Technology, 4.Laboratory for Atmospheric and Space Physics, University of Colorado, 5.Aerospace and Ocean Engineering, Virginia Tech, 6.Department of Earth and Planetary Science, University of Tokyo, 7.Lunar and Planetary Laboratory Science, University of Arizona, 8.LATMOS, UVSQ/CNES/IPSL)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[PCG25-13] Seasonal variation of the dayside N_2/CO_2 at 140 km altitude derived from MAVEN/IUVS

*Nao Yoshida[1], Hiromu Nakagawa[1], Naoki Terada[1], Nicholas Schnider[2], Scott Evans[3], Sonal Jain[2], Hitoshi Fujiwara[4], Takeshi Imamura[5], Justin Deighan[2], Ian Stewart[2], Michael Stivens[6], Roger Yelle[7] (1.Dep. Geophysics Graduate School of Science Tohoku University, 2.Laboratory for Atmospheric and Space Physics, Boulder, USA, 3.Computational Physics, Inc., Springfield, Virginia, USA, 4.Faculty of Science and Technology, Seikei University, 5.Department of Complexity Science and Engineering, Graduate School of Frontier Sciences, The University of Tokyo, 6.Naval Research Laboratory, Washington, USA, 7.Department of Planetary Sciences, University of Arizona)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[PCG25-14] Automated segmentation of Martian dust storms in MGS/MOC images using a deep learning technique

*Kazunori Ogohara[1], Ryusei Gichu[2] (1.School of Engineering, University of Shiga Prefecture, 2.Graduate School of Engineering, University of Shiga Prefecture)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[PCG25-15] Investigation of variation mechanisms of the Jovian radiation belt using ALMA

*Hajime Kita[1], Hideo Sagawa[2], Takahiro Iino[3], Chihiro Tao[4], Takeshi Kuroda[4], Fuminori Tsuchiya[5], Hiroaki Misawa[5], Yasumasa Kasaba[5], Masaki Fujimoto[1] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency , 2.Faculty of Science, Kyoto Sangyo University, 3.Nature and Science Museum, Tokyo University of Agriculture and Technology, 4.National Institute of Information and Communications Technology, 5.Tohoku University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[PCG25-16] Jupiter's radio Riddle arcs observed by LWA and Juno

*Kazumasa Imai[1], Charles A. Higgins[2], Masafumi Imai[3], Tracy Clarke[4] (1.Department of Social Design Engineering, National Institute of Technology, Kochi College, 2.Middle Tennessee State University, 3.University of Iowa, 4.Naval Research Laboratory)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 106 1F

[A-OS17] Kuroshio Large Meander

convener:Toru Miyama(Japan Agency for Marine-Earth Science and Technology, Application Laboratory), Norihisa Usui(Meteorological Research Institute), Takashi Setou(National Research Institute of Fisheries Science, Fisheries Research and Education Agency), Chairperson:Toru Miyama, Takashi Setou, Norihisa Usui

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[AOS17-01] The progress of the Kuroshio large meander in and after 2017

★Invited Papers

*Toshiyuki Sakurai[1], Mikitoshi Hirabara[1], Yoshikazu Fukuda[1], Mika Kimura[1], Kotaro Mine[1], Masaomi Takahashi[1], Kensaku Kobayashi[1], Yuka Okunaka[1], Hiromu Kobayashi[1] (1.Japan Meteorological Agency)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[AOS17-02] Influences of the Kuroshio path variation south of Honshu on summer surface air temperature in Kanto district, Japan

*Shusaku Sugimoto[1] (1.Graduate School of Science, Tohoku University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[AOS17-03] Bio-chemilcal difference between the large meander and the non case of the Kuroshio current

*Takashi Setou[1], Tuneo Ono[2], Kiyotaka Hidaka[1], Yugo Shimizu[1], Atsushi Nishimoto[1], Sayaka Sogawa[1], Akira Kusaka[1], Daisuke Ambe[1], Daiki Itoh[1], Takashiko Kameda[1], Yutaka Hiroe[3] (1.National Research Institute of Fisheries Science, Fisheries Research and Education Agency , 2.National Research Institute of Far Seas Fisheires,Fisheries Research and Education Agency , 3.National Research Institute of Far Seas Fisheires,Seikai National Fisheries Research Institute)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[AOS17-04] The late arrival of 2017-18 Japanese eel recruitment and its links to ocean circulation

*Yu-Lin Eda Chang[1], Yasumasa Miyazawa[1], Michael Miller[2], Katsumi Tsukamoto[2] (1.Application Laboratory, Japan Agency for Marine-Earth Science and Technology, 2.Department of Aquatic Bioscience, The University of Tokyo)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[AOS17-05] A probabilistic forecast of the Kuroshio current path variability using an 80-member ensemble simulation.

*Kunihiro Aoki[1], Yasumasa Miyazawa[1], Tsutomu Hihara[1] (1.JAMSTEC)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[AOS17-06] Long-term forecast of the Kuroshio large meander in 2017

*Norihisa Usui[1], Nariaki Hirose[1], Kei Sakamoto[1], Yosuke Fujii[1], Nadao Kohno[1] (1.Meteorological Research Institute)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 106 1F

[A-OS18] Physical Oceanography (General)

convener:Yoshimi Kawai(Research and Development Center for Global Change, Japan Agency for Marine-Earth Science and Technology), Tomoki Tozuka(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Kitade Yujiro(Tokyo University of Marine Science and Technology), Chairperson:Yoshimi Kawai(Japan Agency for Marine-Earth Science and Technology), Tomoki Tozuka(The University of Tokyo)

1:50 PM - 2:05 PM JST | 4:50 AM - 5:05 AM UTC

[AOS18-01] **Real-Time Subsurface Moorings as a Promising Component of Global Ocean Monitoring System**

*Jianing Wang[1], Fan Wang[1] (1.Institute of Oceanology, Chinese Academy of Sciences)

2:05 PM - 2:20 PM JST | 5:05 AM - 5:20 AM UTC

[AOS18-02] Seasonal Variation of the Mixed Layer Depth at 60°S and its governing dynamics

*Matheus Ferreira Azevedo[1], Yujiro Kitade[1], Shigeru Aoki[2] (1.Tokyo University of Marine Science and Technology, 2.Institute of Low Temperature Science, Hokkaido University)

2:20 PM - 2:40 PM JST | 5:20 AM - 5:40 AM UTC

[AOS18-03] **21st-Century Flood Hazards along the U.S. Atlantic Coast: Impacts of Sea Level Rise and Tropical Cyclone Climatology Change**

★Invited Papers

*Reza Marsooli[1], Ning Lin[2], Kerry Emanuel[3] (1.Stevens Institute of Technology, 2.Princeton University, 3.Massachusetts Institute of Technology)

2:40 PM - 3:00 PM JST | 5:40 AM - 6:00 AM UTC

[AOS18-04] **The Effect of Ocean Waves on an Explosive Cyclone Development: Investigation with a Coupled Model**

★Invited Papers

*Yuki Kita[1], Takuji Waseda[1] (1.University of Tokyo)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 106 1F

[A-OS20] Global ocean observing systems, obtained results and system optimization: toward OceanObs19

convener:Shigeki Hosoda(Japan Marine-Earth Science and Technology), Shuhei Masuda(Japan Agency for Marine-Earth Science and Technology), Yosuke Fujii(Meteorological Research Institute, Japan Meteorological Agency), Fujiki Tetsuichi(Japan Agency for Marine-Earth Science and Technology), Chairperson:Shigeki Hosoda(Japan Agency for Marine-Earth Science and Technology)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[AOS20-01] Global Ocean Observing System: The Past, the Present and the Future

★Invited Papers

*Toshio Suga[1,2] (1.Graduate School of Science, Tohoku University, 2.JAMSTEC)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[AOS20-02] Observed long-term change and variability in the global upper-ocean stratification

*Ryohei Yamaguchi[1], Toshio Suga[1,2] (1.Graduate School of Science, Tohoku University, 2.Japan Agency for Marine-Earth Science and Technology)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[AOS20-03] Estimation of changes in salinity and dissolved oxygen based on observational networks

★Invited Papers

*Shinya Kouketsu[1] (1.JAMSTEC Japan Agency for Marine-Earth Science and Technology)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[AOS20-04] Remotely forced decadal physical and biogeochemical variability of North Pacific Subtropical Mode Water over the last 40 years

*Daisuke Sasano[1], Eitarou Oka[2], Yudai Yamada[2], Enyo Kazutaka[1], Toshiya Nakano[1], Masao Ishii[3] (1.Japan Meteorological Agency, 2.Atmosphere and Ocean Research Institute, The University of Tokyo, 3.Meteorological Research Institute)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[AOS20-05] Asessing the impact of the global ocean observing system using ocean data assimilation systems

*Yosuke Fujii[1] (1.Meteorological Research Institute, Japan Meteorological Agency)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[AOS20-06] **Global ocean state estimation with new float observations**

*Shuhei Masuda[1], Satoshi Osafune[1], Tadashi Hemmi[1] (1.Japan Agency for Marine-Earth Science and Technology)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CC Cryospheric Sciences & Cold District Environment

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 201B 2F

[A-CC26] Ice cores and paleoenvironmental modeling

convener:Ryu Uemura(University of the Ryukyus), Kenji Kawamura(National Institute of Polar Research, Research Organization of Information and Systems), Ayako Abe-Ouchi(Atmosphere and Ocean Research Institute, The University of Tokyo), Nozomu Takeuchi(Chiba University), Chairperson:Ryu Uemura(University of the Ryukyus), Ikumi Oyabu(National Institute of Polar Research)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[ACC26-01] Aerosols and climate change in the Arctic in the historical experiments using the MRI Earth System Model

★Invited Papers

*Naga Oshima[1], Taichu Y Tanaka[1], Tsuyoshi Koshiro[1], Makoto Deushi[1], Takuro Aizawa[1], Masahiro Hosaka[1], Hideaki Kawai[1], Seiji Yukimoto[1], Iizuka Yoshinori[2], Kumiko Goto-Azuma[3], Teruo Aoki[4] (1.Meteorological Research Institute, 2.Institute of Low Temperature Science, Hokkaido University, 3.National Institute of Polar Research, 4.Okayama University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[ACC26-02] Particles in ice layers of SIGMA-A ice core, northwestern Greenland

*Kaoru Kawakami[1,2], Yoshinori Iizuka[2], Sumito Matoba[2], Teruo Aoki[3], Shin Sugiyama[2], Takuto Ando[4] (1.Graduate School of Environmental Science, Hokkaido University, 2.Institute of Low Temperature Science, Hokkaido University, 3.Graduate School of Natural Science and Technology, Okayama University, 4.Arctic Research Center, Hokkaido University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[ACC26-03] Snow modification due to climate change in southeastern high-accumulation area of Greenland over the last 60 years evaluated by physical properties of firn core.

*Takuto Ando[1], Iizuka Yoshinori[2,3], Mai Shibata[2,3], Sumito Matoba[2,3], Shin Sugiyama[2,3], Satoru Adachi[4], Satoru Yamaguchi[4], Koji Fujita[5], Akira Hori[6], Teruo Aoki[7], Shuji Fujita[8] (1.Arctic Research Center, Hokkaido University, 2.Institute of Low Temperature Science, Hokkaido University, 3.Graduate School of Environmental Science, Hokkaido University, 4.National Research Institute for Earth Science and Disaster Resilience, 5.Graduate School of Environmental Studies, Nagoya University, 6.Department of Civil and Environmental Engineering, Kitami Institute of Technology, 7.Graduate School of Natural Science and Technology, Okayama University, 8. National Institute of Polar Research)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[ACC26-04] **Temporal variations of concentrations, size distributions, and seasonal variations of anthropogenic and natural black carbon in Greenland**

*Kumiko Goto-Azuma[1,2], Yoshimi Ogawa-Tsukagawa[1], Yutaka Kondo[1], Remi Dallmayr[1,10], Motohiro Hirabayashi[1], Jun Ogata[1], Kyotaro Kitamura[1], Kenji Kawamura[1,2], Hideaki Motoyama[1,2], Sumito Matoba[3], Teruo Aoki[4], Nobuhiro Moteki[5], Sho Ohata[5], Tatsuhiro Mori[6], Makoto Koike[5], Yuki Komuro[7], Akane Tsushima[8,9], Naoko Nagatsuka[1], Wataru Shigeyama[1,2], Koji Fujita[9] (1.National Institute of Polar Research, 2.SOKENDAI, 3.Hokkaido University, 4.Okayama University, 5.University of Tokyo, 6.University of Science, 7.Yamagata University, 8.Research Institute for Humanity and Nature, 9.Nagoya University, 10.AWI)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[ACC26-05] Mineral composition of dust layers in a shallow ice core drilled in Pamir Alay Mountains of Central Asia

*Shunsuke Takeuchi[1], Nozomu Takeuchi[1], Koji Fujita[2], Kenji Kawamura[3], Akane Tsushima[2], Vladimir Aizen[4] (1.Chiba University, 2.Nagoya University, 3.National Institute of Polar Research, 4.Idaho University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[ACC26-06] Estimation of snow surface patterns from the coast to the inland, Dome-Fuji Station, of Antarctica, using camera images

*Konosuke Sugiura[1], Kengo Watanabe[1], Naohiko Hirasawa[2], Kenji Kawamura[2], Fumio Nakazawa[2], Hiroshi Ohno[3], Shuji Fujita[2], Ikumi Oyabu[2], Takashi Yamanouchi[2], Hideaki Motoyama[2] (1.University of Toyama, 2.National Institute of Polar Research, 3.Kitami Institute of Technology)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CC Cryospheric Sciences & Cold District Environment

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 201B 2F

[A-CC26] Ice cores and paleoenvironmental modeling

convener:Ryu Uemura(University of the Ryukyus), Kenji Kawamura(National Institute of Polar Research, Research Organization of Information and Systems), Ayako Abe-Ouchi(Atmosphere and Ocean Research Institute, The University of Tokyo), Nozomu Takeuchi(Chiba University), Chairperson:Nozomu Takeuchi(千葉大学), Kenji Kawamura(国立極地研究所)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[ACC26-07] Isolation of living fungi from Antarctic ice cores

★Invited Papers

*Masaharu Tsuji[1] (1.National Institute of Polar Research)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[ACC26-08] **Study of ancient fungi resting in the polar ice cores and its future prospects**

*Fumio Nakazawa[1,2], Masaharu Tsuji[1], Satoshi Imura[1,2] (1.National Institute of Polar Research, 2.SOKENDAI (The Graduate University of Advanced Studies))

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[ACC26-09] **Flux, provenance and modification of terrestrial dust and sea salt in the Dome C and Dome Fuji ice cores from Last Glacial Maximum to early Holocene by ice-sublimation and single-particle measurement of soluble and insoluble particles**

*Ikumi Oyabu[1,2], Iizuka Yoshinori[3], Kenji Kawamura[1,4,5], Eric Wolff[6], Mirko Severi[7], Margareta Hansson[8] (1.National Institute of Polar Research, Research Organization of Information and Systems, 2.Japan Society for the Promotion of Science, 3.Institute of Low Temperature Science, Hokkaido University, 4.SOKENDAI (The Graduate University of Advanced Studies), 5.Japan Agency for Marine Science and Technology (JAMSTEC), 6.Department of Earth Sciences, University of Cambridge, 7.Department of Chemistry “Ugo Schiff”, University of Florence, 8.Department of Physical Geography, Stockholm University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[ACC26-10] Spatial variation of surface mass balance over the last few millennia in the Dome Fuji area from the analyses of shallow ice cores

*Kenji Kawamura[1], Ikumi Oyabu[1], Fumio Nakazawa[1,2], Shuji Fujita[1,2], Kyohei Yamada[1], Naoyuki Kurita[4], Shun Tsutaki[5], Hiroshi Ohno[6], Konosuke Sugiura[7], Kumiko Goto-Azuma[1,2], Hideaki Motoyama[1,2], Ayako Abe-Ouchi[5,3] (1.National Institute of Polar Research, Research Organization of Information and Systems, 2.SOKENDAI (The Graduate University of Advanced Studies), 3.JAMSTEC, 4.Nagoya University, 5.University of Tokyo, 6.Kitami Institute of Technology, 7.University of Toyama)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[ACC26-11] Sensitivity of global nonhydrostatic atmospheric model to changes in orbital forcing for the early Holocene

*Minoru Chikira[1], Ayako Abe-Ouchi[1], Masaki Satoh[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[ACC26-12] **Roles of sea ice–surface wind feedback in maintaining contrasting modes of glacial Atlantic meridional overturning circulation and climate**

*Sam Sherriff-Tadano[1], Ayako Abe-Ouchi[1] (1.Atmosphere and Ocean Research Institute, the University of Tokyo)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CC Cryospheric Sciences & Cold District Environment

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 201B 2F

[A-CC26] Ice cores and paleoenvironmental modeling

convener:Ryu Uemura(University of the Ryukyus), Kenji Kawamura(National Institute of Polar Research, Research Organization of Information and Systems), Ayako Abe-Ouchi(Atmosphere and Ocean Research Institute, The University of Tokyo), Nozomu Takeuchi(Chiba University), Chairperson:Ayako Abe-Ouchi(東京大学大気海洋研究所), Sam Sherriff-Tadano(University of Tokyo)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[ACC26-13] Simulated Dansgaard-Oeschger like oscillations and abrupt climate changes

*Ayako Abe-Ouchi[1,2,3], Wing-Le Chan[1], Sam Sherriff-Tadano[1], Takashi Obase[1], Masakazu Yoshimori[1], Akira Oka[1], Kenji Kawamura[3], Rumi Ohgaito[2] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.JAMSTEC, 3.National Institute of Polar Research)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[ACC26-14] **Reproduction of the increasing amplitude and period in the glacial cycles using a model incorporating diatomaceous activity.**

*Tasuku Akagi[1], Takahiro Hasegawa[2] (1.Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University, 2.Graduate School of Science, Kyushu University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[ACC26-15] Development of an Ice Sheet Model coupled General Circulation Model and application of Energy Balance Model on the estimation of Ice Sheet mass balance

*Ryouta O'ishi[1], Ayako Abe-Ouchi[2,1], Fuyuki SAITO[2], Takashi Obase[1] (1.Atmosphere and Ocean Research Institute, the Universitoy of Tokyo, 2.JAMSTEC)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[ACC26-16] An ice-flow modeling study for evaluation of sites for and oldest ice core around Dome Fuji, Antarctica

★Invited Papers

*Takashi Obase[1], Ayako Abe-Ouchi[1,2], Fuyuki SAITO[2], Shun Tsutaki[1], Shuji Fujita[3], Kenny Matsuoka[4], Kenji Kawamura[3,5,2], Ralf Greve[6] (1.Atmosphere and Ocean Research Institute, the University of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology, 3.National Institute of Polar Research, Research Organization of Information and Systems, 4.Norwegian Polar Institute, 5.SOKENDAI (The Graduate University of Advanced Studies), 6.Institute of Low Temperature Science, Hokkaido University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[ACC26-17] International studies of ice sheet and bedrock at Dome Fuji, East Antarctica

*Shuji Fujita[1,2], Kenji Kawamura[1,2,10], Prasad Gogineni[3], Ayako Abe-Ouchi[4], David Braaten[5], Jean-Charles Gallet[6], Elisabeth Isaksson[6], Brice van Liefferinge[6], Kenny Matsuoka[6], Charles O'Neill[3], John Paden[5], Fernando Rodriguez-Morales[5], Ryan A. Taylor[3], Shun Tsutaki[4], Jie-Bang Yan[3], Kumiko Goto-Azuma[1,2], Ralf Greve[7], Stephen Hudson[6], Jack Kohler[6], Shriniwas Kolpuke[3], Linfeng Li[3], Geir Moholdt[6], Hideaki Motoyama[1,2], Fumio Nakazawa[1], Takashi Obase[4], Hiroshi Ohno[8], Ikumi Oyabu[9,1], Fuyuki Saito[10], Konosuke Sugiura[11] (1.National Institute of Polar Research, Research Organization of Information and Systems(ROIS), 2.Department of Polar Science, The Graduate University for Advanced Studies (SOKENDAI), Japan, 3.The University of Alabama, USA, 4.Atmosphere and Ocean Research Institute, The University of Tokyo, Japan, 5.CReSIS, University of Kansas, USA, 6.Norwegian Polar Institute, Norway, 7.Institute of Low Temperature Science, Hokkaido University, Japan, 8.Kitami Institute of Technology, Japan, 9.JSPS, Japan, 10.Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Japan, 11.University of Toyama, Japan)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[ACC26-18] Possible cause for rapid deformation of ice from glacial periods, investigated from laboratory-based deformation experiments and microstructural observations

*Tomotaka Saruya[1], Morimasa Takata[1], Tomoyuki Homma[1], Nobuhiko Azuma[1], Kumiko Goto-Azuma[2,3] (1.Nagaoka University of Technology, 2.National Institute of Polar Research, 3.SOKENDAI (The Graduate University for Advaced Research))

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-GE Geological & Soil Environment

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 202 2F

[A-GE30] Conservation and Restoration of Soil Environment at Terrestrial Surface

convener:Yasushi Mori(Graduate School of Environmental and Life Science, Okayama University), Chairperson:Yasushi Mori(Okayama University)

1:50 PM - 2:05 PM JST | 4:50 AM - 5:05 AM UTC

[AGE30-01] Soil Organic Cabon Contents Estimation using Neural Network System

Ikumi Kaida[1], *Yasushi Mori[1], Takayuki Shuku[1] (1.Graduate School of Environmental and Life Science, Okayama University)

2:05 PM - 2:25 PM JST | 5:05 AM - 5:25 AM UTC

[AGE30-02] Methane emission from rice paddies and its response to climate change

★Invited Papers

*Takeshi Tokida[1] (1.Institute for Agro-Environmental Sciences, National Agriculture and Food Research Organization)

2:25 PM - 2:40 PM JST | 5:25 AM - 5:40 AM UTC

[AGE30-03] **Relationship between degradation of rice grain quality due to chalky kernels and available nutrients in soil**

*Shingo Matsumoto[1], Junko Kasuga[1] (1.Shimane University)

2:40 PM - 2:55 PM JST | 5:40 AM - 5:55 AM UTC

[AGE30-04] The effects of trenching and insertion of crop residue on infiltration and soil erosion in a farmland

*Kazutoshi Osawa[1], Yasushi Mori[2], Akira Hoshikawa (1.Utsunomiya University, 2.Graduate school of Environmental and Life Science, Okayama University)

2:55 PM - 3:15 PM JST | 5:55 AM - 6:15 AM UTC

[AGE30-05] Measuring wide-range soil water content using GPS signals

★Invited Papers

*Kosuke Noborio[1], Natsumi Naganuma[1] (1.Meiji University)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-GE Geological & Soil Environment

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 202 2F

[A-GE31] New Roles of Soil Science for Extraterrestrials

convener:Kosuke Noborio(Meiji University), Masaru Mizoguchi(Graduate school of Agricultural and Life Sciences, The University of Tokyo), Chairperson:Naoto Sato

3:30 PM - 4:00 PM JST | 6:30 AM - 7:00 AM UTC

[AGE31-01] Life search on Mars by Life Detection Microscope (LDM)

★Invited Papers

*Yoshitaka Yoshimura[1] (1.College of Agriculture, Tamagawa University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[AGE31-02] **Moisture movement in sand during evaporation under reduced pressure**

*Masaru Mizoguchi[1] (1.Graduate school of Agricultural and Life Sciences, The University of Tokyo)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[AGE31-03] Gravity effects on liquid behavior in porous media of uniform glass beads.

*Naoto Sato[1], Natsumi Naganuma[2], Kento Nogawa[2], Yuichi Maruo[2], Kosuke Noborio[1] (1.School of Agriculture, Meiji University, 2.Graduate School of Agriculture, Meiji University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[AGE31-04] Effects of changes in viscosity under low gravity on infiltration rate

*Kento Nogawa[1], Naoto Sato[2], Yuichi Maruo[1], Natsumi Naganuma[1], Kosuke Noborio[2] (1.Graduate School of Agriculture, Meiji University, 2.School of Agriculture, Meiji University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[AGE31-05] Differences in infiltration process on the planets under different gravity.

*Yasushi Mori[1] (1.Graduate School of Environmental and Life Science, Okayama University)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 104 1F

[A-CG38] Multi-scale ocean-atmosphere interaction in the tropical Indo-Pacific region

convener:Ayako Seiki(Japan Agency for Marine-Earth Science and Technology), Tomoki Tozuka(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Motoki Nagura(Japan Agency for Marine-Earth Science and Technology), Youichi Kamae(Faculty of Life and Environmental Sciences, University of Tsukuba), Chairperson:Ayako Seiki(Japan Agency for Marine-Earth Science and Technology), Motoki Nagura(Japan Agency for Marine-Earth Science and Technology)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[ACG38-01] Various aspects of climate system variability associated with ENSO

★Invited Papers

*Shuhei Maeda[1] (1.Climate Prediction Division, Japan Meteorological Agency)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[ACG38-02] Influence and mechanism of the tropical Pacific variability on the Arctic and its seasonality

*Tsubasa Takigawa[1], Yu Kosaka[1], Bunmei Taguchi[1], Lea Svendsen[2] (1.Research Center for Advanced Science and Technology, University of Tokyo, 2.Bjerknes Centre for Climate Research, University of Bergen)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[ACG38-03] Subsurface nonlinear dynamical heating and ENSO asymmetry in CMIP5: Implications for anthropogenic tropical-warming uncertainties

★Invited Papers

*Michiya Hayashi[1], Fei-Fei Jin[1] (1.Department of Atmospheric Sciences, University of Hawaii at Manoa)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[ACG38-04] **Uncertainty in the projections of ENSO amplitude change under global warming: Role of the response of atmospheric circulation to SST anomalies**

*Jun Ying[1] (1.Second institute of Oceanography, Ministry of Natural Resources)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[ACG38-05] Impact of atmospheric variability on Indian Ocean Dipole mode

*Yuya Baba[1] (1.JAMSTEC Japan Agency for Marine-Earth Science and Technology)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[ACG38-06] Do salinity anomalies matter for the evolution of the IOD? –Experimental assessments using a regional ocean model-

*Shoichiro Kido[1], Tomoki Tozuka[1], Weiqing Han[2] (1.Graduate School of Science, The University of Tokyo, 2.Department of Atmospheric and Oceanic Sciences, University of Colorado Boulder)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 104 1F

[A-CG38] Multi-scale ocean-atmosphere interaction in the tropical Indo-Pacific region

convener:Ayako Seiki(Japan Agency for Marine-Earth Science and Technology), Tomoki Tozuka(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Motoki Nagura(Japan Agency for Marine-Earth Science and Technology), Youichi Kamae(Faculty of Life and Environmental Sciences, University of Tsukuba), Chairperson:Tomoki Tozuka(The University of Tokyo), Youichi Kamae(University of Tsukuba)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[ACG38-07] Mechanisms of future changes in equatorial upwelling: CMIP5 inter-model analysis

★Invited Papers

*Shoshiro Minobe[1,2], Mio Terada[2], Curtis Deutsch[3] (1.Earth and Planetary Sciences, Faculty of Science, Hokkaido University, 2.Graduate School of Science, Hokkaido University, 3.School of Oceanography, University of Washington)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[ACG38-08] The Indo-Pacific cross-basin interaction of the decadal climate variability under the progress of the global warming

*Yuma Miyaji[1], Youichi Tanimoto[2] (1.Hokkaido University, Graduate School of Environmental Science, 2.Hokkaido University, Faculty of Environmental Earth Science)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[ACG38-09] Air-sea flux observation by unmanned autonomous sea surface vehicle in the Tropics - Application of the Wave Glider -

★Invited Papers

*Iwao Ueki[1] (1.JAMSTEC Japan Agency for Marine-Earth Science and Technology)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[ACG38-10] **Radar-derived Fresh water flux and its possible impact to the oceanic stratification observed during the Years of the Maritime Continent (YMC)**

*Masaki Katsumata[1], Biao Geng[1], Satoru Yokoi[1], Shuichi Mori[1], Iwao Ueki[1] (1.Japan Agency for Marine-Earth Science and Technology)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[ACG38-11] **Driving Mechanism of Inter-Annual Precipitation Variability during Monsoon Season over the Northern Part of Sumatra Island, Indonesia**

*Yahya Darmawan[1,2,3], Huang-Hsiung Hsu[2] (1.Taiwan International Graduation Program, Academia Sinica, 2.Research Center for Environmental Changes, Academia Sinica, 3.Indonesian Agency for Meteorology, Climatology and Geophysics (BMKG))

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[ACG38-12] The impact of diurnal precipitation over the maritime continent on synoptic disturbances and its relation to the MJO

*Ayako Seiki[1], Satoru Yokoi[1], Masaki Katsumata[1], Kunio Yoneyama[1] (1.Japan Agency for Marine-Earth Science and Technology)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 301A 3F

[A-CG39] Biogeochemical cycles in Land Ecosystem

convener:Tomomichi Kato(Research Faculty of Agriculture, Hokkaido University), Kazuhito Ichii(Chiba University), Takeshi Ise(FSERC, Kyoto University), Munemasa Teramoto(National Institute for Environmental Studies), Chairperson:Tomomichi Kato(Hokkaido University)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[ACG39-01] Laboratory examination of combined effects of temperature rising and increased water fluctuation on CO_2 release from volcanic ash soils

*Hirohiko Nagano[1], Mariko Atarashi-Andoh[1], Jun Koarashi[1] (1.Japan Atomic Energy Agency)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[ACG39-02] Field observation of GHGs emission from pome palm oil mill effluent (POME) treatment ponds in an oil palm plantation in tropical peatland.

*Yoshiyuki Takahashi[1], Takashi Onodera[2], Ryuichi Hirata[1], Kazuya Nishina[2], Joseph Wenceslaus Waili[3], Kevin Kemudang Musin[3], Edward Baran Aeries[3], Frankie Kiew[3], Guan Xhuan Wong[3], Zufaqar Sa'adi[3], Lulie Melling[3] (1.Center for Global Environmental Research, National Institute for Environmental Studies, 2.Center for Regional Environmental Research, National Institute for Environmental Studies, 3.Sarawak Tropical Peat Research Institute)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[ACG39-03] Soil CO_2 efflux dynamics with land-use changes in Southeast Asia

*HAJIME TOMIMATSU[1], NAISHEN LIANG[1], MUNEMASA TERAMOTO[1], JIYE ZENG[1], ZHAO XIN[1] (1.National Institute for Environmental Studies)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[ACG39-04] Individual-based analyses of the carry-over effects from recent climatic conditions on the interannual variability of LAI of an evergreen conifer stand

*Akihiro Sumida[1], Tsutomu Watanabe[1], Tomiyasu Miyaura[2] (1.Institute of Low Temperature Science, Hokkaido University, 2.Faculty of Science and Technology, Ryukoku University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[ACG39-05] Carbon dioxide balance of an oil palm plantation on tropical peat

*Takashi Hirano[1], Frankie Kiew[2], Ryuichi Hirata[3], Guan Xhuan Wong[2], Edward Baran Aries[2], Kevin Kemudang[2], Joseph Wenceslaus[2], Lo Kim San[2], Lulie Melling[2] (1.Research Faculty of Agriculture, Hokkaido University, 2.Sarawak Tropical Peat Research Institute, 3.CGER, National Institute for Environmental Studies)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[ACG39-06] The effect of heat wave in the summer of 2018 on carbon and water fluxes in an open black spruce forest in an interior Alaska

*Hideki Kobayashi[1], Robert Busey[2], Yongwon Kim[2], Sigrid Dengel[3], Stephen Chan[3] (1.Japan Agency for Marine-Earch Science and Technology, 2.International Arctic Research Center, University of Alaska, Fairbanks, 3.Lawrence Berkeley National Laboratory)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 301A 3F

[A-CG39] Biogeochemical cycles in Land Ecosystem

convener:Tomomichi Kato(Research Faculty of Agriculture, Hokkaido University), Kazuhito Ichii(Chiba University), Takeshi Ise(FSERC, Kyoto University), Munemasa Teramoto(National Institute for Environmental Studies), Chairperson:Tomomichi Kato(Hokkaido University)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[ACG39-07] Evaluation of feasibility of continental vegetation monitoring using Himawari-8.

*Kodai Hayashi[1], Kazuhito Ichii[1], Hiroki Yoshioka[2], Kazutaka Murakami[3], Reiko Ide[3], Kenlo Nasahara[4], Tomoko Akitsu[4], Tomoaki Miura[5] (1.Chiba Univ., 2.Aichi Prefectural Univ., 3.NIES, 4.Tsukuba Univ., 5.Univ. Hawaii)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[ACG39-08] Estimation of global carbon dioxide emissions by fires

*Tomohiro Shiraishi[1], Ryuichi Hirata[1] (1.National Institute for Environmental Studies)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[ACG39-09] Interactions between topography, permafrost, and vegetation in Siberian larch forest: a simulation study

*Hisashi Sato[1] (1.Institute of Arctic Climate and Environment Research, Japan Agency for Marine-Earth Science and Technology (JAMSTEC))

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[ACG39-10] Data assimilation experiments with MODIS LAI observation and the dynamic global vegetation model SEIB-DGVM in Japan

*Hazuki Arakida[1], Shunji Kotsuki[1], Shigenori Otsuka[1], Takemasa Miyoshi[1] (1.RIKEN Center for Computational Science)

11:45 AM - 12:15 PM JST | 2:45 AM - 3:15 AM UTC

[ACG39-11] Studying ecosystem dynamics with deep neural networks

★Invited Papers

*Takeshi Ise[1], Masanori Onishi[2] (1.FSERC, Kyoto University, 2.Grad. School of Agriculture, Kyoto University)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 102 1F

[A-CG40] Coastal Ecosystems - 1. Water Cycle and Land-Ocean Interactions

convener:Masahiko Fujii(Faculty of Environmental Earth Science), Makoto Yamada(Faculty of Economics, Ryukoku University), Jun Shoji(The University of Tokyo), Ryo Sugimoto(Faculty of Marine Biosciences, Fukui Prefectural University), Chairperson:Masahiko Fujii, Makoto Yamada

9:05 AM - 9:20 AM JST | 12:05 AM - 12:20 AM UTC

[ACG40-01] Submarine groundwater discharge from Mt. Fuji in Suruga Bay(VI)

*Yasuhide Muranaka[1], Takafumi Kamitani[1], Noriaki Fushimi[1], Tomoya Oka[1], Masahiko Ono[2], Atsunao Marui[2] (1.Shizuoka Institute of Environment and Hygiene, 2.National Institute of Advanced Industrial Science and Technology)

9:20 AM - 9:35 AM JST | 12:20 AM - 12:35 AM UTC

[ACG40-02] Relationship between the distribution of freshwater groundwater under the seabed at Obama Bay and the surrounding terrain of the land

*Makoto Yamada[1], Ryo Sugimoto[2], Toshimi Nakajima[3] (1.Faculty of Economics, Ryukoku University, 2.Fuculty of Marine Biosciences, Fukui Prefectural University, 3.Fukui Prefectural University)

9:35 AM - 9:50 AM JST | 12:35 AM - 12:50 AM UTC

[ACG40-03] Influence of recirculated submarine groundwater discharge on phytoplankton dynamics in Moune Bay, Kesennuma

*Toshimi Nakajima[1], Takahiro Kusunoki[1], Yoshitake Takao[1], Ryo Sugimoto[1] (1.Fukui Prefectural University)

9:50 AM - 10:05 AM JST | 12:50 AM - 1:05 AM UTC

[ACG40-04] Estimation of contribution rate of Submarine Groundwater Discharge to *Ulva pertusa* using nitrogen stable isotope ratio analysis

*Tatsuhiro Ishida[1], Masaru Takeuchi[1], Toshimi Nakajima[1], Ryo Sugimoto[1], Shiho Kobayashi[2], Keisuke Koba[3], Keitaro Fukushima[3], Osamu Tominaga[1] (1.Fukui Prefectural University, 2.Kyoto University, 3.Center for Ecological Research,Kyoto Univrsity)

10:05 AM - 10:20 AM JST | 1:05 AM - 1:20 AM UTC

[ACG40-05] Evaluation of the environmental condition of Submarine Groundwater Discharge (SGD) using carbon and oxygen stable isotope ratio of the sessile bivalve *Crassostrea nippona* shell

*Osamu Tominaga[1], Takeuchi Masaru[1], Ryo Sugimoto[1], Ishida Tatsuhiro[1], Takeru Hirai[1], Toshimi Nakajima[1], Jun Shoji[2], Hisami Honda[4], Makoto Taniguchi[3] (1.Fukui Prefectural University, 2.Tokyo Univ. AORI, 3.RIHN, 4.Fukui Pref Gov)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 102 1F

[A-CG40] Coastal Ecosystems - 1. Water Cycle and Land-Ocean Interactions

convener:Masahiko Fujii(Faculty of Environmental Earth Science), Makoto Yamada(Faculty of Economics, Ryukoku University), Jun Shoji(The University of Tokyo), Ryo Sugimoto(Faculty of Marine Biosciences, Fukui Prefectural University), Chairperson:Masahiko Fujii, Makoto Yamada

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[ACG40-06] Influence of climate change on river and submarine groundwater discharge for three decades and the change of nutrient fluxes from the land to the coastal area

*Saki KATAZAKAI[1], Jing ZHANG[2], Kota NOJIMA[3] (1.Graduate School of Science and Engineer, University of Toyama, 2.Graduate School of Science and Engineering for Science, University of Toyama, 3.University of Toyama)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[ACG40-07] The assessment of human impacts on the distribution patterns of mangroves: a comparative study between the Rewa and Ba delta, Fiji

*Masahiko Fujii[1], Jone Ravuci Sassen[2] (1.Faculty of Environmental Earth Science, 2.Graduate School of Environmental Science)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[ACG40-08] Landscape factors affect persistence and accumulation of organic carbon in sediment of secondary mangrove forests: A preliminary study

*Toshihiro Miyajima[1], Rempei Suwa[2], Keith Limuel C. Bejasa[3], Rene N. Rollon[3], Maria Lourdes San Diego-McGlone[3], Caroline M.B. Jaraula[3], Fernando P. Siringan[3], Kenji Ono[4], Yasmin H. Primavera Tirol[5], Yosuke Miyairi[1], Yusuke Yokoyama[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Japan International Research Center for Agricultural Sciences, 3.Marine Science Institute, University of the Philippines, 4.Forestry and Forest Products Research Institute, 5.Aklan State University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[ACG40-09] Multiple benefits of blue carbon ecosystems in promoting blue economy and reinforcing resilience in coastal communities

*Atsushi Watanabe[1] (1.The ocean policy research institute, The Sasakawa peace foundation)

11:45 AM - 12:05 PM JST | 2:45 AM - 3:05 AM UTC

[ACG40-10] Significant storage of organic carbon in mineral matrix in both land and ocean and the role of Fe

★Invited Papers

*Rota Wagai[1] (1.NARO, Institute for Agro-Environmental Sciences)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 201B 2F

[A-CG41] Promotion of Application and Utilization of Aircrafts for Earth sciences

convener:Nobuhiro Takahashi(Institute for Space-Earth Environmental Research, Nagoya University), Makoto Koike(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Toshinobu Machida(National Institute for Environmental Studies), Taro Shinoda(Institute for Space-Earth Environmental Research, Nagoya University), Chairperson:Nobuhiro Takahashi(Institute for Space-Earth Environmental Research, Nagoya University)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[ACG41-01] In situ observation of typhoon central pressure using dropsondes

*Kazuhisa Tsuboki[1], Hiroyuki Yamada[2], Yukihiro Takahashi[3], Taro Shinoda[1], Tadayasu Ohigashi[4], Munehiko Yamaguchi[5], Hisayuki Kubota[3], Tetsuo Nakazawa[5], Norio Nagahama[6], Kensaku Shimizu[6], Masaya Kato[1], Sachie Kanada[1], Mayumi Yoshioka[1], Nobuhiro Takahashi[1] (1. Institute for Space-Earth Environmental Research, Nagoya University, 2.University of the Ryukyus, 3.Hokkaido University, 4.National Research Institute for Earth Science and Disaster Resilience, 5.Meteorological Research Institute, Japan Meteorological Agency, 6.Meisei Electric Co. Ltd.)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[ACG41-02] New observation strategies for typhoon intensity over the western North Pacific

*Hiroyuki Yamada[1], Kazuhisa Tsuboki[2], Taro Shinoda[2], Hisayuki Kubota[3], Yukihiro Takahashi[3], Norio Nagahama[4], Kensaku Shimizu[4], Tadayasu Ohigashi[5], Kosuke Ito[1], Munehiko Yamaguchi[6], Tetsuo Nakazawa[6] (1.University of the Ryukyus, 2.Nagoya University, 3.Hokkaido University, 4.Meisei Electric, 5.National Research Institute for Earth Science and Disaster Resilience, 6.Meteorological Research Institute, Japan Meteorological Agency)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[ACG41-03] Observing System Experiment for Typhoon Trami (2018) using T-PARCII dropsondes and JMA Global Forecasting System

*Munehiko Yamaguchi[1], Toshiyuki Ishibashi[1], Tetsuo Nakazawa[1], Kosuke Ito[2], Hiroyuki Yamada[2], Tadayasu Ohigashi[3], Norio Nagahama[4], Kensaku Shimizu[4], Hisayuki Kubota[5], Yukihiro Takahashi[5], Masaya Kato[6], Sachie Kanada[6], Mayumi Yoshioka[6], Taro Shinoda[6], Nobuhiro Takahashi[6], Kazuhisa Tsuboki[6] (1.Meteorological Research Institute, Japan Meteorological Agency, 2.Faculty of Science, University of the Ryukyus, 3.National Research Institute for Earth Science and Disaster Resilience, 4.Meisei Electric, 5.Graduate School of Science, Hokkaido University, 6.Institute for Space-Earth Environmental Research, Nagoya University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[ACG41-04] Fundamental characteristics of black carbon and iron oxide aerosols in the troposphere revealed from the aircraft measurements

*Nobuhiro Moteki[1], Makoto Koike[1], Sho Ohata[2], Yutaka Kondo[3], Nobuyuki Takegawa[5], Kouji Adachi[4], Naga Oshima[4], Hitoshi Matsui[2], Kazuyuki Kita[6], Tatsuhiro Mori[7], Atsushi Yoshida[1] (1.The Univerisity of Tokyo, 2.Nagoya University, 3.National Institute for Polar Research, 4.Meteorological Research Institute, 5.Tokyo Metropolitan University, 6.Ibaraki University, 7.Tokyo University of Science)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[ACG41-05] Aerosol measurements around the ridge of East Antarctica using a Rogallo wing UAV

*Ryohei Haraguchi[1], Masahiko Hayashi[1], Keiichiro Hara[1], Naohiko Hirasawa[2], Koki Nakata[3], Kei-ichi Ozuka[4,1] (1.Fukuoka University, 2.National Institute of Polar Research, 3.kkt Inovate Co., Ltd, 4.Nippon Tungsten Co., Ltd)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[ACG41-06] Wind Mesurements Based on In-situ Data -Direct Vector Calculation and Hodograph Analyses-

*Masahiko Hayashi[1], Tomoyuki Onohara[1], Ryohei Haraguchi[1,3], Kei-ichi Ozuka[2,4], Kazuo Okabe[3] (1.Faculty of Science, Fukuoka University, 2.Nippon Tungsten Co.,Ltd, 3.SkyRemote Co.,Ltd, 4.FIT-EH, Fukuoka University)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 102 1F

[A-CG44] Coastal Ecosystems 2 Coral reefs, seagrass and macroalgal beds, and mangrove

convener:Yu Umezawa(Tokyo University of Agriculture and Technology), Toshihiro Miyajima(Marine Biogeochemistry Group, Division of Ocean-Earth System Science, Atmosphere and Ocean Research Institute, The University of Tokyo), Atsushi Watanabe(The ocean policy research institute, The Sasakawa peace foundation), Tomihiko Higuchi(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Yu Umezawa(Tokyo University of Agriculture and Technology), Toshihiro Miyajima(The University of Tokyo), Tomihiko Higuchi(Atmosphere and Ocean Research Institute, The University of Tokyo), Atsushi Watanabe(Tokyo Institute of Technology)

1:50 PM - 2:10 PM JST | 4:50 AM - 5:10 AM UTC

[ACG44-01] Evaluation of mangrove ecosystems as a dissolved iron supplying system to tropical coastal waters

★Invited Papers

*Yasuhiro Nakanishi[1], Ko Hinokidani[1] (1.Tokyo University of Agriculture)

2:10 PM - 2:25 PM JST | 5:10 AM - 5:25 AM UTC

[ACG44-02] Dissolved organic carbon and optical properties in tropical and subtropical mangrove environments

*Raghab Ray[1], Toshihiro Miyajima[1], Charissa M Ferrera[2], Chia-Jung Lu[1], M.L San Diego-McGlone[2], Hiroshi Ogawa[1], Kazuo Nadaoka[3] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Marine Science Institute, University of the Philippines, Diliman, 3.School of Environment and Society, Tokyo Institute of Technology)

2:25 PM - 2:45 PM JST | 5:25 AM - 5:45 AM UTC

[ACG44-03] Modeling coral polyp-scale bleaching phenomenon and upscaling to reef-scale

★Invited Papers

*Takashi Nakamura[1], Tomihiko Higuchi[2], Toshihiro Miyajima[2], Lawrence Patrick Cases Bernardo[1], Kazuo Nadaoka[1], Atsushi Watanabe[1,3], Hiroyuki Fujimura[4] (1.School of Environment and Society, Tokyo Institute of Technology, 2.AORI, The University of Tokyo, 3.The ocean policy research institute, The Sasakawa peace foundation, 4.University of the Ryukyus)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[ACG44-04] Reversal of surface ocean acidification and recovery potential of calcification: ecology of proton concentration control

*Kazuhiko Ichikawa[1] (1.(post) Graduate School of Environmental Earth Science, Hokkaido University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[ACG44-05] Revisit of massive *Porites* coral growth under the outbreak of crown-of-thorns starfish and thermal stress in Sekisei Lagoon, Japan

*Kohki Sowa[1] (1.Japan Agency for Marine-Earth Science and Technology)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 102 1F

[A-CG44] Coastal Ecosystems 2 Coral reefs, seagrass and macroalgal beds, and mangrove

convener:Yu Umezawa(Tokyo University of Agriculture and Technology), Toshihiro Miyajima(Marine Biogeochemistry Group, Division of Ocean-Earth System Science, Atmosphere and Ocean Research Institute, The University of Tokyo), Atsushi Watanabe(The ocean policy research institute, The Sasakawa peace foundation), Tomihiko Higuchi(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Yu Umezawa(Tokyo University of Agriculture and Technology), Toshihiro Miyajima(The University of Tokyo), Atsushi Watanabe(Tokyo Institute of Technology), Tomihiko Higuchi(Atmosphere and Ocean Research Institute, The University of Tokyo)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[ACG44-06] Reconstructing sedimentation process of lagoon sediment in the Eastern Kume Island, Ryukyus

*Wataru Sano[1], Shoko Hirabayashi[2], Yusuke Yokoyama[3], Yosuke Miyairi[3], Kazuhiko Fujita[4], Hironobu Kan[2], Lauren T. Toth[5], Richard B. Aronson[6] (1.Graduate School of Integrated Sciences for Global Society, Kyushu University, 2.Graduate School of Social and Cultural Studies, Kyushu University, 3.Atmosphere and Ocean Research Institute, University of Tokyo, 4.Department of Physics and Earth Sciences, University of the Ryukyus, 5.United States Geological Survey, 6.Florida Institute of Technology)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[ACG44-07] Addressing challenges in long-term coral reef monitoring: Statistical tools to address the effect of new methods

*Iwao Fujii[1,2], Jennifer Selgrath[3,2], Amanda Vincent[2] (1.The Ocean Policy Research Institute of the Sasakawa Peace Foundation, 2.Project Seahorse, Institute of the Oceans and Fisheries, The University of British Columbia, 3.Hopkins Marine Station, Stanford University)

4:00 PM - 4:20 PM JST | 7:00 AM - 7:20 AM UTC

[ACG44-08] Ocean currents and herbivory drive macroalgae-to-coral community shift under climate warming

★Invited Papers

*Naoki H. Kumagai[1], Jorge García Molinos[2], Hiroya Yamano[1], Shintaro Takao[1], Masahiko Fujii[2], Yasuhiro Yamanaka[2] (1.National Institute for Environmental Studies, 2.Hokkaido University)

4:20 PM - 4:35 PM JST | 7:20 AM - 7:35 AM UTC

[ACG44-09] Estimation of temperature of seaweed bed vegetation boundary in the Western Seto Inland Sea using satellite SST

*Naoki Yoshie[1], Anri Kabe[1], Hiromori Shimabukuro[2], Goro Yoshida[2] (1.Center for Marine Environmental Studies, Ehime University, 2.Japan Fisheries Research and Education Agency)

4:35 PM - 4:55 PM JST | 7:35 AM - 7:55 AM UTC

[ACG44-10] Fate of macroalgal organic matter and its effects on in and outside of algal bed

★Invited Papers

*Shigeki Wada[1], Yuko Omori[1], Takeo Hama[1,2] (1.University of Tsukuba, 2.Dokkyo University)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 103 1F

[A-CG45] Visible Remote Sensing of Hydrospheric Science and Its Application

convener:Joji Ishizaka(Institute for Space-Earth Environmental Research, Nagoya University), Mitsuhiro Toratani(School of Engineering, Tokai University), Yuji Sakuno(Graduate School of Engineering, Hiroshima University), Toru Hirawake(Faculty of Fisheries Sciences, Hokkaido University), Chairperson:Yuji Sakuno(広島大学大学院工学研究科)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[ACG45-01] Further information in the coastal areas from 250-m resolution multiple bands of GCOM-C “SHIKISAI”

★Invited Papers

*Hiroshi Murakami[1], Manabu Shimizu[2], Goh Onizuka[3] (1.Earth Observation Research Center, Japan Aerospace Exploration Agency, 2.Japan Fisheries Research and Education Agency, 3.National Research Institute of Fisheries and Environment of Inland Sea, Japan Fisheries Research and Education Agency)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[ACG45-02] Features of GCOM-C/SGLI standard atmospheric correction scheme and its processing results

*Mitsuhiro Toratani[1], Kazunori Ogata[2], Hajime Fukushima[3] (1.School of Engineering, Tokai University, 2.Japan Aerospace Exploration Agency/Earth Observation Research Center, 3.Tokai University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[ACG45-03] Verification of GCOM-C/SGLI-derived chlorophyll *a* data in the western North Pacific during May 2018 aboard the R/V *Shinsei Maru*

*Koji Suzuki[1], Stanford B. Hooker[2], Tomonori Isada[1], Kazunori Ogata[3], Mitsuhiro Toratani[4], Hiroshi Murakami[3] (1.Hokkaido University, 2.NASA, 3.JAXA, 4.Tokai University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[ACG45-04] **Toward a global retrieval of in-water optical properties using Deep Neural Network**

*Salem Ibrahim Salem[1], Hiroto Higa[2], Kazuo Oki[1], Taikan Oki[1] (1.The University of Tokyo, 2.Yokohama National University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[ACG45-05] Development of atmosphere and in-water combining algorithm using GCOM-C/SGLI in Tokyo Bay

*Taiga Nakayama[1], HIROTO HIGA[1], Kazuki Ogata[2] (1.Yokohama National University, 2.Japan Aerospace eXploration Agency)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[ACG45-06] Analysis of the uncertainty of backscattering coefficient by radiative transfer simulation in coastal areas and lakes

*Hidehito Taki[1], Hiroto Higa[1], Yoshiyuki Nakamura[1], Takayuki Suzuki[1] (1.Graduate School of Urban Innovation, Yokohama National University)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 103 1F

[A-CG45] Visible Remote Sensing of Hydrospheric Science and Its Application

convener:Joji Ishizaka(Institute for Space-Earth Environmental Research, Nagoya University), Mitsuhiro Toratani(School of Engineering, Tokai University), Yuji Sakuno(Graduate School of Engineering, Hiroshima University), Toru Hirawake(Faculty of Fisheries Sciences, Hokkaido University), Chairperson:Joji Ishizaka(名古屋大学宇宙地球環境研究所)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[ACG45-07] Development of a blue tide estimation method based on the optical properties of sulfur colloid particles by geostationary ocean color satellite

*HIROTO HIGA[1], WATARU NAKAMURA[1] (1.Yokohama National University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[ACG45-08] Characteristics of water quality and red tide distribution in the Seto Inland Sea immediately after heavy rain in the western Japan by GCOM-C SGLI data

*Yuji Sakuno[1], Hiroto Higa[2], Hiroshi Kobayashi[3], Mitsuhiro Toratani[4] (1.Hiroshima University, 2.Yokohama National University, 3.Yamanashi University, 4.Tokai University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[ACG45-09] Application of Satellite Remote Sensing to Monitor Eutrophication Status of Inland Lakes

*Wei Yang[1], Bunkei Matsushita[2] (1.Chiba University, 2.University of Tsukuba)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[ACG45-10] **Exploring the Potentials of Google Earth Engine for Global Assessment of Coastal Eutrophication Based on Chlorophyll-*a* concentration**

*Eligio de Raus Maure[1], Genki Terauchi[1], Joji Ishizaka[2] (1.Northwest Pacific Region Environmental Cooperation Center, 2.Institute for Space-Earth Environmental Research, Nagoya University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[ACG45-11] Seasonal and interannual variability of seagrass distribution detected by Landsat TM, ETM+ and OLI images in western Nanao Bay

*Genki Terauchi[1] (1.Northwest Pacific Region Environmental Cooperation Center)

[J] Oral | H (Human Geosciences)：H-DS Disaster geosciences

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Convention Hall B 2F

[H-DS13] Tsunami and Tsunami Forecast

convener:Naotaka YAMAMOTO CHIKASADA(National Research Institute for Earth Science and Disaster Resilience), Hiroaki Tsushima(Japan Meteorological Agency), Tatsuya Kubota(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Osamu Sandanbata, Tatsuya Kubota

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[HDS13-01] Sensibility analysis for the inundation tsunami height due to 2018 Sulawesi earthquake and tsunami

★Invited Papers

*Taro Arikawa[1], Abdul Muhari[3], Shota Takeda[1], Anawat Suppasri[2], Fumihiko Imamura[2] (1.Chuo University, 2.IRIDES, Tohoku University, 3.Ministry of Marine Affairs and Fisheries, Indonesia)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[HDS13-02] Tsunami Source of the 2018 Sulawesi Earthquake Estimated from Tsunami and InSAR Data

*Tungcheng Ho[1], Kenji Satake[1], Shingo Watada[1], Ray Y Chuang[2], Chih-Heng Lu[2] (1.Earthquake Research Institute,The University of Tokyo, 2.Department of Geography, National Taiwan University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[HDS13-03] **Source Models of the Two September and December 2018 Indonesia Tsunamis Based on Spectral Analyses and Numerical Modeling**

*Mohammad Heidarzadeh[1], Abdul Muhari[2], Tomoya HARADA[3], Takeo Ishibe[4], Antonius Wijanarto[5] (1.Brunel University London, 2.Ministry of Marine Affairs and Fisheries, Jakarta 10110, Indonesia, 3.Earthquake Research Institute, The University of Tokyo, Japan, 4.Association for the Development of Earthquake Prediction, Tokyo, 101-0064, Japan, 5.Badan Informasi Geospasial, Cibinong, Indonesia)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[HDS13-04] Abrupt Large Uplift Caused by Volcanic Tsunami Earthquakes near the Kermadec Islands, New Zealand

*Osamu Sandanbata[1], Shingo Watada[1], Kenji Satake[1] (1.Earthquake Research Institute, the University of Tokyo)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[HDS13-05] **Adaptive tsunami waveform inversion for estimating coseismic vertical displacements and slip distribution**

*Iyan E. Mulia[1], Aditya Riadi Gusman[2], M. Jakir Hossen[3], Kenji Satake[1] (1.Earthquake Research Institute, The University of Tokyo, 2.GNS Science, 3.BRAC University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[HDS13-06] Real-time tsunami prediction in a coastal zone, using a superposition of Green’s function

*Seiji Tsuno[1], Norihiko Hashimoto[2] (1.Railway Technical Research Institute, 2.ITOCHU Techno-Solutions Corporation)

[J] Oral | H (Human Geosciences)：H-RE Resource and Engineering Geology

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 301B 3F

[H-RE17] Application of earth science data towards the renewable energy field

convener:Hideaki Ohtake(National Institute of Advanced Industrial Science and Technology), Fumichika Uno(National Institute of Advanced Industrial Science and Technology), Teruhisa Shimada(Graduate School of Science and Technology, Hirosaki University), Daisuke Nohara(Central Research Institute of Electric Power Industry), Chairperson:Hideaki Ohtake(National Institute of Advanced Industrial Science and Technology (AIST))

3:30 PM - 3:55 PM JST | 6:30 AM - 6:55 AM UTC

[HRE17-01] Application of geological dara to ground source heat pump systems with special reference to thermal conductivity of geological materials

★Invited Papers

*Masakatsu SASADA[1] (1.Geo-Heat Promotion Association of Japan)

3:55 PM - 4:10 PM JST | 6:55 AM - 7:10 AM UTC

[HRE17-02] Use of groundwater in the Nishi-Osaka Area and its activities.

*Naoko Kitada[1], Hiroko Ito[1], Tomoo Echigo[1], Teruyuki Fujiwara[1], Makoto Nishigaki[2] (1.Geo-Research Institute, 2.Okayama University)

4:10 PM - 4:25 PM JST | 7:10 AM - 7:25 AM UTC

[HRE17-03] Improvement of prediction of wind power ramp by using monitoring data

*Shinji Kadokura[1], Daisuke Nohara[1], Masamichi Ohba[1], Atsushi Hashimoto[1], Keisuke Nakao[1], Yasuo Hattori[1], Takeshi Watanabe[1], Hiromaru Hirakuchi[1] (1.Central Research Institute of Electric Power Industry)

4:25 PM - 4:40 PM JST | 7:25 AM - 7:40 AM UTC

[HRE17-04] **A study of the use of meteorological data for energy management**

*Hideaki Ohtake[1], Takashi Oozeki[1], Junichi Imura[2] (1.National Institute of Advanced Industrial Science and Technology, 2.Tokyo institute of technology)

[J] Oral | H (Human Geosciences)：H-TT Technology & Techniques

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 301B 3F

[H-TT22] New Developments in Shallow Geophysics

convener:Kyosuke Onishi(Public Works Research Institute), Kunio Aoike(Oyo corporation), Keisuke Inoue(National Agriculture and Food Research Organization), Tishiyuki Yokota(National Institute of Advanced Industrial Science and Technology), Chairperson:Toshiyuki Yokota, Keisuke Inoue

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[HTT22-01] High-frequency seismic reflection measurements for imaging internal structure of a sabo dam damaged by a huge debris flow

*Tomio INAZAKI[1], Hiroshi Kisanuki[2], Takanori Ogahara[1], Takeshi Shimizu[1], Naoki Fujimura[1] (1.Public Works Research Institute, Tsukuba Central Institute, 2.PWRI (Present address: OYO Corporation))

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[HTT22-02] Development and applications of 3D ambient noise tomography

*Chisato Konishi[1], Koichi Hayashi[1] (1.OYO Corporation)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[HTT22-03] An Attempt to Estimate the Level of Non-confind Groundwater by Earthing Resistance (I) - Outline of Theory -

*Kunihiro Ryoki[1] (1.Polytechnic University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[HTT22-04] Experimental and Theoretical Studies for Seafloor Survey by Ground Penetrating Radar

*Jun Sonoda[1], Tomoyuki Kimoto[2] (1.National Institute of Technology, Sendai College, 2.National Institute of Technology, Oita College)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[HTT22-05] Evaluation of the 3-D Distribution of Fractures in a Rock Mass using Directional Borehole Radar Data from a Horizontal Borehole

*Kazuhiko Masumoto[1], Tomoaki Matsushita[2], Suguru Shirasagi[1], Takashi Ueki[3], Shinsuke Karasawa[3], Daiki Makino[3], Kazushige Wada[4] (1.Kajima Technical Research Institute, 2.Kajima Corporation, 3.Matsunaga Geo-Survey Co., Ltd., 4.Mitsui Mineral Development Engineering Co., Ltd.)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[HTT22-06] Automatic Detection of Deteriorated Concrete Bridge Deck using 2 GHz Horn Antennae

*Kunio Aoike[1], Shogo Tanaka[2], Naoto Takase[1], Akio Matsuyama[1], Masaya Yamauchi[1], Yoshinori Uno[1] (1.OYO Corporation, 2.Professor Emeritus of Yamaguchi Univ.)

[J] Oral | S (Solid Earth Sciences)：S-GD Geodesy

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 303 3F

[S-GD01] Gravity and Geoid

convener:Tokuro Kodama(Geospatial Information Authority of Japan), Daisuke Oka(Geological Survey of Hokkaido, Environmental and Geological Research Department, Local Independent Administrative Agency, Hokkaido Research Organization), Chairperson:Toshiyuki Tanaka, Takahito Kazama

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SGD01-01] Seasonal variation of gravity values at the Ishioka Geodetic Observing Station

*Akira Tomiyama[1], Tokuro Kodama[1], Shuichi Oomori[1], Yoshifumi Hiraoka[1], Toshihiro Yahagi[1] (1.GSI of Japan)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SGD01-02] Installation of the First Gravity Station in the Mount Fuji Research Institute, and the Phase-Free gravity measurement

*Ryo Honda[1], Yuichi Imanishi[2], Kazunari Nawa[3], Toshiyuki Tanaka[4], Tokuro Kodama[5], Akira Tomiyama[5] (1.MFRI, Yamanashi Prefectural Government, 2.ERI, University of Tokyo, 3.GSJ, AIST, 4.TRIES, ADEP, 5.GSI)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SGD01-03] Absolute gravity and GNSS measurements on bedrock outcrops in Dronning Maud Land, East Antarctica

*Takahito Kazama[1], Yuichi Aoyama[2], Yoichi Fukuda[1], Koichiro Doi[2] (1.Graduate School of Science, Kyoto University, 2.National Institute of Polar Research)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SGD01-04] **Capability of ICA Method for separating GIA and Ice Mass Signals in Antarctica**

*SHI TIANYAN[1], Yoichi Fukuda[1] (1.Graduate School of Science, Kyoto University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SGD01-05] Preliminary result of continuous observation with an iGrav superconducting gravimeter at the Teshikaga observatory, eastern Hokkaido, Japan

*Kazunari Nawa[1], Hiroaki Takahashi[2], Mako Ohzono[2], Kazumi Okada[2], Teruhiro Yamaguchi[2], Daisuke Oka[3], Noritoshi Okazaki[3], Ryo Honda[4], Hiroshi Ikeda[5] (1.National Institute of Advanced Industrial Science and Technology, 2.Hokkaido University, 3.Geological Survey of Hokkaido, 4.Mount Fuji Research Institute, 5.University of Tsukuba)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SGD01-06] On the anomalous temporal gravity change between VERA and F-net stations at Ishigakijima, Japan

*Kazunari Nawa[1], Yuichi Imanishi[2], Yoshiaki Tamura[3], Hiroshi Ikeda[4], Takeshi Kimura[5] (1.National Institute of Advanced Industrial Science and Technology, 2.Earthquake Research Institute, The University of Tokyo, 3.National Astronomical Observatory of Japan, 4.University of Tsukuba, 5.National Research Institute for Earth Science and Disaster Resilience)

[J] Oral | S (Solid Earth Sciences)：S-GD Geodesy

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 303 3F

[S-GD01] Gravity and Geoid

convener:Tokuro Kodama(Geospatial Information Authority of Japan), Daisuke Oka(Geological Survey of Hokkaido, Environmental and Geological Research Department, Local Independent Administrative Agency, Hokkaido Research Organization), Chairperson:Kazunari Nawa, Ryo Honda(山梨県富士山科学研究所)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SGD01-07] **Absolute gravity signals at the Sakurajima volcano since 2009 through 2018**

*Shuhei Okubo[1], Keigo Yamamoto[2], Masato Iguchi[2], Yoshiyuki Tanaka[3], Yuichi Imanishi[1], Ryuichi Nishiyama[1], Miwako Ando[1], Atsushi Watanabe[1] (1.Earthquake Research Institute, The University of Tokyo, 2.Disaster Prevention Research Institute, Kyoto University, 3.Graduate School of Science, The University of Tokyo)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SGD01-08] Detection of Earthquake-induced Prompt Gravity Signals in Multi-channel Data

*Masaya Kimura[1], Nobuki Kame[1], Shingo Watada[1], Makiko Ohtani[2], Akito Araya[1], Yuichi Imanishi[1], Masaki Ando[3], Takashi Kunugi[4] (1.Earthquake Research Institute,The University of Tokyo, 2.National Institute of Advanced Industrial Science and Technology, 3.Department of Physics, The University of Tokyo, 4.National Research Institute for Earth Science and Disaster Resilience)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SGD01-09] Evaluation of atmospheric attraction effect using local-scale objective analysis (LANAL)

*Toshiyuki Tanaka[1] (1.Tono Research Institute of Earthquake Science, Association for the Development of Earthquake Prediction)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SGD01-10] Airborne gravity survey for establishment of a new precise gravimetric geoid model

*Tokuro Kodama[1], Akira Tomiyama[1], Shuichi Oomori[1], Erika Wada[1], Toshihiro Yahagi[1], Yoshifumi Hiraoka[1], Hiroshi Kawawa[1] (1.GSI of Japan)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SGD01-11] Gravimetric geoid modeling using airborne gravity data : a case study in Colorado, U.S.A.

*Koji Matsuo[1], Rene Forsberg[2] (1.GSI of Japan, 2.Denmark Technical University)

[J] Oral | S (Solid Earth Sciences)：S-GD Geodesy

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 105 1F

[S-GD02] Engineering Application of Space Geodesy

convener:Seiichi Shimada(Graduate School of Frontier Sciences, University of Tokyo Nippo Co. Ltd.), Shuichi Rokugawa(The University of Tokyo), Basara Miyahara(GSI of Japan), Toshiaki Tsujii(Department of Aerospace Engineering, Osaka Prefecture University), Chairperson:Masaatsu Aichi, Kazuki Sakai

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SGD02-01] Future vision of the society for utilizing highly precise three dimensional positioning data by applying crustal deformation and precise gravimetric geoid model

*Toshihiro Yahagi[1], Kensuke Kokado[1], Kenji Yoshida[1], Takashi Toyofuku[1], Masao Iwata[1], Basara Miyahara[1] (1.GSI of Japan)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SGD02-02] Preliminary study on the application of satelite-based monitoring for land surface displacement to inverse analyses of groundater flow/land subsidence modeling

*Masaatsu Aichi[1] (1.Graduate School of Frontier Sciences, The University of Tokyo)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SGD02-03] Monitoring of ground deformation all over Japan by InSAR and utilizing 2.5-D analysis

*Kazuki Sakai[1], Kyonosuke Hayahsi[1], Masaki Kuwahara[1], Tatsuya Yamashita[1], Masaki Honda[1], Hiroshi Munekane[1] (1.GSI of Japan)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SGD02-04] Resource Exploration using Interferometric Synthetic Aperture Radar Measurement Technology

*Shuichi Rokugawa[1], Takako Nakamura[1] (1.The University of Tokyo)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SGD02-05] The application example of GNSS for natural gas development together with PDCA Management Method

★Invited Papers

*Yoshiyuki Muramoto[1], Susumu Hayatsu[1], Michiharu Hiyama[1], Daisuke Murai[1], Shoji Kunisue[1] (1.KANTO NATURAL GAS DEVELOPMENT CO., LTD)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SGD02-06] New threats and countermeasures in the aviation field where the use of GNSS satellite navigation expands

★Invited Papers

*Takeshi Fujiwara[1], Toshiaki Tsujii[2] (1.Japan Aerospace Exploration Agency, 2.Osaka Prefecture University)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A10 TOKYO BAY MAKUHARI HALL

[S-SS10] Seismicity

convener:Kei Katsumata(Institute of Seismology and Volcanology, Hokkaido University), Chairperson:Aitaro Kato(Earthquake Research Institute, University of Tokyo), Shinji Toda(東北大学)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SSS10-01] Seasonal variations in crustal seismicity in San-in district, southwest Japan

*Taku Ueda[1], Aitaro Kato[1] (1.Earthquake Research Institute, the University of Tokyo)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SSS10-02] **Source fault model of the 2018 M_W 5.6 northern Osaka earthquake, Japan, inferred from the aftershock sequence**

*Aitaro Kato[1], Taku Ueda[1] (1.Earthquake Research Institute, the University of Tokyo)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SSS10-03] The 2018 Hokkaido Eastern Iburi earthquake (M_{JMA} = 6.7) was triggered by a strike-slip faulting in a stepover segment: Insights from the aftershock distribution and the focal mechanism solution of the mainshock

*Kei Katsumata[1], Mako Ohzono[1], Hiroshi Aoyama[1], Ryo Tanaka[1], Masamitsu Takada[1], Masayoshi Ichiyanagi[1], Teruhiro Yamaguchi[1], Kazumi Okada[1], Hiroaki Takahashi[1], Shin'ichi Sakai[2], Satoshi Matsumoto[3], Tomomi Okada[4], Toru Matsuzawa[4], Shuichiro Hirano[5], Toshiko Terakawa[6], Shinichiro Horikawa[6], Masahiro Kosuga[7], Hiroshi Katao[8], Yoshihisa Iio[8], Airi Nagaoka[8], Noriko Tsumura[9], Tomotake Ueno[10], the Group for the Aftershock Observations of the 2018 Hokkaido Eastern Iburi Earthquake (1.Institute of Seismology and Volcanology, Faculty of Science, Hokkaido University, 2.Earthquake Research Institute, University of Tokyo, 3.Institute of Seismology and Volcanology, Faculty of Science, Kyushu University, 4.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University, 5.Nansei-Toko Observatory for Earthquakes and Volcanoes, Graduate School of Science and Engineering, Kagoshima University, 6.Earthquake and Volcano Research Center, Graduate School of Environmental Studies, Nagoya University, 7.Graduate School of Science and Technology, Hirosaki University, 8.Research Center for Earthquake Prediction, Disaster Prevention Research Institute, Kyoto University, 9.Graduate School of Science, Chiba University, 10.National Research Institute for Earth Science and Disaster Prevention)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SSS10-04] Layered structure of the upper mantle and the crust revealed in the time series analyses of the aftershocks of the 2018 Hokkaido Eastern Iburi Earthquake

*Takayuki Kawabe[1] (1.Faculty of Education, Arts and Sciences, Yamagata University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SSS10-05] Aftershock sequence of the 1847 Zenkoji earthquake: Temporal decay presented in four historical materials and best fit values of paramaters for Omori-Utsu law

*Kentaro Hattori[1], Ichiro Nakanishi[1] (1.Kyoto Univ.)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SSS10-06] The aseismic islands, Amakusa-Kamishima and Shimoshima, Kumamoto Prefecture, southwest Japan: What persistently shuts off regional seismicity

*Shinji Toda[1] (1.International Research Institute of Disaster Science, Tohoku University)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A10 TOKYO BAY MAKUHARI HALL

[S-SS10] Seismicity

convener:Kei Katsumata(Institute of Seismology and Volcanology, Hokkaido University), Chairperson:Akio Katsumata(気象研究所地震津波研究部第一研究室), Yasushi Harada(東海大学)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SSS10-07] Seismicity in the matle wedge around Ogasawara Islands and Lesser Antilles

*Akio Katsumata[1], Kenji Nakata[1], Akio Kobayashi[1], Fuyuki Hirose[1], Takahito Nishimiya[1] (1.Meteorological Research Institute, Japan Meteorological Agency)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SSS10-08] Improvement of the accuracy of the unified Japan Earthquake Catalog using ocean bottom seismographs

*Hiroshi UENO[1], Mitsuharu Ueda[1], Hiromi Misu[1], Hirofumi Yokoyama[1], Yuriko Iwasaki[1], Iwakiri Kazuhiro[1] (1.Seismology and Volcanology Department, Japan Meteorological Agency)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SSS10-09] Spatial distribution of seismic activity and stress field in the source region after the 2011 Tohoku-Oki earthquake

Tomoya Nishimori[1], *Ryota Hino[1], Masanao Shinohara[2] (1.Graduate School of Science, Tohoku University, 2.Earthquake Research Institute, The University of Tokyo)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SSS10-10] Assessment for a large earthquake occurrence on the northern side of the focal region of the 2011 off-Tohoku mega-thrust earthquake

*Kazuyoshi Nanjo[1], Kazuki Miyaoka[2], Akio Yoshida[3] (1.University of Shizuoka, 2.Japan Meteorological Agency, 3.Shizuoka University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SSS10-11] Spatial and temporal distributions of *b*-values related to long-term slow-slip and low-frequency earthquakes in the Bungo Channel and Hyuga-nada regions, Japan

*Keita Chiba[1] (1.Institute of Seismology and Volcanology, Faculty of Science, Kyushu University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SSS10-12] 4D b-Value Mapping for Japan

*Yasushi Harada[1], Yuichi Akamine[1], Masayoshi Anzai[1] (1.School of Marine Science and Technology, Tokai University)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-SS11] Seismic wave propagation: Theory and Application

convener:Kiwamu Nishida(Earthquake Research Institute, University of Tokyo), Kazuya Shiraishi(Japan Agency for Marine-Earth Science and Technology), Takao Nibe(JAPEX), Kaoru Sawazaki(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Shunsuke Takemura(防災科研)

9:01 AM - 9:23 AM JST | 12:01 AM - 12:23 AM UTC

[SSS11-13] Fluid flows inferred from microseismic events associated with injection test in Okuaizu Geothermal Field

★Invited Papers

*Kyosuke Okamoto[1], Li Yi[2], Hiroshi Asanuma[1], Takashi Okabe[3], Yasuyuki Abe[4], Masatoshi Tsuzuki[5] (1.National Institute of Advanced Industrial Science and Technology, 2.Osaka University, 3.Geothermal Energy Research and Development Co., Ltd., 4.Okuaizu Geothermal Co., Ltd., 5.Japan Oil, Gas and Metals National Corporation)

9:23 AM - 9:45 AM JST | 12:23 AM - 12:45 AM UTC

[SSS11-14] 3D distribution of intrinsic attenuation factors and random velocity fluctuations in southwestern Japan inferred from seismogram envelopes

★Invited Papers

*Masashi Ogiso[1] (1.Meteorological Research Institute, Japan Meteorological Agency)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SSS11-15] Regional to teleseismic strong ground motions from a 610 km deep 24 May 2013 Sea of Okhotsk earthquake

*Takashi Furumura[1], Brian LN Kennett[2] (1.Earthquake Research Institute The University of Tokyo, 2.Research School of Earth Sciences, The Australian National University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SSS11-16] Trial estimation of eclogitization depths within subducting oceanic crust of the Philippine Sea slab inferred from head wave propagating along the oceanic Moho

*Shunsuke Takemura[1], Takashi Tonegawa[2], Junichi Nakajima[3], Katsuhiko Shiomi[1] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Japan Agency for Marine-Earth Science and Technology , 3.Tokyo Institute of Technology)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SSS11-17] **Transient gravity perturbations due to a buried gravitational source in a homogeneous elastic half space**

*Aditya Nitin Deshmukh[1], Pratik Laxman Borate[1], Abhishek Venkatesh Chitgopkar[1], Nobuki Kame[2], Ranjith Kunnath[1] (1.Mahindra Ecole Centrale, Hyderabad, India , 2.Division of Theoretical Geoscience, Earthquake Research Institute, University of Tokyo, Japan)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-SS14] Fault Rheology and Earthquake Physics

convener:Keishi Okazaki(Japan Agency for Marine-Earth Science and Technology), Hideki Mukoyoshi(Department of Geoscience Interdisciplinary Graduate School of Science and Engineering, Shimane University), Hiroyuki Noda(Kyoto University, Disaster Prevention Research Institute), Keisuke Yoshida(Tohoku University), Chairperson:Keisuke Yoshida(東北大学大学院理学研究科 地球物理学専攻), Keishi Okazaki(JAMSTEC)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SSS14-01] **Spatio-temporal Evolution of Micro-Earthquakes illuminated by “0.1 manten” Hyper Dense Seismic Observation: Implication of Fault Growth**

*Aitaro Kato[1], Shin'ichi Sakai[1], Satoshi Matsumoto[2], Yoshihisa Iio[3] (1.Earthquake Research Institute, the University of Tokyo, 2.Kyushu University, 3.Kyoto University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SSS14-02] Estimation of fault model of the 2017 Pohang, South Korea earthquake using seismic and geodetic analyses

*Sun-Cheon Park[1], Won-Jin Lee[2], Geunyoung Song[1], Duk Kee Lee[1] (1.Korea Meteorological Administration, 2.National Institute of Environmental Research)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SSS14-03] Estimation of rupture directivity, fault plane, and stress drop of small earthquakes in inland areas of Japan

*Keisuke Yoshida[1], Tatsuhiko Saito[2], Kentaro Emoto[1], Yumi Urata[2] (1.Tohoku University, 2.NIED)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SSS14-04] **Possible aseismic phenomena causing the hypocenter migration in the precursory activity and aftershocks of the 2017 M 5.3 Kagoshima Bay earthquake, Kyusyu, SW Japan**

*Yoshiaki Matsumoto[1], Keisuke Yoshida[1], Toru Matsuzawa[1], Akira Hasegawa[1] (1.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Tohoku University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SSS14-05] Stress and pore fluid pressure changes in fault zone preceding the earthquake occurrence

*Teruo Yamashita

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SSS14-06] Micromechanical model of fluid-induced seismicity to reproduce observed spatiotemporal changes in source parameters and on-fault fluid diffusion

*Daisuke Sato[1], Keisuke Yoshida[2] (1.Disaster Prevention Research Institute, Kyoto University, 2.Tohoku University)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[S-SS15] Active faults and paleoseismology

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Takashi OGAMI(National Institute of Advanced Industrial Science and Technology), Ryosuke Doke(Hot Springs Research Institute of Kanagawa Prefecture), Hisao Kondo(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Chairperson:Mamoru KOARAI(Ibaraki University), Taku Komatsubara(産業技術総合研究所)

3:30 PM - 4:00 PM JST | 6:30 AM - 7:00 AM UTC

[SSS15-01] Historical documents and oral transmissions on historical tsunamis in the Paciffic coast of Tohoku

★Invited Papers

*ebina yuichi[1] (1.International Research Institute of Disaster Science)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SSS15-02] Co-seismic crustal movements along reverse faults which subsidence component is larger than uplifting component

*Taku Komatsubara[1] (1.Institute of Geology and Geoinformation, Advanced Industrial Science and Technology)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SSS15-03] The Iyo-Bungo, southwest Japan, earthquake on September 1st, 1596 as deduced from contemporary historical records

*Katsuhiko Ishibashi[1] (1.Emeritus Professor, Kobe University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SSS15-04] Geologically recorded historical and prehistoric tsunamis in the Tonankai region

*Shigehiro Fujino[1], Haruo Kimura[2], Junko Komatsubara[3], Dan Matsumoto[3], Yuichi Namegaya[3], Yuki Sawai[3], Masanobu Shishikura[3] (1.Faculty of Life and Environmental Sciences, University of Tsukuba, 2.Civil Engineering Research Laboratory, Central Research Institute of Electric Power Industry, 3.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST))

[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | IC 2F

[S-VC38] Active Volcanism

convener:Yuta Maeda(Nagoya University), Takahiro Miwa(National research institute for earth science and disaster prevention), Takeshi Nishimura(Department of Geophysics, Graduate School of Science, Tohoku University), Chairperson:Fukashi Maeno, Yosuke Aoki

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SVC38-06] A sequence of volcanic flank collapse and tsunami event on 22 December 2018 at Anak Krakatau volcano, Indonesia

*Fukashi Maeno[1], Takayuki Kaneko[1] (1.Earthquake Research Institute, University of Tokyo)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SVC38-07] The 2018 eddifice collapse event of Anak Krakatau, Indonesia: Telseismic waveform analysis and tsunami simulation

*Shingo Watada[1], Iyan E. Mulia[1], Masumi Yamada[2], Dimas Sianipar[3] (1.Earthquake Research Institute, University of Tokyo, 2.Disaster Prevention Research Institute, Kyoto University, 3.TIGP-ESS Academia Sinica, National Central University, Taiwan)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SVC38-08] The 2018 edifice collapse event of Anak Krakatau, Indonesia: Landslide movement history estimated from seismic waveforms

*Masumi Yamada[1], Shingo Watada[2], Haruhisa Nakamichi[1], Iyan Mulia[2], Karyono Dr.[3] (1.Disaster Prevention Research Institute, Kyoto University, 2.Earthquake Research Institute, University of Tokyo, 3.Center for Earthquake and Tsunami, BMKG)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SVC38-09] Intense Swarm Activity in the Vicinity of Yake-dake Volcano, Central Japan, Started in November 2018

*Shiro Ohmi[1] (1.Earthquake Hazards Division, Disaster Prevention Research Institute, Kyoto University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SVC38-10] Change of the volcanic activity at Kuju volcano.

*Mori Takehiko[1], Muga Yaguchi[1], Yasushi Kawamura[2], Hideyuki Hiramatsu[3], Keiji Ikeda[2], Sugai Akira[2], Michitomo Sugahara[2], Kenichi Takata[2], Kyo Matsumoto[2], Fukuoka Regional Headquarters Japan Meteorological Agency, Oita Meteorological Office Japan Meteorological Agency (1. Meteorological Research Institute, Japan Meteorological Agency, 2.Fukuoka Regional Headquarters, Japan Meteorological Agency, 3.Oita Meteorological Office, Japan Meteorological Agency)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SVC38-11] Posteruptive Thermoelastic Deflation of Intruded Magma in Usu Volcano, Japan, 1992–2017

*Yosuke Aoki[1], Xiaowen Wang[1] (1.Earthquake Research Institute, University of Tokyo)

[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | IC 2F

[S-VC38] Active Volcanism

convener:Yuta Maeda(Nagoya University), Takahiro Miwa(National research institute for earth science and disaster prevention), Takeshi Nishimura(Department of Geophysics, Graduate School of Science, Tohoku University), Chairperson:Jun Oikawa, Takeshi Tameguri

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SVC38-12] Volcanic tremors and ash fall volumes associated with the 2018 vulcanian eruptions of Shinmoe-dake

*Jun Oikawa[1], Yasuhisa Tajima[2] (1.Earthquake Research Institute, University of Tokyo, 2.NIPPON KOEI CO.,LTD.)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SVC38-13] Crustal deformation around the Kirishima Volcano Group detected by GNSS and SAR observation after 2018 eruption.

*Hiroshi Yarai[1], Tomokazu Kobayashi[1], Satoshi Fujiwara[1], Tomokazu Kobayashi[1], Hiroshi Munekane[1], Masaki Honda[1], Kyonosuke Hayahsi[1], Satoshi Kawamoto[1], Atsuko Oowaki[1] (1.GSI of Japan)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SVC38-14] Harmonic tremor during 2011 eruption at Shinmoedake, Japan

*Minoru Takeo[1] (1.Earthquake Research Institute, University of Tokyo)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SVC38-15] Forecasting Volcanic Eruption of Sakurajima Volcano Based on Magma Intrusion Rate

*Masato Iguchi[1], Takeshi Tameguri[1], Jun-ichi Hirabayashi, Haruhisa Nakamichi[1] (1.Sakurajima Volcano Research Center, Disaster Prevention Research Institute, Kyoto University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SVC38-16] Tilt and strain change before and after the explosion at Minami-dake, Sakurajima, in 2017

*Kohei Hotta[1], Masato Iguchi[2] (1.University of Toyama, 2.Disaster Prevention Research Institute, Kyoto University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SVC38-17] Pyroclastic Flow Accompanied with an Eruption on June 16, 2018 at Sakurajima Volcano

*Takeshi Tameguri[1], Masato Iguchi[1], Masayuki Maki[2], Haruhisa Nakamichi[1], Daisuke Miki[1] (1.Sakurajima Volcano Research Center,Disaster Prevention Research Institute, Kyoto University, 2.Research Field in Integrated Studies,Kagoshima University)

[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | IC 2F

[S-VC38] Active Volcanism

convener:Yuta Maeda(Nagoya University), Takahiro Miwa(National research institute for earth science and disaster prevention), Takeshi Nishimura(Department of Geophysics, Graduate School of Science, Tohoku University), Chairperson:Hiroshi Aoyama, Satoshi Miura

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SVC38-18] Ground deformation observed at the crater area of Tokachidake volcano

*Hiroshi Aoyama[1], Takeshi Hashimoto[1], Ryo Tanaka[1], Hiromitsu Oshima[1], Koichiro Saito[2], Tsuyoshi Michishita[2], Satoshi Okuyama[2], Volcanic Observation and Warning Center Sapporo Regional Headquarters[2] (1.Institute of Seismology and Volcanology, Faculty of Science, Hokkaido University, 2.Japan Meteorological Agency)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SVC38-19] Moment tensor inversion of very-long-period seismicity at Stromboli volcano based on a very-near-field observation

*Shunsuke Sugimura[1,2], Maurizio Ripepe[2], Giorgio Lacanna[2], Denis Legrand[3], Sébastien Valade[4], Takeshi Nishimura[1] (1.Department of Geophysics, Graduate School of Science, Tohoku University, 2.Department of Earth Sciences, University of Florence, Italy, 3.UNAM University, Mexico, 4.GFZ-German Research Centre for Geosciences, Potsdam, Germany)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SVC38-20] Pressure source estimation of tilt changes associated with small explosions at Stromboli volcano

*Ayumu Ishikawa[1], Takeshi Nishimura[1], Hiroshi Aoyama[2], Ryohei Kawaguchi[3], Eisuke Fujita[4], Takahiro Miwa[4], Taishi Yamada[4], Maurizio Ripepe[5], Riccardo Genco[5] (1.Graduate school of science, Tohoku university, 2.Faculty of science, Hokkaido university, 3.Meteorological Research Institute, 4.National Research Institute for Earth Science and Disaster Resilience, 5.University of Florence)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SVC38-21] Seismic and acoustic waves excited by volcanic explosion: analyses of energy ratio and source spectra

*Mohammad Hasib[1], Takeshi Nishimura[1], Hisashi Nakahara[1] (1.Department of Geophysics, Graduate School of Science, Tohoku University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SVC38-22] Field survey report on Zao Volcano (2012–2018)

*Akio Goto[1], Noriyoshi Tsuchiya[2], Nobuo Hirano[2], Miwa Kuri[3], Tetsuya Matsunaka[4], Kengo Sawayama[2] (1.Center for Northeast Asian Studies, Tohoku University, 2.Graduate School of Environmental Studies, Tohoku University, 3.International Research Institute of Disaster Science, Tohoku University, 4.Institute of Nature and Environmental Technology, Kanazawa University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SVC38-23] Inflation Event of Zao Volcano in 2015

*Satoshi Miura[1], Mare Yamamoto[1], Masahiro Ichiki[1], Tomotsugu Demachi[1] (1.Graduate School of Science, Tohoku University)

[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | IC 2F

[S-VC38] Active Volcanism

convener:Yuta Maeda(Nagoya University), Takahiro Miwa(National research institute for earth science and disaster prevention), Takeshi Nishimura(Department of Geophysics, Graduate School of Science, Tohoku University), Chairperson:Mare Yamamoto, Yuta Maeda(Nagoya University)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SVC38-24] A machine-learning-based estimation of large amplitude regions for monitoring volcano seismicity

*Yuta Maeda[1] (1.Nagoya University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SVC38-25] Development of a technique for automatic determination of volcanic earthquakes with unclear onsets - Application to Mt. Asama -

*Takao Ohminato[1], Shigeki Horiuchi[2] (1.Earthquake Research Institute, Tokyo University, 2.Home Seismometer Corporation)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SVC38-26] Amplitude source location method with depth-dependent scattering and attenuation structures for volcano-seismic signals

*Hiroyuki Kumagai[1], John Makario Lonodno[2], Alvaro Esteban Acevedo Rivas[2], Yuta Maeda[1] (1.Graduate School of Environmental Studies, Nagoya University, 2.Colombian Geological Survey)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SVC38-27] Seismic interferometry at active volcanoes in Japan: Analyses of seismic records of JMA for the period from 2012 to 2018

*Takeshi Nishimura[1], Tomoya Takano[1], Takashi Hirose[1], Hisashi Nakahara[1] (1.Department of Geophysics, Graduate School of Science, Tohoku University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SVC38-28] Empirical relation for *Q* factors of crack resonances and its use to estimate source properties of volcanic LP events

*Kimiko Taguchi[1], Hiroyuki Kumagai[1], Yuta Maeda[1], Roberto Torres[2] (1.Nagoya University Environmental Studies, 2.Colombian Geological Survey)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SVC38-29] A study on the radiation pattern for resonating fluid-filled crack

*Mare Yamamoto[1] (1.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University)

[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-CG54] Rheology, fracture and friction in Earth and planetary sciences

convener:Miki Tasaka(Shimane University), Osamu Kuwano(Japan Agency for Marine-Earth Science and Technology), Ichiko Shimizu(Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University), Hidemi Ishibashi(Faculty of Science, Shizuoka University), Chairperson:Osamu Kuwano(Japan Agency for Marine-Earth Science and Technology (JAMSTEC)), Ichiko Shimizu

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SCG54-01] Rheology of granular materials near the jamming transition under oscillatory shear

★Invited Papers

*Michio Otsuki[1], Hisao Hayakawa[2] (1.Graduate School of Engineering Science, Osaka University, 2.Yukawa Institute for Theoretical Physics, Kyoto University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SCG54-02] The real-scale numerical sandbox experiments for understanding stress state in accretionary prisms

*Mikito Furuichi[1], Arthur Bauville[1], Daisuke Nishiura[1], Takane Hori[1], Osamu Kuwano[1] (1.Japan Agency for Marine-Earth Science and Technology)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SCG54-03] Numerical analysis on the fracture of Maxwell fluid by phase field models

*Masaharu Kameda[1], Keita Yamanishi[1], Akinori Yamanaka[1], Mie Ichihara[2] (1.Department of Mechanical Systems Engineering, Tokyo University of Agriculture and Technology, 2.Earthquake Research Institute, The University of Tokyo)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SCG54-04] Diagenesis- and earthquake-driven transformations of carbonaceous materials and their implication for frictional strength and earthquake rupture dynamics in carbon-bearing plate-subduction faults

*Shunya Kaneki[1], Tetsuro Hirono[1] (1.Graduate School of Science, Osaka University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SCG54-05] Viscous behavior of chert during frictional melting

*Ginta Motohashi[1], Kiyokazu Oohashi[2], Kohtaro Ujiie[1] (1.University of Tsukuba, 2.Yamaguchi University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SCG54-06] Effect of friction and comminution on the optically-stimulated luminescence of quartz grains

*Kiyokazu Oohashi[1], Koji Akasegawa[2], Yuki Minomo[1], Noriko Hasebe[3], Kazumasa Miura[4] (1.Graduate School of Sciences and Technology for Innovation, Yamaguchi University, 2.Daiwa Exploration & Consulting Co., Ltd., 3.Institute of Nature and Environmental Technology, Kanazawa University, 4.Graduate School of Natural Science & Technology, Kanazawa University)

[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-CG54] Rheology, fracture and friction in Earth and planetary sciences

convener:Miki Tasaka(Shimane University), Osamu Kuwano(Japan Agency for Marine-Earth Science and Technology), Ichiko Shimizu(Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University), Hidemi Ishibashi(Faculty of Science, Shizuoka University), Chairperson:Miki Tasaka(島根大学), Hidemi Ishibashi(Shizuoka University)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SCG54-07] Frictional behaviors of smectite clay: constraints for the mobility of slow-moving landslides in the cold season

★Invited Papers

*Tatsuya Shibasaki[1], Sumio Matsuura[2] (1.Japan Conservation Engineers and Co., Ltd, 2.DPRI, Kyoto University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SCG54-08] Strength of a deep fault zone along the Median Tectonic Line: Influence of chrolite friction

*Ichiko Shimizu[1], Ayumi S. Okamoto, Andre R. Niemeijer[2], Christopher J. Spiers[2], Shun Arai[3], Toru Takeshita[4] (1.Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University, 2.Faculty of Geosciences, Utrecht University, 3.Tohoku University, 4.Hokkaido University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SCG54-09] Changes in seismic wave velocity during brittle deformation of gabbro and peridotite

*Yuya Akamatsu[1], Ikuo Katayama[1] (1.Hiroshima University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SCG54-10] Dislocation textures in shock-compressed MgO and their formation mechanisms

*Kiyoshi Fujino[1], Xun Liu[2], Tsutomu Mashimo[2] (1.Geodynamics Research Center, Ehime University, 2.Institute of Pulsed Power Science, Kumamoto University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SCG54-11] Development of rotational diamond anvil cell and large strain deformation experiments of lower-mantle materials

★Invited Papers

*Shintaro Azuma[1,2], Ryuichi Nomura[3,4], Kentaro Uesugi[5], Yu Nishihara[4], Doi Shunta[4], Takeshi Arimoto[4], Tetsuo Irifune[4] (1.Tokyo Tech., 2.Kyushu Univ., 3.Kyoto Univ., 4.Ehime Univ., 5.Japan Synchrotron Radiation Research Institute (JASRI))

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SCG54-12] Rheology of hcp-iron

*Yu Nishihara[1], Doi Shunta[1], Noriyoshi Tsujino[2], Daisuke Yamazaki[2], Yuji Higo[3] (1.Geodynamics Research Center, Ehime University, 2.Institute of Planetary Materials, Okayama University, 3.Japan Synchrotron Radiation Research Institute)

[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Convention Hall A 2F

[S-CG61] Dynamics in mobile belts

convener:Yukitoshi Fukahata(Disaster Prevention Research Institute, Kyoto University), Toru Takeshita(Department of Natural History Sciences, Graduate School of Science, Hokkaido University), Hikaru Iwamori(Geochemical Evolution Research Program, Japan Agency for Marine-Earth Science and Technology), Chairperson:Keisuke Yoshida(東北大学大学院理学研究科 地球物理学専攻), Masaoki Uno(東北大学)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SCG61-13] Deciphering dynamics of thermal events at lithosphere-asthenosphere boundary from peridotite xenoliths of Ichinomegata maar, NE Japan

*Yuto Sato[1], Kazuhito Ozawa[1] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SCG61-14] **Experimental investigation of reaction-induced stress and permeability evolution in MgO–H_2O system**

*Masaoki Uno[1], Hisamu Kasahara[1], Atsushi Okamoto[1], Noriyoshi Tsuchiya[1] (1.Graduate School of Environmental Studies, Tohoku University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SCG61-15] Fluid-Flow, Resistivity and Elastic Wave Velocity Simulation of Digital Rock Fracture and Comparison with Experimental Data

*Kazuki Sawayama[1], Fei Jiang[2], Takuya ISHIBASHI[3], Takeshi Tsuji[4], Yasuhiro Fujimitsu[4] (1.Department of Earth Resources Engineering, Graduate school of engineering, Kyushu University, 2.Department of Mechanical Engineering, Faculty of Engineering, Yamaguchi University, 3.Fukushima Renewable Energy Institute, National Institute of Advanced Industrial Science and Technology, 4.Department of Earth Resources Engineering, Faculty of engineering, Kyushu University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SCG61-16] Fluid distribution in the crust – inference from seismic velocity and electrical conductivity

*Tohru Watanabe[1], Kenta Yoshida[2] (1.Gradudate School of Science and Engineering, University of Toyama, 2.Research and Development Center for Ocean Drilling Science, Japan Agency for Marine-earth Science and Technology)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SCG61-17] The seismological structure about fault zone extending to the lower crust in the northern Kinki district, southwestern Japan

*Shinya Kato[1], Yoshihisa Iio[1], Takuo Shibutani[1], Hiroshi Katao[1], Masayo Sawada[1], Kazuhide Tomisaka[1] (1.Disater Prevention Research Institute, Kyoto University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SCG61-18] Inland repeating earthquakes in the vicinity of low frequency earthquakes around Hakodate, Hokkaido

*Keisuke Yoshida[1], Akira Hasegawa[1], Shinako Noguchi[2], Keiji Kasahara[2] (1.Tohoku University, 2. Association for the Development of Earthquake Prediction)

[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Convention Hall A 2F

[S-CG61] Dynamics in mobile belts

convener:Yukitoshi Fukahata(Disaster Prevention Research Institute, Kyoto University), Toru Takeshita(Department of Natural History Sciences, Graduate School of Science, Hokkaido University), Hikaru Iwamori(Geochemical Evolution Research Program, Japan Agency for Marine-Earth Science and Technology), Chairperson:Bunichiro Shibazaki, Daisuke Sato

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SCG61-19] Modeling strain concentration and mountain building processes in central Japan considering heterogeneous rheological structure

*Bunichiro Shibazaki[1] (1.International Institute of Seismology and Earthquake Engineering, Building Research Institute)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SCG61-20] Inelastic strain rate and deviatoric stress field of the seismic gap in west part of Kyushu, Japan, estimated from seismic and geodetic data

*Yuhei Yuasa[1], Satoshi Matsumoto[2], Shigeru Nakao[3], Takeshi Matsushima[2], Takahiro Ohkura[4] (1.Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2.Institute of Seismology and Volcanology, Faculty of Sciences, Kyushu University, 3.Department of Earth and Environmental Sciences, Graduate School of Science and Engineering, Kagoshima University, 4.Aso Volcanological Laboratory, Institute for Geothermal Sciences, Graduate School of Science, Kyoto University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SCG61-21] Persistent and time-dependent crustal deformation in northern Fossa Magna and its tectonic implications

*Takeshi Sagiya[1], Koki Kumagai[2], Angela Meneses-Gutierrez[3], Nobuhisa Matsuta[4], Daisuke Hirouchi[5], Kenjiro Matsuhiro[2], Takashi OKUDA[2] (1.Disaster Mitigation Research Center, Nagoya University, 2.Graduate School of Environmental Studies, Nagoya University, 3.Disaster Prevention Research Institute, Kyoto University, 4.Graduate School of Education, Okayama University, 5.Faculty of Education, Shinshu University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SCG61-22] Unexpected relationship between ΔCFF and the strain-rate paradox: separation of plastic strain from inelastic strain

*Yukitoshi Fukahata[1], Angela Meneses-Gutierrez[1], Takeshi Sagiya[2] (1.Disaster Prevention Research Institute, Kyoto University, 2.Disaster Mitigation Research Center, Nagoya University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SCG61-23] Active period of inland earthquakes based on numerical simulation of megathrust earthquake cycle incorporating viscoelasticity

*Tsukasa MITOGAWA[1], Takuya NISHIMURA[2] (1.Graduate School of Science, Kyoto University, 2.Disaster Prevention Research Institute, Kyoto University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SCG61-24] Influence of viscoelastic relaxation on estimated interplate coupling along the Nankai Trough, southwest Japan

*Takuya NISHIMURA[1], Fred F Pollitz[2] (1.Disaster Prevention Research Institute, Kyoto University, 2.U.S. Geological Survey)

[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Convention Hall A 2F

[S-CG61] Dynamics in mobile belts

convener:Yukitoshi Fukahata(Disaster Prevention Research Institute, Kyoto University), Toru Takeshita(Department of Natural History Sciences, Graduate School of Science, Hokkaido University), Hikaru Iwamori(Geochemical Evolution Research Program, Japan Agency for Marine-Earth Science and Technology), Chairperson:Naoki Uchida, Takeshi Iinuma

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SCG61-25] Revisiting the Forearc Sliver Scenario Along the Southern Kurile Trench to Reconcile Interdisciplinary Observations

*Yuji ITOH[1], Kelin WANG[2], Takuya NISHIMURA[3] (1.Graduate School of Science, Kyoto University, 2.Pacific Geoscience Centre, Geological Survey of Canada, 3.Disaster Prevention Research Institute, Kyoto University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SCG61-26] Segmentation of crustal deformation area within the Sanriku coast, northeast Japan, on the basis of spatial distribution of millennial-scale crustal movements

*Yuichi Niwa[1] (1.Faculty of Science and Engineering, Chuo University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SCG61-27] Shear wave splitting east off NE Japan based on the S-net data

*Naoki Uchida[1], Junichi Nakajima[2], Ryota Takagi[1], Keisuke Yoshida[1], Takashi NAKAYAMA[1], Ryota Hino[1], Tomomi Okada[1], Youichi Asano[3], Sachiko Tanaka[3] (1.Research Center for Prediction of Earthquakes and Volcanic Eruptions Graduate School of Science, Tohoku University, 2.Department of Earth and Planetary Sciences, Graduate School of Science and Engineering, Tokyo Institute of Technology, Tokyo, 3.National Research Institute for Earth Science and Disaster Resilience)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SCG61-28] Gravity anomaly due to active faults and crustal rheology in the northeastern Japan arc inferred by fault dislocation model

*Mitsuhiro Hirano[1], Hiroyuki Nagahama[1], Jun Muto[1] (1.tohoku university)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SCG61-29] On the temporal decay of the localized strain rate in the Tohoku region after the Tohoku-Oki earthquake

*Youichiro Takada[1], Tomomi Inamatsu[2] (1.Faculty of Science, Hokkaido University, 2.Dept. Natural History Sciences, Hokkaido University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SCG61-30] Revisiting the Coseismic Slip Distribution of the 2011 Tohoku-oki Earthquake Considering Early Postseismic Deformation, Non-linear Viscoelasticity, and Heterogeneous Structure

*Takeshi Iinuma[1], Ryoichiro Agata[1], Yusaku Ohta[2], Ryota Hino[2], Takane Hori[1] (1.Japan Agency for Marine-Earth Science and Technology (JAMSTEC), 2.Graduate School of Science, Tohoku University)

[J] Oral | B (Biogeosciences) : B-BC Biogeochemistry

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 201A 2F

[B-BC03] Interrelation between Life, Water, Mineral, and Atmosphere

convener:Takeshi Kakegawa(Graduate School of Science, Tohoku University), Tadashi Yokoyama(Graduate School of Integrated Arts and Sciences, Hiroshima University), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Fumito Shiraishi(Department of Earth and Planetary Systems Science, Graduate School of Science, Hiroshima University), Chairperson:Tadashi Yokoyama, Keisuke Fukushi

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[BBC03-01] Chemical speciation analysis of the brown and black precipitates observed in the gill chamber of the vent shrimp *Rimicaris kairei*

*Masanari Hikosaka[1], Yoshio Takahashi[2], Chong Chen[3], Robert Jenkins[1] (1.Kanazawa University, 2.Tokyo University, 3.Japan Agency for Marine-Earth Science and Technology)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[BBC03-02] Experimental study on hydrogen generation during low temperature serpentinization by using natural samples

*Shunta Higashino[1], Ryohei Kawakita[1], Tsubasa Otake[2], Tsutomu Sato[2] (1.Graduate School of Engineering, Hokkaido University, 2.Faculty of Engineering, Hokkaido University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[BBC03-03] **Constraint on the origin of methane from Hakuba Happo serpentinite-hosted hot spring by using $^{14}CH_4$ and noble gas isotope**

*Konomi Suda[1], Takahiro AZE[2], Yosuke Miyairi[2], Yusuke Yokoyama[2], Yohei Matsui[3,2], Hisahiro Ueda[3], Takuya Saito[3], Tomohiko Sato[4], Yusuke Sawaki[2], Ryosuke Nakai[1], Hideyuki Tamaki[1], Hiroshi A Takahashi[1], Noritoshi Morikawa[1] (1.National Institute of Advanced Industrial Science and Technology, 2.The University of Tokyo, 3.Japan Agency for Marine-Earth Science and Technology, 4.Tokyo Institute of Technology)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[BBC03-04] Inhibition of calcium silicate hydrate formation by lignosulfonate and lignin

*Kanako Toda[1], Tsubasa Otake[1], Tsutomu Sato[1] (1.Laboratory of Environmental Geology, Faculty of Engineering, Hokkaido University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[BBC03-05] Calcium carbonate formation processes on cyanobacterial surface

*Fumito Shiraishi[1], Takeru Omori[1], Naotaka Tomioka[2], Satoko Motai[2], Hiroki Suga[3], Yoshio Takahashi[3] (1.Hiroshima University, 2.JAMSTEC, 3.The University of Tokyo)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[BBC03-06] Mineralogical and geochemical study on sedimentary rock containing microfossils from 1.9 billion years ago(Ga) Gunflint Formation, Canada

*kouhei Sasaki[1], Akizumi Ishida[1], Takeshi Kakegawa[1] (1.Graduate School of Science, Tohoku University)

[J] Oral | B (Biogeosciences) : B-BC Biogeochemistry

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 201A 2F

[B-BC03] Interrelation between Life, Water, Mineral, and Atmosphere

convener:Takeshi Kakegawa(Graduate School of Science, Tohoku University), Tadashi Yokoyama(Graduate School of Integrated Arts and Sciences, Hiroshima University), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Fumito Shiraishi(Department of Earth and Planetary Systems Science, Graduate School of Science, Hiroshima University), Chairperson:Takeshi Kakegawa, Fumito Shiraishi(Hiroshima Univ.)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[BBC03-07] Secular variation of multiple sulfur isotopic compositions of sulfate and sulfide during long term incubation of *Desulfovibrio desulfuricans*

*Fumihiro Matsuura[1], Hiroko Makita[2], Ken Takai[3], Yuichiro Ueno[1,3] (1.Tokyo Institute of Technology, 2.Tokyo University of Marine Science and Technology, 3.Japan Agency for Marine-Earth Science & Technology (JAMSTEC))

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[BBC03-08] **Origins of volcanic SO_2 on Earth**

*Hiroshi Ohmoto[1] (1.The Pennsylvania State University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[BBC03-09] **Volcanism, sedimentation, and development of life in a Mesoarchaean intracratonic setting: the Dominion Group, South Africa**

*Andrea Agangi[1,2], Axel Hofmann[2], Dora Paprika[2], Andrey Bekker[2,3], Frantz Ossa-Ossa[2,4] (1.Akita University, 2.University of Johannesburg, 3.University of California, 4.University of Tuebingen)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[BBC03-10] New microbial ecology results from genome centered metagenomics studies of iron carbonate and sulfidic hot springs

*Shawn E McGlynn[1], Lewis Ward[2], Takeshi Kakegawa[3], Yuichiro Ueno[1], Mayuko Nakagawa[1] (1.Earth-Life Science Institute, Tokyo Institute of Technology, 2.Harvard University, 3.Tohoku University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[BBC03-11] Superhabitability in ultradeep rocky environments

*Yohey Suzuki[1] (1.Graduate School of Science, The University of Tokyo)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[BBC03-12] Exploring planetary habitability beneath the oceans

★Invited Papers

*Fumio Inagaki[1] (1.Japan Agency for Marine-Earth Science and Technology)

[J] Oral | B (Biogeosciences)：B-CG Complex & General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 105 1F

[B-CG08] Phanerozoic biodiversity change: Extinction and diversification

convener:Yukio Isozaki(Department of Earth Science and Astronomy, Multi-disciplinary Sciences - General Systems Studies, Graduate School of Arts and Sciences, The University of Tokyo), Yusuke Sawaki(The University of Tokyo), Chairperson:Yukio Isozaki(Department of Earth Science and Astronomy, The University of Tokyo), Yusuke Sawaki(The University of Tokyo)

10:50 AM - 11:10 AM JST | 1:50 AM - 2:10 AM UTC

[BCG08-01] **The Ediacaran-Cambrian transition of North China**

★Invited Papers

*Xingliang Zhang[1] (1.State Key Laboratory of Continental Dynamics, Shaanxi Key Laboratory of Early Life and Environments, and Department of Geology, Northwest University)

11:10 AM - 11:30 AM JST | 2:10 AM - 2:30 AM UTC

[BCG08-02] The Qingjiang biota – An extraordinary new Burgess Shale-type fossil Lagerstätte from the early Cambrian of South China

★Invited Papers

*Dongjing Fu[1], Xingliang Zhang[1], Robert R. Gains[2] (1.State Key Laboratory of the Continental Dynamics, Shaanxi Key Laboratory of Early Life and Environment, Department of Geology, Northwest University, Xi'an 710069, PR China, 2.Department of Geology, Pomona College, Claremont, CA 91711, USA)

11:30 AM - 11:50 AM JST | 2:30 AM - 2:50 AM UTC

[BCG08-03] Enhanced flux of extraterrestrial ^{3}He across the Permian–Triassic boundary

★Invited Papers

*Tetsuji Onoue[1], Naoto Takahata[2], Honami Sato[4], Akira Ishikawa[3], Katsuhito Soda[1], Yuji Sano[2], Yukio Isozaki[2] (1.Kumamoto Univ., 2.Univ. Tokyo, 3.Tokyo Inst. Tech., 4.Chiba Inst. Tech.)

11:50 AM - 12:10 PM JST | 2:50 AM - 3:10 AM UTC

[BCG08-04] **End-Triassic Mass Extinction: Causes and Consequences**

★Invited Papers

*Wataru Fujisaki[1] (1.Japan Agency for Marine-Earth Science and Technology)

[J] Oral | B (Biogeosciences) : B-CG Complex & General

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 105 1F

[B-CG08] Phanerozoic biodiversity change: Extinction and diversification

convener:Yukio Isozaki(Department of Earth Science and Astronomy, Multi-disciplinary Sciences - General Systems Studies, Graduate School of Arts and Sciences, The University of Tokyo), Yusuke Sawaki(The University of Tokyo), Chairperson:Wataru Fujisaki(Japan Agency for Marine-Earth Science and Technology)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[BCG08-05] Transition of biodiversity in mobile populations and the small world in local subpopulations

*Kota Imaoka[1], Kazuhito Yamasaki[1] (1.Kobe University Graduate school of Science)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[BCG08-06] Rivision of the lowermost Cambrian SSF stratigraphy

*KONO SENA[1], Yukio Isozaki[1], Tomohiko Sato[2], Xingliang Zhang[3], Wei Liu[3] (1.The University of Tokyo School of Arts &Sciences, 2.Earth-Life Science Institute, Tokyo Institute of Technology, 3.Northwest university, China)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[BCG08-07] δ^{88}Sr and^{87}Sr/^{86}Srrecords of the Middle-Late Permian seawater: mass extinction-relevant change in ocean Sr budget

*Tomomi Kani[1], Yukio Isozaki[2], Keiji Misawa[3], Akira Ishikawa[4], Shigekazu Yoneda[5] (1.Kumamoto University, 2.The University of Tokyo, 3.National Institute of Polar Research, 4.Tokyo Tech, School of Science, 5.National Museum of Nature and Science)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[BCG08-08] Formation of stratiform manganese deposits during the Carnian (Late Triassic) “pluvial event” in the pelagic Panthalassa

*Yuki Tomimatsu[1], Tetsuji Onoue[2], Daisuke Yamashita[3], Tatsuo Nozaki[4,5,6,7], Yutaro Takaya[8] (1.Graduate school of Science and Technology, Kumamoto University, 2.Faculty of Advanced Science and Technology, Kumamoto University , 3.Satsumasendai City Office, 4.Research and Development Center for Submarine Resources, Japan Agency for Marine-Earth Science and Technology, 5.Frontier Research Center for Energy and Resources (FRC- ER), Graduate School of Engineering, Tokyo University, 6.Department of Planetology, Graduate School of Science, Kobe University, 7.Ocean Resources Research Center for Next Generation, Chiba Institute of Technology, 8.Department of Resources and Environmental Engineering School of Creative Science and Enginerring, Waseda University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[BCG08-09] Enrichment of chalcophile elements in Cretaceous–Paleogene boundary clays

*Teruyuki Maruoka[1], Yoshiro Nishio[2] (1.Faculty of Life and Environmental Sciences, University of Tsukuba, 2.Research and Education Faculty, Kochi University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[BCG08-10] Mass extinctions: hierarchy of causes and cosmoclimatological perspective

*Yukio Isozaki[1] (1.Department of Earth Science and Astronomy, Multi-disciplinary Sciences - General Systems Studies, Graduate School of Arts and Sciences, The University of Tokyo)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 303 3F

[M-IS10] Interface- and nano-phenomena on crystal growth and dissolution

convener:Yuki Kimura(Institute of Low Temperature Science, Hokkaido University), Hitoshi Miura(Graduate School of Natural Sciences, Department of Information and Basic Science, Nagoya City University), Hisao Satoh(Naka Energy Research Laboratory, Mitsubishi Materials Corporation), Katsuo Tsukamoto(Graduate School of Engineering, Osaka University), Chairperson:Yuki Kimura (Institute of Low Temperature Science, Hokkaido University)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[MIS10-01] Fabrication of octacalcium phosphate block through a dissolutionprecipitation reaction and its biological evaluation

*Yuki Sugiura[1], Munar L Melvin[2], Kunio Ishikawa[2] (1.National Institute of Advanced Industrial Science and Technology, 2.Kyushu University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[MIS10-02] Development of optimized incineration process of fisheries waste for synthesizing a functional heat storage material

*Hidekazu Kobatake[1], SHinji Kirihara[1] (1.Hirosaki University Institute of Regional Innovation)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[MIS10-03] “Manipulated” Organic Crystallization and Two-step Dissolution Process Attained by Plasmonic Optical Tweezers

*Hiromasa Niinomi[1], Teruki Sugiyama[2,3,4], Miho Tagawa[5], Toru Ujihara[5], Katsuhiko Miyamoto[6,7], Takashige Omatsu[6,7], Jun Nozawa[1], Junpei Okada[1], Satoshi Uda[1] (1.Institute for Materials Research, Tohoku University, 2.Department of Applied Chemistry, National Chiao Tung University, 3.Center for Emergent Functional Matter Science, National Chiao Tung University, 4.Division of Materials Science, Nara Institute of Science and Technology, 5.Institute of Materials and Systems for Sustainability (IMaSS), Nagoya University, 6.Molecular Chirality Research Center (MCRC), Chiba University, 7.Graduate School of Engineering, Chiba University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[MIS10-04] Investigation of liquid cell transmission electron microscopy combined with antisolvent crystallization

*Tomoya Yamazaki[1], Yuki Kimura[1] (1.Institute of Low Temperature Science Hokkkaido University)

10:00 AM - 10:30 AM JST | 1:00 AM - 1:30 AM UTC

[MIS10-05] DNA-guided crystallization of nanoparticles: optimization of crystallization conditions and structure analysis

★Invited Papers

*Miho Tagawa[1], Shoko Kojima[1], Hayato Sumi[1], Arisa Nishibu[1], Takumi Isogai[1], Maasa Yokomori[2], Shunta Harada[1], Toru Ujihara[1], Katsuo Tsukamoto[1] (1.Nagoya University, 2.The University of Tokyo)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 303 3F

[M-IS10] Interface- and nano-phenomena on crystal growth and dissolution

convener:Yuki Kimura(Institute of Low Temperature Science, Hokkaido University), Hitoshi Miura(Graduate School of Natural Sciences, Department of Information and Basic Science, Nagoya City University), Hisao Satoh(Naka Energy Research Laboratory, Mitsubishi Materials Corporation), Katsuo Tsukamoto(Graduate School of Engineering, Osaka University), Chairperson:Hisao Satoh

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MIS10-06] Growth mechanism of binary colloidal crystals

*Jun Nozawa[1], Suxia Guo[1], Hiromasa Niinomi[1], Junpei Okada[1], Satoshi Uda[1] (1.Tohoku University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MIS10-07] Solution-Mediated-Transformation Kinetics of Norsethite

*Harutoshi Asakawa[1], Hiroshi Uneda[1], Itaru Echigo[1], Ryuichi Komatsu[1] (1.Graduate School of Sciences and Technology for Innovation Yamaguchi University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MIS10-08] Formation of low-crystalline magnesium silicate in natural alkaline environment and flow-through experiments

*Yuto Nishiki[1], Misato Shimbashi[1], Tsutomu Sato[2], Tsubasa Otake[2] (1.Graduate School of Engineering, Hokkaido University, 2.Faculty of Engineering, Hokkaido University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MIS10-09] Homogeneous Nucleation from Vapor in Al-O Binary System

*Shinnosuke Ishizuka[1], Jun Kawano[2], Tomoya Yamazaki[3], Tetsuya Hama[3], Yuki Kimura[3] (1.National Institute for Environmental Studies, 2.Faculty of Science, Hokkaido University, 3.Institute of Low Temperature Science, Hokkaido University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MIS10-10] Crystal growth hysteresis in birth-and-spread mechanism

*Hitoshi Miura[1] (1.Graduate School of Natural Sciences, Department of Information and Basic Science, Nagoya City University)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[M-IS11] Aqua planetology

convener:Yasuhito Sekine(Earth-Life Science Insitute, Tokyo Institute of Technology), Tomohiro Usui(Earth-Life Science Institute, Tokyo Institute of Technology), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Takazo Shibuya(Japan Agency for Marine-Earth Science and Technology), Chairperson:Yasuhito Sekine(Dept. Earth & Planetary Sci., University of Tokyo), Takazo Shibuya(JAMSTEC), Tomohiro Usui

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[MIS11-13] A forward modeling of infrared reflectance spectra of asteroids

*Hiroyuki Kurokawa[1], Takazo Shibuya[2], Yasuhito Sekine[1], Bethany L Ehlmann[3,4] (1.ELSI, Tokyo Tech, 2.JAMSTEC, 3.Caltech, 4.JPL)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[MIS11-14] Estimation of formation mechanism and morphological condition in calcite concretion

*Takayuki Ihara[1], Sin-iti Sirono[1] (1.Nagoya University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[MIS11-15] Reconstructing groundwater hydrology and water-rock reactions around Gale Crater on early Mars

*Natsumi Noda[1,2], Yasuhito Sekine[1], Shuya Tan[1,2], Takazo Shibuya[3], Hidenori Genda[1] (1.Earth-Life Science Institute, Tokyo Institute of Technology, 2.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 3.Department of Subsurface Geobiological Analysis and Research, Japan Agency for Marine-Earth Science and Technology)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[MIS11-16] Habitable zone for a land planet

*Takanori Kodama[1], Hidenori Genda[2], Ryouta O'ishi[3], Ayako Abe-Ouchi[3] (1.University of Bordeaux, 2.Earth-Life Science Institute, Tokyo Institute of Technology, 3.Atmosphere and Ocean Research Institute, University of Tokyo)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[MIS11-17] A study on the dependence of ocean planet climate on solar constant: influence of oceanic heat transport in the case of large absorption coefficients of gray atmosphere

*Yuta Kawai[1,2], Yoshiyuki O. Takahashi[1], Masaki Ishiwatari[5], Kensuke Nakajima[3], Shin-ichi Takehiro[4], Hiroki Kashimura[1,6], Seiya Nishizawa[2], Hirofumi Tomita[2], Yoshi-Yuki Hayashi[1,6] (1.Kobe University, 2.RIKEN Center for Computational Science, 3.Kyusyu University, 4.Kyoto University , 5.Hokkaido University, 6.Center for Planetary Science)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[MIS11-18] Water cycle and its evolution: High-speed H_2O transport to upper atmosphere on Mars

★Invited Papers

*Hiromu Nakagawa[1], Shohei Aoki[1], Nao Yoshida[1], Naoki Terada[1], Takeshi Imamura[2], Kazunori Ogohara[3], Toru Kouyama[4], Hiroki Ando[6], Katsuyuki Noguchi[5], Akiho Miyamoto[1], Kosuke Takami[1], Isao Murata[1], Yasumasa Kasaba[1], IUVS team MAVEN (1.Planetary Atmosphere Physics Laboratory, Department of Geophysics, Graduate School of Science, Tohoku University, 2.Graduate school of Frontier sciences, University of Tokyo, 3.University of Shiga prefecture, 4.The National Institute of Advanced Industrial Science and Technology, 5.Nara Women's university, 6.Kyoto Sangyo university)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[M-IS21] Gas hydrate in environmental-resource sciences

convener:Hitoshi Tomaru(Department of Earth Sciences, Chiba University), Akihiro Hachikubo(Kitami Institute of Technology), Atsushi Tani(Graduate School of Human Development and Environment, Kobe University), Shusaku Goto(Institute for Geo-Resources and Environment National Institute of Advanced Industrial Science and Technology), Chairperson:Naoto Ishida, 戸丸 仁

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MIS21-01] Equilibrium pressure of clathrate hydrates encaged $^{13}CH_4$

*Yuki Kikuchi[1], Akihiro Hachikubo[1], Takahiro Ozeki[1], Satoshi Takeya[2] (1.Kitami Institute of Technology, 2.National Institute of Advanced Industrial Science and Technology (AIST))

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MIS21-02] Hydrogen isotopic fractionation of ethane encaged in different crystallographic structure

*Jumpei Matsuda[1], Akihiro Hachikubo[1], Satoshi Takeya[2] (1.Kitami Institute of Technology, 2.National Institute of Advanced Industrial Science and Technology (AIST))

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MIS21-03] Trend of effect of temperature on C–H symmetric stretching vibrational frequencies of hydrocarbon molecules in 12, 14 and 16-hedra cages of gas hydrates

*Go Fuseya[1], Satoshi Takeya[2], Akihiro Hachikubo[1] (1.Kitami Institute of Technology, 2.National Institute of Advanced Industrial Science and Technology (AIST))

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MIS21-04] The study on relations of the methane plume and atmospheric methane concentration

*Chiharu Aoyama[1] (1.Tokyo University of Marine Science and Technology)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MIS21-05] Sampling of Methane Bubble Plumes and Solid Gas Hydrate on the Cascadia Margin, Pacific Northwest

*John E Lupton[1], Tamara Baumberger[1], Robert W. Embley[1], Susan G. Merle[1], Camilla Wilkinson[1], Conrad Young[2] (1.NOAA Pacific Marine Environmental Laboratory, Newport, Oregon, USA, 2.Young Engineering, Ramona, CA. USA)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[M-IS21] Gas hydrate in environmental-resource sciences

convener:Hitoshi Tomaru(Department of Earth Sciences, Chiba University), Akihiro Hachikubo(Kitami Institute of Technology), Atsushi Tani(Graduate School of Human Development and Environment, Kobe University), Shusaku Goto(Institute for Geo-Resources and Environment National Institute of Advanced Industrial Science and Technology), Chairperson:八久保 晶弘(北見工業大学), 戸丸 仁

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MIS21-06] The distribution of atmospheric CH_4 concentration and gas plume location in the sea around Japanese islands.

*Shinsuke Aoki[1], Shujiro Komiya[2], Kosuke Noborio[3], Ryo Matsumoto[4] (1.Graduate School of Agriculture, Meiji Universiy, 2.Max Planck Institute, 3.School of Agriculture, Meiji Universiy, 4.Gas Hydrate Laboratory - Meiji University Organization for the Strategic Coordination of Research and Intellectual Property)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MIS21-07] Reaction/fixation/migration of methane within the gas chimney on the Umitaka Spur, eastern margin of the Japan Sea

*Hitoshi Tomaru[1], Ryo Matsumoto[2] (1.Department of Earth Sciences, Chiba University, 2.Gas Hydrate Research Laboratory, Meiji University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MIS21-08] Slope failures induced by methane hydrate dissociation: a case of submarine slide in the southwestern Oki Trough, Japan Sea

*Naoto Ishida[1], Shota Morihita[2], Takao Ebinuma[1], Hitoshi Tomaru[3], Ryo Matsumoto[4] (1.Social Systems and Civil Engineering, Graduate School of Engineering, Tottori University, 2.Department of Social Systems and Civil Engineering, Faculty of Engineering, Tottori University, 3.Department of Earth Sciences, Faculty of Science, Chiba University, 4.Gas Hydrate Research Laboratory, Organization for the Strategic Coordination of Research and Intellectual Properties, Meiji University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MIS21-09] Origin and evolution of H_2S-bearing methane hydrate in the Sea of Japan

*Ryo Matsumoto[1], Tomoko Fukazawa[2], Akihiro Hiruta[1], Glen Snyder[1] (1.Organization for the Strategic Laboratory of Research and Intellectual Properties, Meiji University, 2.Department of Applied Chemistry, School of Science and Technoloty, Meiji University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MIS21-10] Discovery of gas hydrate at the new point off Abashiri, the Sea of Okhotsk

*Akihiro Hachikubo[1], Jumpei Matsuda[1], Satoshi Yamashita[1], Hirotoshi Sakagami[1], Masaaki Konishi[1], Hirotsugu Minami[1], Kenji Nishina[2], Kenji Sakaguchi[3] (1.Kitami Institute of Technology, 2.Geological Survey of Hokkaido, Hokkaido Research Organization, 3.Kushiro Fisheries Research Institute, Hokkaido Research Organization)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MIS21-11] All about gas hydrates and heat flow offshore Chile

*LUCIA ALEJANDRA VILLAR MUNOZ[1], IVAN VARGAS-CORDERO[2], JOAQUIM P. BENTO[3], JAN BEHRMANN[1], UMBERTA TINIVELLA[4], MICHELA GIUSTINIANI[4] (1.Helmholtz Centre for Ocean Research, 2.Universidad Andres Bello , 3.Pontificia Universidad Catolica de Valparaiso, 4.Istituto Nazionale di Oceanografia e di Geofisica Sperimentale)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 202 2F

[M-IS27] Atmospheric electricity: Applications toward natural disaster mitigation

convener:Yasuhide Hobara(Graduate School of Information and Engineering Department of Communication Engineering and Informatics, The University of Electro-Communications), Masashi Kamogawa(Department of Physics, Tokyo Gakugei University), Chairperson:Takeshi Morimoto

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[MIS27-01] Advantage and Disadvantage of the Phased Array Weather Radar

*Tomoo Ushio[1], Tomoaki Mega[1], Hiroshi Kikuchi[2], Eiichi Yoshikawa[3] (1.Tokyo Metropolitan University, 2.University of Electro-Communications, 3.JAXA)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[MIS27-02] Initial Observations with X-band Dual Polarimetric Phased Array Weather Radar in Tokyo

*Hiroshi Kikuchi[1], Taku Suezawa[2], Yasuhide Hobara[1], Tomoo Ushio[2] (1.The University of Electro-Communications, 2.Tokyo Metropolitan University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[MIS27-03] Three-dimensional total lightning characteristics of convective cells observed by the Tokyo LMA in the summer season in Tokyo Metropolitan area

*Namiko Sakurai[1], Paul R. Krehbiel[2], William Rison[2], Ronald J. Thomas[2], Daniel Rodeheffer[2], Shingo Shimizu[1], Koyuru Iwanami[1], Takeshi Maesaka[1], Kaori Kieda[1], Yasushi Uji[1] (1.National Research Institute For Earth Science and Disaster Resilience, 2.New Mexico Tech.)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[MIS27-04] Estimating rainfall in heavy rain events using lightning data in Japan

*Ogawa Tetsuya[1], Yasuhide Hobara[1], Hiroyuki IWASAKI[2], Stan Heckman[3], Michael Stock[3] (1.University of Electro-Communications, 2.Gunma University, 3.EarthNetworks)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[MIS27-05] The Effect of Lightning Phenomena on Lightning Protection for Objects on the Ground

★Invited Papers

*Yokoyama Shigeru[1] (1.Shizuoka University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[MIS27-06] Lightning charge moment changes deduced from highly sensitive ELF magnetic field observations in Southeast Asia

*Yasuhide Hobara[1], Amir Izzani Mohamed[2], Chandima Gomes[3], Wan Ismail Bin Ibrahim[2], Zulkurnain Abdul-Malek[4], Syahrun Nizam[5], Michael Stock[6], Kazuo Shiokawa[7], Hiroshi Kikuchi[1], Takuo T. Tsuda[1] (1.Graduate School of Information and Engineering Department of Communication Engineering and Informatics, The University of Electro-Communications, 2.University of Malaysia Pahang Pekan, Malaysia, 3.University of the Witwatersrand Johannesburg, South Africa, 4.Universiti Teknologi Malaysia Johor Bahru, Malaysia, 5.University Malaysia Perlis Perlis, Malaysia, 6.EarthNetworks, Inc. Germantown, USA, 7.Nagoya University, Nagoya, Japan)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 202 2F

[M-IS27] Atmospheric electricity: Applications toward natural disaster mitigation

convener:Yasuhide Hobara(Graduate School of Information and Engineering Department of Communication Engineering and Informatics, The University of Electro-Communications), Masashi Kamogawa(Department of Physics, Tokyo Gakugei University), Chairperson:Yasuhide Hobara

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MIS27-07] Earthquake precursory electromagnetic phenoma : Summary and prospective

★Invited Papers

*Masashi Hayakawa[1] (1.Hayakawa Institute of Seismo Electromagnetics.Co. LTD. University of Electro-Communications venture company)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MIS27-08] Detection of lower ionospheric anomaly preceding earthquake using nonlinear autoregressive neural network

*Kakeru Matsuki[1], Hayato Iibuchi[1], Hendy Santosa[3], Yasuhide Hobara[1], Michael A Balikhin[2] (1.The University of Electro-Communications , 2.University of Sheffield, 3.University of Bengkulu)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MIS27-09] Analysis of multipoint measurements of plasma turbulence

*Michael A Balikhin[1], Simon N Walker[1] (1.University of Sheffield)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MIS27-10] Progress of Observation Project for High-energy Phenomena in Winter Thunderstorms

*Yuuki Wada[1,2], Teruaki Enoto[3], Takahiro Matsumoto[1], Kazuhiro Nakazawa[4], Yoshihiro Furuta[5], Takayuki Yuasa, Harufumi Tsuchiya[5], Daisuke Yonetoku[6], Tatsuya Sawano[6], Kazuo Makishima[1,2], Masashi Kamogawa[7], Yoshitaka Nakamura[8], Takeshi Morimoto[9], Mitsuteru Sato[10], Hideo Sakai[11], Hidehito Nanto[12], Tomoo Ushio[13] (1.The University of Tokyo, 2.RIKEN, 3.Kyoto University, 4.Nagoya University, 5.Japan Atomic Energy Agency, 6.Kanazawa University, 7.Tokyo Gakugei University, 8.Kobe City College of Technology, 9.Kindai University, 10.Hokkaido University, 11.University of Toyama, 12.Kanazawa Institute of Technology, 13.Tokyo Metropolitan University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MIS27-11] Electromagnetic and stroke current observations on rocket-triggered lightning

*Takeshi Morimoto[1], Shinya Kurokawa[1], Yoshitaka Nakamura[2], Kazuo Yamamoto[3] (1.Kindai University, 2.Kobe City College of Technology, 3.Chubu University)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[M-GI34] Marine Manganese Minerals

convener:Akira Usui(Marine Core Research Center, Kochi University), Yoshio Takahashi(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Katsuhiko Suzuki(Research and Development Center for Submarine Resources, Japan Agency for Marine-Earth Science and Technology), Takashi Ito(Faculty of Education, Ibaraki University), Chairperson:takashi ito(Ibaraki Univ.), Yoshio Takahashi(東京大学), Katsuhiko Suzuki(JAMSTEC)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MGI34-01] Challenges in microstratigraphy on the hydrogenetic ferromanganese crusts: Depositional processes and environments recorded as secular variations in microstructure, chemical and mineralogical compositions.

*Akira Usui[1], Anna Nagaoka[2], Go-Ichiro Uramoto[1], Masafumi MURAYAMA[3] (1.Marine Core Research Center, Kochi University, 2.Graduate School of Science, Kochi University, 3.Fac. Agriculture and Marine Sciences, Kochi University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MGI34-02] Abundant ferromanganese microparticles in oxic pelagic sediments

*Go-Ichiro Uramoto[1,2], Yuki Morono[2], Naotaka Tomioka[2], Shigeyuki Wakaki[2], Ryoichi Nakada[2], Rota Wagai[3], Kentaro Uesugi[4], Akihisa Takeuchi[4], Masato Hoshino[4], Yoshio Suzuki[4,5], Satoshi Mitsunobu[6], Fumito Shiraishi[7], Hiroki Suga[5], Yasuo Takeichi[8], Yoshio Takahashi[5], Fumio Inagaki[2] (1.Kochi University, 2.Japan Agency for Marine-Earth Science and Technology, 3.National Agriculture and Food Research Organization, 4.Japan Synchrotron Radiation Research Institute, 5.University of Tokyo, 6.Ehime University, 7.Hiroshima University, 8.High Energy Accelerator Research Organization)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MGI34-03] Fractionation of Zirconium-Hafnium in ferromanganese crusts

*Aya Sakaguchi[1], Junpei Inagaki[1], Minami Inoue[2], Akira Usui[3], Hiromitsu Haba[4], Masashi Kaneko[5], Shinya Yamasaki[1], Keisuke Sueki[1], Yoshio Takahashi[6] (1.Faculty of Pure and Applied Science, 2.Graduate School of Science, Hiroshima University, 3.Center for Advanced Marine Core Research , Kochi University, 4.Nishina Center, Riken, 5.Nuclear Science and Engineering Center, Japan Atomic Energy Agency, 6.Graduate School of Science, The University of Tokyo)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MGI34-04] Isotope fractionation of Mo-like elements during adsorption to ferromanganese oxides

*Masato Tanaka[1], Yoshio Takahashi[1] (1.Graduate School of Science, The University of Tokyo)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MGI34-05] **Distinct distribution trends of arsenate and molybdate in marine ferromanganese nodules**

*Shitong Yang[1], Soichiro Uesugi[1], Haibo Qin[1], Akira Usui[2], Yoshio Takahashi[1] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2.Geology Department, Kochi University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MGI34-06] Mineralogical and geochemical characteristics of ferromanganese nodules in the Minamitorishima EEZ

*Kentaro Nakamura[1], Koichi Horinouchi[1], Ryo Shimomura[1], Shiki Machida[2], Kazutaka Yasukawa[1,2], Koichiro Fujinaga[1,2], Yasuhiro Kato[1,2] (1.Department of Systems Innovation, School of Engineering, University of Tokyo, 2.ORCeNG, Chiba Institute of Technology)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 301B 3F

[M-GI35] Development of computational sciences on planetary formation, evolution and surface environment

convener:Yoshi-Yuki Hayashi(Department of Planetology/CPS, Graduate School of Science, Kobe University), Masaki Ogawa(Division of General Systems Studies, Graduate School of Arts and Sciences, University of Tokyo), Shigeru Ida(Earth-Life Science Institute, Tokyo Institute of Technology), Kanya Kusano(Institute for Space-Earth Environmental Research, Nagoya University), Chairperson:Hiroki Kashimura

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MGI35-01] Simulation Studies of Solar Activities as a Cause of Solar-Terrestrial Environment Variation

*Kanya Kusano[1], Hideyuki Hotta[2] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Faculty of Science and Engineering, Chiba University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MGI35-02] Development of a global non-hydrostatic Martian atmospheric model and its high-resolution simulation

*Hiroki Kashimura[1], Hisashi Yashiro[2], Seiya Nishizawa[2], Hirofumi Tomita[2], Kensuke Nakajima[3], Masaki Ishiwatari[4], Yoshiyuki O. Takahashi[1], Yoshi-Yuki Hayashi[1] (1.Kobe University/Center for Planetary Science, 2.RIKEN Center for Computational Science, 3.Kyushu University, 4.Hokkaido University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MGI35-03] Numerical simulations on the collision, adhesion, and growth of dust particles in turbulent gas in a protoplanetary disk

*Takashi Ishihara[1], Kohei Hamabata[2], Yoshiki Sakurai[2], Masayuki Umemura[3] (1.Graduate School of Environmental and Life Science, Okayama University, 2.Graduate School of Engineering, Nagoya University, 3.Center for Computational Sciences, University of Tsukuba)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MGI35-04] Development of N-body Simulation Code for Planetary System Formation With Particle-Particle Particle-Tree Scheme

*Yota Ishigaki[1,4], Junko Kominami[2], Junichiro Makino[3], Masaki Fujimoto[4] (1.University of Tokyo, 2.Tokyo Institute of Technology, 3.RIKEN AICS, 4.Institite of Space and Astronautical Science, Japan Aerospace Exploration Agency)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MGI35-05] Current status of post-K Exploratory Challenge, computational planetary science

*Junichiro Makino[1,2] (1.Kobe Univ, 2. RIKEN R-CCS)

Wed. May 29, 2019

[J] Oral | U (Union)：Union

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 103 1F

[U-04] Capture the fast process in Earth and planetary science

convener:Takashi Yoshino(Institute for Planetary Materials, Okayama University), Yoshinori Tange(Japan Synchrotron Radiation Research Institute), Chairperson:Takashi Yoshino(Okayama University), Yoshio Kono(愛媛大学地球深部ダイナミクスセンター), Yoshinori Tange

1:48 PM - 2:00 PM JST | 4:48 AM - 5:00 AM UTC

[U04-01] Toward organization of a new field on fast process in Earth and planetary science

★Invited Papers

*Takashi Yoshino[1] (1.Institute for Planetary Materials, Okayama University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[U04-02] Fractal particle size distribution of pulverized fault rocks and dynamic fragmentation of rocks

★Invited Papers

*Jun Muto[1], Osamu Nishikawa[2], Hiroyuki Nagahama[1] (1.Department of Earth Sciences, Tohoku University, 2.Graduate School of Engineering and Resource Sciences, Akita University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[U04-03] Universal aspects of acceleration process toward unstable fast rupture

★Invited Papers

*Takahiro Hatano[1] (1.Earthquake Research Institute, University of Tokyo)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[U04-04] Semi-brittle flow in dunite and harzburgite at upper mantle pressures

★Invited Papers

*Tomohiro Ohuchi[1], Xinglin Lei[2], Yuji Higo[3], Yoshinori Tange[3] (1.Geodynamics Research Center, Ehime University, 2.National Institute of Advanced Industrial Science and Technology, 3.Japan Synchrotron Radiation Research Institute)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[U04-05] A mechanism of magma fracturing revealed by in-situ X-ray imaging and diffraction

★Invited Papers

*Satoshi Okumura[1], Kentaro Uesugi[2], Tatsuya Sakamaki[1], Akio Goto[3] (1.Division of Earth and Planetary Materials Science, Department of Earth Science, Graduate School of Science, Tohoku University, 2.SPring-8/JASRI, 3.Center for Northeast Asian Studies, Tohoku University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[U04-06] Estimation of physical parameters of volcanic eruptions based on analysis of eruptive products –Toward understanding of eruption dynamics–

★Invited Papers

*Fukashi Maeno[1] (1.Earthquake Research Institute, University of Tokyo)

[J] Oral | U (Union)：Union

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 103 1F

[U-04] Capture the fast process in Earth and planetary science

convener:Takashi Yoshino(Institute for Planetary Materials, Okayama University), Yoshinori Tange(Japan Synchrotron Radiation Research Institute), Chairperson:Takashi Yoshino(Okayama University), Yoshio Kono(愛媛大学地球深部ダイナミクスセンター), Yoshinori Tange

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[U04-07] Chemical reaction processes bridge between asteroid Ryugu and early evolution of Earth

★Invited Papers

*Seiji Sugita[1,3], Hideharu Kuwahara[2], Kosuke Kurosawa[3] (1.Department of Earth and Planetary Science, Graduate School of Science Sciece, The University of Tokyo, 2.Ehime University, 3.Chiba Institute of Technology)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[U04-08] Time-resolved synchrotron X-ray observations of mineral transformations under static pressures: applications to non-equilibrium behaviors in shocked meteorites

★Invited Papers

*Tomoaki Kubo[1], Masaaki Miyahara[2] (1.Kyushu University, 2.Hiroshima University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[U04-09] Ultrafast pump-probe experiemnts for planetary materials using high-power lasers and XFEL

★Invited Papers

*Norimasa Ozaki[1] (1.Osaka University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[U04-10] Tracking dynamical phenomena with X-ray free-electron lasers

★Invited Papers

*Tetsuo Katayama[1] (1.Japan Synchrotron Radiation Research Institute)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[U04-11] High speed measurement with synchrotron radiation X-ray.

★Invited Papers

*Kentaro Uesugi[1] (1.Japan Synchrotron Radiation Research Institute)

4:45 PM - 4:58 PM JST | 7:45 AM - 7:58 AM UTC

[U04-12] Recent advances in high-pressure synchrotron X-ray experiments on magmas under pressure at the beamline 16-BM-B in Advanced Photon Source

★Invited Papers

*Yoshio Kono[1] (1.Geodynamics Research Center, Ehime University)

[J] Oral | U (Union)：Union

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Convention Hall A 2F

[U-07] How JpGU will manage environment and disaster from the impacts of unforeseen geo-hazards

convener:Koji Okumura(Graduate School of Letters, Hiroshima University), Jun Matsumoto(Deaprtment of Geography, Tokyo Metropolitan University), Daisaku Kawabata(Institute of Geology and Geoinformation, Geological Survey of Japan, AIST), Masaki Matsushima(Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology), Chairperson:Daisaku Kawabata, Koji Okumura(Hiroshima University)

10:45 AM - 10:55 AM JST | 1:45 AM - 1:55 AM UTC

[U07-01] Seismotectonic environments and landscape as keys to mitigate the impacts from unexpected hazards

*Koji Okumura[1] (1.Graduate School of Letters, Hiroshima University)

10:55 AM - 11:10 AM JST | 1:55 AM - 2:10 AM UTC

[U07-02] Activities related with the eruption at Kusatsu-Shiranesan (Motoshiranesan) volcano on 23 Jan,2018 - Focusing on JMA's activities -

*Junichi Miyamura[1] (1.Japan Meteorological Agency)

11:10 AM - 11:25 AM JST | 2:10 AM - 2:25 AM UTC

[U07-03] Correspondences to society events at emergency disaster – In case of the Annual Meeting of the Geological Society of Japan -

*Matsuda Hiroki[1,2] (1.Kumamoto University, 2.the Geological Society of Japan)

11:25 AM - 11:40 AM JST | 2:25 AM - 2:40 AM UTC

[U07-04] Aftershock and microtremor array observation around the source area of the 2018 Hokkaido Eastern Iburi earthquake

*Masayuki Yoshimi[1], Kahori Iiyama[2], Hitoshi Morikawa[2], Hiroyuki Goto[3] (1.Geological Survey of Japan, AIST, 2.Tokyo Institute of Technology, 3.DPRI, Kyoto Univ.)

11:40 AM - 11:55 AM JST | 2:40 AM - 2:55 AM UTC

[U07-05] Effect of non-linear site response on earthquake hazard map

*Takao Kagawa[1] (1.Tottori University Graduate School of Engineering)

11:55 AM - 12:10 PM JST | 2:55 AM - 3:10 AM UTC

[U07-06] Evolution of catastrofic landslides due to rapid valley incision and filling since Last Glacial Age in central Nepal Himalayas

★Invited Papers

*Hiroshi YAGI[1] (1.Faculty of Art, Science and Education, Yamagata University)

[J] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[P-EM16] Physics and Chemistry in the Atmosphere and Ionosphere

convener:Yuichi Otsuka(Institute for Space-Earth Environmental Research, Nagoya University), Takuya Tsugawa(National Institute of Information and Communications Technology), Seiji Kawamura(National Institute of Information and Communications Technology), Chairperson:Mitsumu Ejiri(国立極地研究所), Yuichi Otsuka

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[PEM16-01] The model study of ionospheric variations during the solar eclipse event by assimulating the GNSS TEC observations

*Chia-Hung Chen[1], Charles Lin[1], Tomoko Matsuo[2] (1.Department of Earth Sciences, National Cheng Kung University, 2.Department of Aerospace Engineering Sciences, University of Colorado at Boulder, CO)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[PEM16-02] Characteristics of mesoscale thermospheric-ionospheric dynamics associated with heating in the auroral region

*Tomokazu Oigawa[1], Hiroyuki Shinagawa[2], Satoshi Taguchi[1] (1.Department of Geophysics, Graduate School of Science, Kyoto University, 2.National Institute of Information and Communications Technology)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[PEM16-03] Spatial distribution of the polar thermospheric wind acceleration and importance of the 2D measurement

*Shin-ichiro Oyama[1,2,3], Anita Aikio[2], Mark G Conde[4], Heikki Vanhamaki[2], Ilkka Virtanen[2], Thomas Ulich[5], Urban Brandstrom[6], Pekka Verronen[7], Monika Andersson[7], Niilo Kalakoski[7], Lassi Roininen[8], Sari Lasanen[8], Abiyot Workayehu[2], Kazuo Shiokawa[1], Heqiucen XU[1], Mamoru Ishii[9], Masafumi Hirahara[1], Takeshi Sakanoi[10], Masato Kagitani[10], Juha Sorri[5], Tomi Teppo[5], Yoshimasa Tanaka[3], Christopher Fallen[4], Brenton J Watkins[4], Mikko Orispaa[5], Yasunobu Ogawa[3], Lei Cai[11], Esa Turunen[5], Kirsti Kauristie[7], Takuo T. Tsuda[12], Junichi Kurihara[13] (1.Institute for Space-Earth Environmental Research, Nagoya University, Japan, 2.University of Oulu, Finland, 3.National Institute of Polar Research, Japan, 4.Geophysical Institute, University of Alaska Fairbanks, US, 5.Sodankyla Geophysical Observatory, University of Oulu, Finland, 6.The Swedish Institute of Space Physics (IRF), Sweden, 7.Finnish Meteorological Institute, Finland, 8.Lappeenranta-Lahti University of Technology, Finland, 9.National Institute of Information and Communications Technology, Japan, 10.Tohoku University, Japan, 11.KTH Royal Institute of Technology, Sweden, 12.The University of Electro-Communications, 13.Hokkaido University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[PEM16-04] Analysis of the thermospheric neutral wind vector using observed images of *Trimethylaluminium* (*C6H18Al2*) released from sounding rocket in the upper atmosphere

*Yuki Otsuka[1], Masa-yuki Yamamoto[1], Hiroaki Saito[1] (1.Kochi University of Technology)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[PEM16-05] Establishment of real-time analysis method in a new HRO interferometer system and operation test of comprehensive meteor observation

*Takumi Sato[1], Seiya Takeda[2], Masa-yuki Yamamoto[1] (1.KOCHI UNIVERSITY OF TECHNOLOGY, 2.Inc.Bascule)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[PEM16-06] Solar flare effects of the D-region ionosphere using daytime tweek atmospherics

*Kodai Yamanobe[1], Hiroyo Ohya[2], Hiroyuki Nakata[2], Toshiaki Takano[2], Kazuo Shiokawa[3] (1.Graduate School of Science and Engineering, Chiba University , 2.Graduate School of Science and Engineering, Chiba University, 3.Institute for Space-Earth Environmental Research, Nagoya University)

[J] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[P-EM16] Physics and Chemistry in the Atmosphere and Ionosphere

convener:Yuichi Otsuka(Institute for Space-Earth Environmental Research, Nagoya University), Takuya Tsugawa(National Institute of Information and Communications Technology), Seiji Kawamura(National Institute of Information and Communications Technology), Chairperson:Yuichi Otsuka, Mitsumu Ejiri(国立極地研究所)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[PEM16-07] Toward a detection of sporadic-E episodes by ALOS2 ScaSAR InSAR

*Masato Furuya[1], Jun Maeda[2], Kosuke Heki[1] (1.Department of Earth and Planetary Sciences Hokkaido University, 2.Hokkaido University Library)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[PEM16-08] Vertical fine structure and time evolution of plasma irregularities in the E_s layer, observed by a high resolution Ca^+ lidar

*Mitsumu K. Ejiri[1,2], Takuji Nakamura[1,2], Takuo T. Tsuda[3], Takanori Nishiyama[1,2], Makoto Abo[4], Toru Takahashi[1], Katsuhiko Tsuno[5], Takuya Kawahara[6], Takayo Ogawa[5], Satoshi Wada[5] (1.National Institute of Polar Research, 2.SOKENDAI (Department of Polar Science, The Graduate University for Advanced Studies), 3.The University of Electro-Communications, 4.Tokyo Metropolitan University, 5.RIKEN, RAP, 6.Shinshu University Faculty of Engineering)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[PEM16-09] Study of Effects of Stratospheric Sudden Warming on Medium-Scale Traveling Ionospheric Disturbances Using Total Electron Content Data Obtained from World-Wide GPS Receiver Networks

*Yuichi Otsuka[1], Atsuki Shinbori[1], Prayitno Abadi[2], Takuya Tsugawa[3], Michi Nishioka[3] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.LAPAN, 3.National Institute of Information and Communications Technology)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[PEM16-10] Tsunami-generated ionospheric currents inferred from geomagnetic observations at ground level: Case for the 2011 Tohoku Earthquake

*Takuto Minami[1], Masashi Kamogawa[2], Tsutomu Ogawa[1], Makoto Uyeshima[1], Toru Mogi[3], Hiroshi Ichihara[4] (1.Earthquake Research Institute,The University of Tokyo, 2.Department of Physics, Tokyo Gakugei University, 3.Graduate School of Engineering, Hokkaido University, 4.Graduate School of Environmental Studies, Nagoya University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[PEM16-11] Relationship between the magnitude of Sakurajima eruptions and the disturbance of GPS-TEC

*Kiyoto Shoji[1], Hiroyuki Nakata[1], Toshiaki Takano[1], Hiroyo Ohya[1], Takuya Tsugawa[2], Michi Nishioka[2] (1.Graduate School of Science and Engineering, Chiba University, 2.National Institute of Information and Communications Technology)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[PEM16-12] Water vapor estimation using digital terrestriall broadcasting waves - Simultaneous observation with microwave radiometer -

*Hiroshi HANADO[1], Seiji Kawamura[1], Hironori Iwai[1], Shinsuke Satoh[1], Katsuhiro Nakagawa[1], Takuya Tajiri[2], Narihiro Orikasa[2], Yoshinori Shoji[2], Kentaro Araki[2], Hiromu Seko[2] (1.National Institute of Information and Communications Technology, 2.Meteorological Research Institute)

[J] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 201A 2F

[P-EM18] Heliosphere and Interplanetary Space

convener:Ken Tsubouchi(University of Electro-Communications), Masaki N Nishino(Japan Aerospace Exploration Agency, Institute of Space and Astronautical Science), Yasuhiro Nariyuki(Faculty of Human Development, University of Toyama), Kazumasa Iwai(Institute for Space?Earth Environmental Research (ISEE), Nagoya University), Chairperson:Yasuhiro Nariyuki, Kazumasa Iwai

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[PEM18-01] Problems in determining structures of interplanetary magnetic flux ropes

*Katsuhide Marubashi[1], Yuki Kubo[1], Nobuhiko Nishimura[2], Munetoshi Tokumaru[2], Nada Al-Haddad[3] (1.National Institute of Information and Communications Technology , 2.ISEE, Nagoya University, 3.IACS, Catholic University of America)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[PEM18-02] Validation of estimated interplanetary flux rope axial direction using internal plasma motions: benchmark test

*Nobuhiko Nishimura[1], Munetoshi Tokumaru[1], Katsuhide Marubashi[2] (1.Institute for Space Earth Environmental Research, 2.National Institute of Information and Communications Technology)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[PEM18-03] Effect of line-of-sight integration on locations of coronal mass ejection in the sky projection map of interplanetary scintillation observations

*Munetoshi Tokumaru[1], Ken'ichi Fujiki[1], Kazumasa Iwai[1] (1.Institute for Space-Earth Environmental Research, Nagoya University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[PEM18-04] Estimation of spatial structure of whistler mode wave packets in Earth’s bow shock by multiple spacecraft analysis

*Chika Umegaki[1], Takanobu Amano[1], Naritoshi Kitamura[1] (1.The university of tokyo)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[PEM18-05] Experimental Test for Stochastic Shock Drift Acceleration Theory

*Takanobu Amano[1], Takuma Katou[1], Naritoshi Kitamura[1], Mitsuo Oka[2], Yosuke Matsumoto[3], Masahiro Hoshino[1] (1.Department of Earth and Planetary Science, University of Tokyo, 2.Space Sciences Laboratory, University of California, Berkeley, 3.Department of Physics, Chiba University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[PEM18-06] Radial structure of heliospheric boundary region

*Shuichi Matsukiyo[1], Gary P. Zank[2], Haruichi Washimi[3], Tohru Hada[1] (1.Faculty of Engineering Sciences, Kyushu University, 2.The Center for Space Plasma and Aeronomic Research, University of Alabama in Huntsville, 3.International Center for Space Weather Science and Education, Kyushu University)

[J] Oral | P (Space and Planetary Sciences)：P-CG Complex & General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 105 1F

[P-CG24] New Developments of Planetary Sciences with ALMA

convener:Takayuki Muto(Division of Liberal Arts, Kogakuin University), Munetake Momose(The College of Science, Ibaraki University), Hideo Sagawa(Faculty of Science, Kyoto Sangyo University), Masumi Shimojo(National Astronomical Observatory of Japan), Chairperson:Takayuki Muto

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[PCG24-01] Understanding solar atmosphere by ALMA observations

★Invited Papers

*Tomoko Kawate[1], Takenori J Okamoto[2], Kazumasa Iwai[3], Satoshi Masuda[3], Masumi Shimojo[2] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.National Astronomical Observatory of Japan, 3.Nagoya University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[PCG24-02] **Multi-thermal structures in a spicule observed with ALMA, IRIS, and AIA/SDO**

*Masumi Shimojo[1], Tomoko Kawate[2], Takenori Okamoto[1], Takaaki Yokoyama[3] (1.National Astronomical Observatory of Japan, 2. Institute of Space and Astronautical Science , 3.University of Tokyo)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[PCG24-03] Observing the 2018 global dust storm on Mars with ALMA

Shohei Aoki[2], *Hideo Sagawa[1], Kazi Rigl[3], Geronimo L. Villanueva[4], Bill Dent[5], Hiroyuki Maezawa[6], Severine Robert[2], Hiromu Nakagawa[7], Frank Daerden[2], Takeshi Kuroda[8], Marco Giuranna[10], Kazuya Saigo[9], Michael J. Mumma[4], Yasumasa Kasaba[7], Ann Carine Vandaele[2] (1.Kyoto Sangyo University, 2.Royal Belgian Institute for Space Aeronomy, 3.Italian ALMA Regional Centre, INAF-Istituto di Radioastronomia, 4.NASA Goddard Space Flight Center, USA, 5.ESO ALMA, Chile, 6.Osaka Prefecture University, 7.Tohoku University, 8.NICT Big Data Integration Research Center, 9.NAOJ Chile Observatory, 10.Istituto di Astrofisica e Planetologia Spaziali, Italy)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[PCG24-04] Atmospheric observation of submillimeter wave and the thermal evolution of ice giants

★Invited Papers

*Kenji Kurosaki[1], Masahiro Ikoma[2] (1.Department of Physics, Nagoya University , 2.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

10:00 AM - 10:30 AM JST | 1:00 AM - 1:30 AM UTC

[PCG24-05] Planetary-system formation revealed with ALMA

★Invited Papers

*Misato Fukagawa[1] (1.National Astronomical Observatory of Japan)

[J] Oral | P (Space and Planetary Sciences)：P-CG Complex & General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 105 1F

[P-CG24] New Developments of Planetary Sciences with ALMA

convener:Takayuki Muto(Division of Liberal Arts, Kogakuin University), Munetake Momose(The College of Science, Ibaraki University), Hideo Sagawa(Faculty of Science, Kyoto Sangyo University), Masumi Shimojo(National Astronomical Observatory of Japan), Chairperson:Munetake MOMOSE(Ibaraki University)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[PCG24-06] Probing dust aggregate structure in protoplanetary disks by millimeter-wave polarization

*Ryo Tazaki[1], Hidekazu Tanaka[1], Takayuki Muto[2], Akimasa Kataoka[3], Satoshi Okuzumi[4] (1.Tohoku University, 2.Kogakuin University, 3.NAOJ, 4.Tokyo Institute of Technology)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[PCG24-07] A CONSTRAINT ON THE AMOUNT OF HYDROGEN FROM THE CO CHEMISTRY IN DEBRIS DISKS

*Hiroshi Kobayashi[1], Kazunari Iwasaki[2,4], Aya Higuchi[3] (1.Department of Physics, Nagoya University, 2.NAOJ, 3.RIKEN, 4.Osaka University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[PCG24-08] Structure of the protoplanetary disk around V1094 Sco obtained from dust continuum emission and SED

*Sanemichi Takahashi[1,2], Takayuki Muto[1], Takashi Tsukagoshi[2], Jun Hashimoto[2] (1.Kogakuin University, 2.NAOJ)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[PCG24-09] The Synthetic ALMA Multiband Analysis of the Dust Properties of the TW Hya Protoplanetary Disk

*Seongjoong Kim[1], Hideko Nomura[1], Takashi Tsukagoshi[2], Ryohei Kawabe[2,3,4], Takayuki Muto[5] (1.Department of Earth and Planetary Sciences, Tokyo Institute of Technology, 2.National Astronomical Observatory of Japan, 3.The Graduate University for Advanced Studies (SOKENDAI), 4.Department of Astronomy, School of Science, University of Tokyo, 5.Division of Liberal Arts, Kogakuin University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[PCG24-10] Dust evolution in the protoplanetary disk around TW Hya

*Takayuki Matsuura[1], Satoshi Okuzumi[1] (1.Tokyo Institute of Technology)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[PCG24-11] Discovery of a localized excess in the millimeter emission of the protoplanetary disk around TW Hya

*Takashi Tsukagoshi[1], Takayuki Muto[2], Hideko Nomura[3], Ryohei Kawabe[1,4,5], Kazuhiro Kanagawa[9], Satoshi Okuzumi[3], Shigeru Ida[10], Catherine Walsh[6], Tom J Millar[7], Sanemichi Takahashi[2,1], Jun Hashimoto[8], Taichi Uyama[5], Motohide Tamura[5,8] (1.Division of Radio Astronomy, National Astronomical Observatory of Japan, 2.Division of Liberal Arts, Kogakuin University, 3.Department of Earth and Planetary Sciences, Tokyo Institute of Technology, 4.The Graduate University for Adnvanced Studies, 5.School of Science, University of Tokyo, 6.School of Physics and Astronomy, University of Leeds, 7.Astrophysics Research Centre, Queen's University Belfast, 8.Astrobiology Center, National Institutes of Natural Sciences, 9.Research Center for the Early Universe, University of Tokyo, 10.Earth-Life Science Institute, Tokyo Institute of Technology)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 102 1F

[A-AS04] Atmospheric Chemistry

convener:Tomoki Nakayama(Graduate School of Fisheries and Environmental Sciences, Nagasaki University), Yoko Iwamoto(Graduate School of Biosphere Science, Hiroshima University), Sakae Toyoda(Department of Chemical Science and Engineering, Tokyo Institute of Technology), Nawo Eguchi(Kyushu University), Chairperson:Fumiko Nakagawa(名古屋大学)

9:00 AM - 9:30 AM JST | 12:00 AM - 12:30 AM UTC

[AAS04-01] Reconstruction and fluctuation mechanism of past aerosols preserved in ice cores

★Invited Papers

*Iizuka Yoshinori[1], Ryu Uemura[2], Koji Fujita[3], Shohei Hattori[4], Osamu Seki[1], Naga Oshima[5], Hiroshi Ohno[6], Sumito Matoba[1] (1.Institite of Low Temperature Science, Hokkaido University, 2.Department of Chemistry, Biology, and Marine Science, Faculty of Science, University of the Ryukyus, 3.Graduate School of Environmental Studies, Nagoya University, 4.Department of Chemical Science and Engineering, School of Materials and Chemical Technology, Tokyo Institute of Technology,, 5.Meteorological Research Institute, 6.Kitami Institute of Technology)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[AAS04-02] The 60 years history of atmospheric formation pathways responsible for sulfate based on triple oxygen isotopic composition of sulfate preserved in SE-Dome ice core

*Shohei Hattori[1], Iizuka Yoshinori[2], Koji Fujita[3], Ryu Uemura[4], Sakiko Ishino[1], Naga Oshima[5], Nozomi Suzuki[1], Sumito Matoba[2], Asuka Tsuruta[1], Joel Savarino[6], Naohiro Yoshida[1] (1.Department of Chemical Science and Engineering, School of Materials and Chemical Technology, Tokyo Institute of Technology, 2.Institute of Low Temperature Science, Hokkaido University, 3.Graduate School of Environmental Studies, Nagoya University, Nagoya, Japan., 4.Department of Chemistry, Biology, and Marine Science, Faculty of Science, University of the Ryukyus, 5.Meteorological Research Institute, 6.Institut des Geoscience de l'Environnement, Universite Grenoble Alpes/CNRS)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[AAS04-03] Estimation of high sulfate aerosol sources in 2012 spring at Cape Hedo, Okinawa

*Syuichi Itahashi[1], Shiro Hatakeyama[2], Kojiro Shimada[3], Akinori Takami[4] (1.Central Research Institute of Electric Power Industry, 2.Center for Environmental Science in SaitamaCenter for Environmental Science in Saitama, 3.School of Creative Science and Engineering, Waseda University, 4.National Institute for Environmental Studies)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[AAS04-04] Isotopic constrains on sources and formation pathways of atmospheric nitrate in Mt. Everest

*Kun Wang[1,2,4], Shohei Hattori[2], Shichang Kang[1,3,4], Mang Lin[2], Naohiro Yoshida[2,5] (1.Northwest Institute of Eco-Environment and Resources, Chinese Academy of Sciences , 2.Department of Chemical Science and Engineering, School of Materials and Chemical Technology, Tokyo Institute of Technology, 3.CAS Center for Excellence in Tibetan Plateau Earth Sciences, 4.University of Chinese Academy of Sciences, 5. Earth-Life Science Institute, Tokyo Institute of Technology)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[AAS04-05] Development of a large volume sampling system for measuring stable isotope analysis of carbonyl sulfide and field observation

*Kazuki Kamezaki[1], Shohei Hattori[1], Naohiro Yoshida[1,2] (1.Department of Chemical Science and Engineering, School of Materials and Chemical Technology, Tokyo Institute of Technology, 4259 Nagatsuta-cho, Midori-ku, Yokohama, Kanagawa 226-8502, Japan, 2.Earth-Life Science Institute, Tokyo Institute of Technology, 2-12-1-IE-1 Ookayama, Meguro-ku, Tokyo 152-8550, Japan)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 102 1F

[A-AS04] Atmospheric Chemistry

convener:Tomoki Nakayama(Graduate School of Fisheries and Environmental Sciences, Nagasaki University), Yoko Iwamoto(Graduate School of Biosphere Science, Hiroshima University), Sakae Toyoda(Department of Chemical Science and Engineering, Tokyo Institute of Technology), Nawo Eguchi(Kyushu University), Chairperson:Takashi Maki(気象研究所)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[AAS04-06] Observations of aerosol optical properties by sky radiometers at SKYNET Southeast and South Asian sites

*Al Mashroor Fatmi[1], Hitoshi Irie[1], Hossain Mohammed Syedul Hoque[1], Alessandro Damiani[1], Pradeep Khatri[2], Tamio Takamura[1], Thanawat Jurupongsaku[3], Govindan Pandithurai[4] (1.Center for Environmental Remote Sensing Chiba University , 2.Tohoku University, 3.Chulalongkorn University, 4.Indian Institute of Tropical Metereology)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[AAS04-07] Analysis of factors causing variations in the absorption Ångström exponent of aerosols in Japan using skyradiometers

*Kodai Yamaguchi[1], Hitoshi Irie[1], Pradeep Khatri[2], Toshihiko Takemura[3], Hirokazu Yamamoto[4] (1.Chiba University, 2.Tohoku University, 3.Kyushu University, 4.National Institute of Advanced Industrial Science and Technology)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[AAS04-08] Sources of atmospheric black carbon and related carbonaceous components at Rishiri Island, Japan

*Chunmao Zhu[1], Yugo Kanaya[1], Hisayuki Yoshikawa[2], Tomohisa Irino[2], Osamu Seki[2], Yasunori Tohjima[3] (1.Japan Agency for Marine-Earth Science and Technology, 2.Hokkaido University, 3.National Institute for Environmental Studies)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[AAS04-09] Black Carbon and Inorganic Aerosols in Snowpack over the Arctic

*Tatsuhiro Mori[1], Kumiko Goto-Azuma[2,3], Yutaka Kondo[2], Yoshimi Ogawa-Tsukagawa[2], Kazuhiko Miura[1], Motohiro Hirabayashi[2], Naga Oshima[4], Makoto Koike[5], Kaarle Kupiainen[6], Nobuhiro Moteki[5], Sho Ohata[7], Sinha Puna Ram[8], Konosuke Sugiura[9], Teruo Aoki[10], Martin Schneebeli[11], Konrad Steffen[11], Atsushi Sato[12], Akane Tsushima[13], Vladimir Makarov[14], Satoshi Omiya[15,16], Atsuko Sugimoto[17], Shinya Takano[17] (1.Tokyo University of Science, 2.National Institute of Polar Research, 3.The Graduate University for Advanced Studies, 4.Meteorological Research Institute, 5.Depertment of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 6.Environmental Protection Department Ministry of the Environment, 7.Institute for Space–Earth Environmental Research (ISEE), Nagoya University, 8.Department of Space Indian Space Research Organization, 9.University of Toyama, 10.Okayama University, 11.WSL Institute for Snow and Avalanche Research, 12.former Snow and Ice Research Center, 13.Reserach Institute for Humanity and Nature, 14.Melnikov's Permafrost Institute, 15.Institute of Low Temperature Science, Hokkaido University, 16.Civil Engineering Research Institute for Cold Region, 17.Graduate School of Environmental Science, Hokkaido University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[AAS04-10] The single-particle extinction and scattering method for online characterization of submicron particles: Principles and applications to aerosol research

*Nobuhiro Moteki[1] (1.The Univerisity of Tokyo)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[AAS04-11] High spatial resolution vehicular emissions inventory for China using VEIN model

*Sergio Ibarra Espinosa[1], Xuelei Zhang[1], Aijun Xiu[1], Edmilson Dias de Freitas[2] (1.Research Group of Regional Atmospheric Environment, Northeast Institute of Geography and Agroecology, Chinese Academy of Sciences, P. R. China, 2.Department of Atmospheric Sciences, University of São Paulo, Brazil.)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 102 1F

[A-AS04] Atmospheric Chemistry

convener:Tomoki Nakayama(Graduate School of Fisheries and Environmental Sciences, Nagasaki University), Yoko Iwamoto(Graduate School of Biosphere Science, Hiroshima University), Sakae Toyoda(Department of Chemical Science and Engineering, Tokyo Institute of Technology), Nawo Eguchi(Kyushu University), Chairperson:Kentaro Ishijima(気象研究所)

3:30 PM - 4:00 PM JST | 6:30 AM - 7:00 AM UTC

[AAS04-12] Effect of land use change on GHG fluxes of tropical peat forests in Borneo island

★Invited Papers

*Ryuichi Hirata[1], Habura Borjigin[1], Tomohiro Shiraishi[1], Takashi Hirano[2], Lulie Melling[3] (1.National Institute for Environmental Studies, 2.Hokkaido University, 3.Sarawak Tropical Peat Research Institute)

4:00 PM - 4:30 PM JST | 7:00 AM - 7:30 AM UTC

[AAS04-13] Remote sensing of carbon assimilation function of terrestrial ecosystem by Earth-observation satellite

★Invited Papers

*Hibiki M Noda[1], Yukio Yoshida[1], Haruki Oshio[1], Tomoki Kiyono[1], Tatsuya Miyauchi[1], Tsuneo Matsunaga[1] (1.NIES National Institute of Environmental Studies)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[AAS04-14] Analysis of the carbon dioxide in the upper troposphere and lower stratosphere by the data from GOSAT TANSO-FTS TIR

*Nawo Eguchi[1], Akihiro Honda[1], Naoko Saitoh[2], Yosuke Niwa[3] (1.Kyushu University, 2.Chiba University, 3.National Institute for Environmental Studies)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[AAS04-15] Seasonal and interannual variations of the Atmospheric Potential Oxygen over the Western North Pacific observed by using a cargo aircraft C-130H

*Shigeyuki Ishidoya[1], Kazuhiro Tsuboi[2], Yosuke Niwa[3], Shohei Murayama[1], Hidekazu Matsueda[2], Yousuke Sawa[2], Nobuyuki Aoki[1], Kentaro Ishijima[2], Kentaro Kozumi[4], Genta Umezawa[4], Kazuya Yukita[4], Shigeharu Nishida[4], Megumi Yamamoto[4] (1.National Institute of Advanced Industrial Science and Technology (AIST), 2.Meteorological Research Institute, 3.National Institute for Environmental Studies, 4.Japan Meteorological Agency)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 201B 2F

[A-AS05] Stratosphere-troposphere Processes And their Role in Climate

convener:Yoshio Kawatani(Japan Agency for Marine-Earth Science and Technology), Shingo Watanabe(Japan Agency for Marine-Earth Science and Technology), Takashi Sekiya(Japan Agency for Marine-Earth Science and Technology), Kaoru Sato(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Chairperson:Watanabe Shingo(海洋研究開発機構)

9:10 AM - 9:40 AM JST | 12:10 AM - 12:40 AM UTC

[AAS05-01] Turbulent kinetic energy dissipation rates depending on the polar vortex and on synoptic-scale disturbances in the UTLS region in the Antarctic

★Invited Papers

*Masashi Kohma[1], Kaoru Sato[1], Koji Nishimura[2], Masaki Tsutsumi[2] (1.Department of Earth and Planet Science, Graduate School of Science, The University of Tokyo, 2.National Institute of Polar Research and The Graduate University for Advanced Studies (SOKENDAI))

9:40 AM - 9:55 AM JST | 12:40 AM - 12:55 AM UTC

[AAS05-02] Momentum budget of semiannual oscillation around the tropical stratopause

*Yoshihiro Tomikawa[1,2], V. Lynn Harvey[3], John A. Knox[4], Masatomo Fujiwara[5] (1.National Institute of Polar Research, 2.SOKENDAI, 3.University of Colorado Boulder, 4.University of Georgia, 5.Hokkaido University)

9:55 AM - 10:10 AM JST | 12:55 AM - 1:10 AM UTC

[AAS05-03] A study on sources of gravity waves that reach the summer stratosphere and mesosphere based on high-resolution radiosonde data

*Haruka Okui[1], Masashi Kohma[1], Kaoru Sato[1] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

10:10 AM - 10:25 AM JST | 1:10 AM - 1:25 AM UTC

[AAS05-04] Stratospheric initial conditions provide seasonal predictability of the North Atlantic and Arctic Oscillations

*Yu Nie[1], Adam Scaife[2,3], Hong-Li Ren[1,4], Ruth Comer[2], Martin Andrews[2] (1.Laboratory for Climate Studies, National Climate Center, China Meteorological Administration, Beijing, China, 2.Met Office Hadley Centre, Exeter, UK, 3.College of Engineering, Mathematics and Physical Sciences, University of Exeter, Exeter, UK, 4.Department of Atmospheric Science, School of Environmental Studies, China University of Geoscience, Wuhan, China)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 201B 2F

[A-AS05] Stratosphere-troposphere Processes And their Role in Climate

convener:Yoshio Kawatani(Japan Agency for Marine-Earth Science and Technology), Shingo Watanabe(Japan Agency for Marine-Earth Science and Technology), Takashi Sekiya(Japan Agency for Marine-Earth Science and Technology), Kaoru Sato(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Chairperson:Takashi Sekiya

10:45 AM - 11:15 AM JST | 1:45 AM - 2:15 AM UTC

[AAS05-05] Transport of trace gases into the extratropical upper troposphere/lower stratosphere

★Invited Papers

*Yoichi Inai[1], Ryo Fujita[2,1], Toshinobu Machida[3], Hidekazu Matsueda[4], Yousuke Sawa[4], Kazuhiro Tsuboi[4], Keiichi Katsumata[3,5], Shinji Morimoto[1], Shuji Aoki[1], Takakiyo Nakazawa[1] (1.Tohoku Univ., 2.Imperial College London, 3.NIES, 4.MRI, 5.Takachiho Chem. Industrial)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[AAS05-06] Possible impacts of stratospheric ozone on circulation changes in the tropical troppposphere following a stratospheric sudden warming event

*Makoto Deushi[1] (1.Department of Atmospheric Environment and Applied Meteorology, Meteorological Research Institute)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[AAS05-07] **Stratosphere-troposphere exchange of ozone and carbon monoxide over the northern Pacific Ocean in northern winter using two chemical reanalysis data sets**

*Haosen Xi[1], Masatomo Fujiwara[1], Kazuyuki Miyazaki[2] (1.Graduate School of Environmental Science, Hokkaido University, 2.NASA Jet Propulsion Laboratory, California Institute of Technology, USA)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[AAS05-08] **Inter-comparison of Upper Air Temperature in China between Satellite MSU and Radiosonde Datasts**

*Yanjun GUO[1], Cheng-zhi Zou[2], Panmao Zhai[3], Guofu Wang[1] (1.National Climate Center(NCC), China Meteorological Administration(CMA) , 2.Center for Satellite Applications and Research, NOAA/NESDIS, 3.Chinese Academy of Meteorolgical Sciences (CAMS), China Meteorological Administration (CMA))

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[AAS05-09] Environmental Characterization of the Atmosphere Using WACCM-X

*Rose Tseng[1], Michelle Kanipe[1], Brian Urbancic[1], Robert Tournay[1], Omar Nava[1], Daniel Emmons[1], Robert Loper[1], Charlton Lewis[1] (1.Air Force Institute of Technology)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 201B 2F

[A-AS05] Stratosphere-troposphere Processes And their Role in Climate

convener:Yoshio Kawatani(Japan Agency for Marine-Earth Science and Technology), Shingo Watanabe(Japan Agency for Marine-Earth Science and Technology), Takashi Sekiya(Japan Agency for Marine-Earth Science and Technology), Kaoru Sato(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Chairperson:Yoshio Kawatani

1:45 PM - 2:15 PM JST | 4:45 AM - 5:15 AM UTC

[AAS05-10] Diagnostics of a WN2-type major sudden stratospheric warming event in February 2018 using a new three-dimensional wave activity flux

★Invited Papers

*Yayoi Harada[1], Kaoru Sato[2], Takenari Kinoshita[3], Ryosuke Yasui[2], Toshihiko Hirooka[4], Hiroaki Naoe[1] (1.Meteorological Research Institute, 2.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 3.Japan Agency for Marine-Earth Science and Technology, 4.Department of Earth and Planetary Sciences, Kyushu University)

2:15 PM - 2:45 PM JST | 5:15 AM - 5:45 AM UTC

[AAS05-11] Response of the Southern Hemisphere atmosphere to the QBO from winter to early summer

★Invited Papers

*Yousuke Yamashita[1], Hiroaki Naoe[2], Makoto Inoue[3], Masaaki Takahashi[4] (1.Japan Agency for Marine-Earth Science and Technology, 2.Meteorological Research Institute, 3.Akita Prefectural University, 4.National Institute for Environmental Studies)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[AAS05-12] Influence of QBO-like Oscillation on Tropical Convective Systems in a Three-Dimensional Minimal Model Framework of the Stratosphere-Troposphere Coupled System

*Shigeo Yoden[1], Hai Bui[2], Takahiro Banno[1] (1.Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University, 2.Geophysical Institute, University of Bergen)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[AAS05-13] Downward Propagation of Planetary Wave Packets from the Stratosphere to the Troposphere During Northern Hemisphere Winter

*Matsuyama Yuya[1], Toshihiko Hirooka[2] (1.Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2.Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 301A 3F

[A-OS14] Coastal physical processes associated with mixing, eddies, internal waves

convener:Eiji Masunaga(Ibaraki University), Taira Nagai(Graduate School of Science, The University of Tokyo), TSUTSUMI EISUKE(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Eiji Masunaga, Eisuke Tsutsumi

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[AOS14-01] The cooling of sea surface temperature in the southern Indonesian Seas due to a combination of the Ekman transport and tidal mixing in narrow straits

*Taira Nagai[1], Toshiyuki Hibiya[1] (1.Graduate School of Science, The University of Tokyo)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[AOS14-02] A reanalysis of regional circulations in the Southern South China Sea using a HYCOM-ROMS downscaling ocean model

*Naru Takaura[1], Yusuke Uchiyama[1], Nizamani Zafarullah[2], Akihiko Nakayama[2] (1.Kobe Univ, 2.Tunku Abdul Rahman University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[AOS14-03] Nutrient and phytoplankton dynamics in the continental slope region of the East China Sea associated with the Kuroshio frontal eddy

*Naoki Yoshie[1], Anri Kabe[1], Kazuki Ohgi[1], Eisuke Tsutsumi[2], Shigenobu Takeda[3], Joji Ishizaka[4], Xinyu Guo[1] (1.Center for Marine Environmental Studies, Ehime University, 2.Research Institute for Applied Mechanics, Kyushu University, 3.Faculty of Fisheries, Nagasaki University, 4.Institute for Space-Earth Environmental Research, Nagoya University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[AOS14-04] Dissipation and transport due to internal tides generated by multiple submarine canyons

*Qiang Li[1], Xianzhong Mao[1], Ran Liao[1] (1.Tsinghua University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[AOS14-05] Measurement of Physical structure in Kasumigaura using high resolution tow-yo instrument

*Daiki Asaoka[1], Eiji Masunaga[1], Shunsuke Komuro[2], Shunichi Matsumoto[2], Masahiko Ono[3], Hiroaki Banba[3] (1.Ibaraki University, 2.Ibaraki Kasumigaura Environmental Science Center, 3.Ministry of Land, Infrastructure, Transport and Tourism)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[AOS14-06] Mixing and baroclinic structure in a stratified shallow lake, Lake Kasumigaura, Japan

*Eiji Masunaga[1], Daiki Asaoka[1], Shunsuke Komuro[2], Shunichi Matsumoto[2], Masahiko Ono[3], Hiroaki Banba[3] (1.Ibaraki University, 2.Ibaraki Kasumigaura Environmental Science Center, 3.Ministry of Land, Infrastructure, Transport and Tourism)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 301A 3F

[A-OS14] Coastal physical processes associated with mixing, eddies, internal waves

convener:Eiji Masunaga(Ibaraki University), Taira Nagai(Graduate School of Science, The University of Tokyo), TSUTSUMI EISUKE(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Eiji Masunaga, Taira Nagai

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[AOS14-07] Turbulent mixing and vertical nitrate flux in the Bungo Channel, Japan

*TSUTSUMI EISUKE[1], Naoki Yoshie[2], Takashi Mano[3], Kanda Taisei[3], Naoki Fujii[4], Xinyu Guo[2] (1.Research Institute for Applied Mechanics, Kyushu University, 2.Center for Marine Environmental Studies, Ehime Univeristy, 3.Graduate School for Science and Engineering, Ehime University, 4.Faculty of Agriculture, Saga Univerisity)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[AOS14-08] Numerical Analysis of Submerged Turbulent Buoyant Jet in River Mouth

*Yen-Chen Mou[1], Gene You[1], Chih-Chieh Young[2] (1.National Taiwan University, 2.National Taiwan Ocean University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[AOS14-09] Implementing regional downscaling capability in the STEAMER radionuclide dispersion prediction system based on multi-nested ROMS model

*Kamidaira Yuki[1], Hideyuki Kawamura[1], Takuya Kobayashi[1], Yusuke Uchiyama[2] (1.Japan Atomic Energy Agency, 2.Kobe University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[AOS14-10] Transport processes around the Izu-chain islands investigated with a Lagrangian particle tracking model

*Waku Kimura[1], Eiji Masunaga[1], Taichi Kosako[2], Yusuke Uchiyama[3] (1.Ibaraki University, 2.Port and Airport Research Institute, 3.Kobe University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[AOS14-11] Fates and dynamical roles of pinch-off mesoscale eddies originated from the Kuroshio Extension Jet

*Yusuke Uchiyama[1], Nobue Okada[1], Changming Dong[2] (1.Graduate School of Engineering, Kobe University, 2.Nanjing University of Information Science & Technology)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CC Cryospheric Sciences & Cold District Environment

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 303 3F

[A-CC27] Glaciology

convener:Takayuki Nuimura(Tokyo Denki University), Ishikawa Mamoru(Hokkaido University), Kzutaka Tateyama(National University Corporation Kitami Institute of Technology), Hiroto Nagai(Waseda Univ., School of Education), Chairperson:Hiroto Nagai(Japan Aerospace Exploration Agency)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[ACC27-01] The early validation results of the GCOM-C/SGLI cryosphere standard product

★Invited Papers

*Rigen Shimada[1], Masahiro Hori[1], Teruo Aoki[2,3], Tomonori Tanikawa[2], Sumito Matoba[4], Masashi Niwano[2], Knut Stamnes[5], Wei Li[5], Nan Chen[5] (1.Japan Aerospace Exploration Agency, 2.Meteorological Research Institute, 3.Okayama University, 4.Institute of Low Temperature Science, Hokkaido University, 5.Stevens Institute of Technology)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[ACC27-02] Overview of the cryospheric variables derived from GCOM-C/SGLI observations: The first-year results

★Invited Papers

*Masahiro Hori[1], Teruo Aoki[2,4], Knut Stamnes[3], Wei Li[3], Nan Chen[3], Rigen Shimada[1], Tomonori Tanikawa[4], Masashi Niwano[4] (1.Earth Observation Reseacrh Center, Japan Aerospace Exploration Agency, 2.Okayama University, 3.Stevens Institute of Technology, 4.Meteorological Research Institute)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[ACC27-03] Relationships between PASAR-2 backscatter amplitude changes and snow depths

*Hiroto Nagai[1], Satoru Yamaguchi[2], Katsuya Yamashita[2], Mayumi Kashima[3] (1.Waseda University, School of Education, 2. National Research Institute for Earth Science and Disaster Resilience, 3.Esri Japan Corporation)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[ACC27-04] Breaking-off of hanging glaciers at Mt. Langtang-Lirung in Nepal

Honami Watanabe[2], *Chiyuki Narama[1], Yoshitaka Mori[2], Katsuhisa Kawashima[3] (1.Niigata University, Program of Field Research in the Environmental Sciences, 2.Graduate School of Science and Technology, Niigata University, 3.Research Institute for Natural Hazards & Disaster Recovery, Niigata University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[ACC27-05] Spatial distribution of ice cliff in the Trakarding glacier, Nepal Himalaya

*Yota Sato[1], Koji Fujita[1], Hiroshi Inoue[2], Sojiro Sunako[1], Akiko Sakai[1], Akane Tsushima[1], Evgeny Podolskiy[3,4], Etienne Berthier[5], Rijan Kayastha[6] (1.Graduate School of Environmental Studies, Nagoya University, 2.National Research Institute for Earth Science and Disaster Resilience, 3.Arctic Research Center, Hokkaido University, 4.Global Station for Arctic Research, Global Institution for Collaborative Research and Education, Hokkaido University, 5.Centre National de la Recherche Scientifique, 6.School of Science, Kathmandu University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[ACC27-06] Quantify the range of projections of future changes in glacier mass caused by differences among observed past climate datasets

*Megumi Watanabe[1], Aki Yanagawa[2], Yukiko Hirabayashi[3], Satoshi Watanabe[4], Shinjiro Kanae[1] (1.Tokyo Institute of Technology, 2.Meisei University, 3.Shibaura Institute of Technology, 4.The University of Tokyo)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CC Cryospheric Sciences & Cold District Environment

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 303 3F

[A-CC27] Glaciology

convener:Takayuki Nuimura(Tokyo Denki University), Ishikawa Mamoru(Hokkaido University), Kzutaka Tateyama(National University Corporation Kitami Institute of Technology), Hiroto Nagai(Waseda Univ., School of Education), Chairperson:Takayuki Nuimura(Chiba Institute of Science)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[ACC27-07] Preliminary analysis result of the Handheld Integrating Sphere Snow Grain Sizer (HISSGraS)

*Teruo Aoki[1,2,3], Masashi Niwano[2], Satoru Yamaguchi[4], Sumito Matoba[5], Tomonori Tanikawa[2], Masahiro Hori[6], Rigen Shimada[6], Akihiro Hachikubo[7] (1.The Graduate School of Natural Science and Technology, Okayama University, 2.Meteorological Research Institute, Japan Meteorological Agency, 3.National Institute of Polar Research, 4.National Research Institute for Earth Science and Disaster Resilience, 5.Institute of Low Temperature Sciences, Hokkaido University, 6.Earth Observation Research Center, Japan Aerospace Exploration Agency, 7.Kitami Institute of Technology)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[ACC27-08] Experimental study on compaction process of highly porous ice: Implications for density change of icy regolith layer on icy bodies

Minami Yabe[1], *Minami Yasui[1], Masahiko Arakawa[1] (1.Department of Planetology, Graduate School of Science, Kobe University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[ACC27-09] **Effect of snow impurities on the radiation budget and snow melting observed at Sapporo during 10 winter seasons**

*Yoichiro Hirozawa[1], Teruo Aoki[1,2], Masashi Niwano[2], Sumito Matoba[3], Yuji Kodama[4], Tomonori Tanikawa[2] (1.Okayama University, Graduate School of Natural Science and Technology, 2.Meteorological Research Institute, 3.Institute of Low Temperature Science, Hokkaido University, 4.National Institute of Polar Research)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 102 1F

[A-CG42] Biogeochemical linkages between the surface ocean and atmosphere

convener:Yuzo Miyazaki(Institute of Low Temperature Science, Hokkaido University), Jun Nishioka(Hokkaido University, Institute of low temperature sciences), Koji Suzuki(Hokkaido University), Yoko Iwamoto(Graduate School of Biosphere Science, Hiroshima University), Chairperson:Yuzo Miyazaki(Institute of low temperature science, Hokkaido University), Jun Nishioka(Institute of low temperature science, Hokkaido University)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[ACG42-01] Production of bromoform in sea ice and emission to the atmosphere

*Daiki Nomura[1], Atsushi Ooki[1], Ellen Damm[2], Gerhard Dieckmann[2], Bruno Delille[3], Markus Frey[4], Mats Granskog[5], Klaus Meiners[6,7], Anna Silyakova[8], Takeshi Tamura[9], Jean-Louis Tison[10], Youhei Yamashita[11] (1.Faculty of Fisheries Sciences, Hokkaido University, 2.Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany, 3.Université de Liège, Liège, Belgium., 4.British Antarctic Survey, Cambridge, United Kingdom., 5.Norwegian Polar Institute, Tromsø, Norway., 6.Antarctic Climate andEcosystems Cooperative Research Centre, University of Tasmania, Hobart, Australia., 7.Australian Antarctic Division, Kingston, Australia., 8.Centre for Arctic Gas Hydrate, Environment and Climate, Tromsø, Norway., 9.National Institute of Polar Research, Tokyo, Japan., 10.Université Libre de Bruxelles, Bruxelles, Belgium., 11.Graduate School of Environmental Sceince, Hokkaido University, Sapporo, Japan.)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[ACG42-02] Accumulation processes of trace metals into arctic sea ice: distribution of Fe, Mn and Cd associated with ice structure

*La Kenya Evans[1], Jun Nishioka[1] (1.Institute of Low Temperature Sciences, Hokkaido University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[ACG42-03] Is halogen chemistry responsible for low ozone levels observed over western Pacific equatorial region? - From observations on R/V Mirai

*Yugo Kanaya[1], Kazuyuki Miyazaki[1], Fumikazu Taketani[1], Takuma Miyakawa[1], Hisahiro Takashima[1,2], Yuichi Komazaki[1], Xiaole PAN[3,1], Saki Kato[2], Kengo Sudo[4,1] (1.Research and Development Center for Global Change, Japan Agency for Marine-Earth Science and Technology, 2.Fukuoka University, 3.Institute of Atmospheric Physics, Chinese Academy of Sciences, China, 4.Nagoya University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[ACG42-04] Very low $\delta^{15}N$ of atmospheric nitrate found in the earstern equatorial Pacific and its implication to dynamic nitrogen recycle between ocean and lower atmosphere

*Shohei Hattori[1], Kazuki Kamezaki[1], Yoko Iwamoto[2], Sakiko Ishino[1], Mitsuo Uematsu[3], Kazuhiko Miura[4], Naohiro Yoshida[1] (1.Department of Chemical Science and Engineering, School of Materials and Chemical Technology, Tokyo Institute of Technology, 2.Hiroshima University, 3.University of Tokyo, 4.Tokyo University of Science)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[ACG42-05] Origin of water-soluble organic nitrogen in marine atmospheric aerosols in the subtropical North Pacific

*Tsukasa Dobashi[1,2], Yuzo Miyazaki[1], Eri Tachibana[1], Yoko Iwamoto[3], Kazutaka Takahashi[4], Sachiko Horii[4], Shu-Kuan Wong[5], Koji Hamasaki[5] (1.Institute of Low Temperature Science, Hokkaido Univ., 2.Graduate School of Env. Sci., Hokkaido Univ., 3.Graduate School of Biosphere Science, Hiroshima Univ., 4.Graduate School of Agricultural and Life Sciences, Univ. of Tokyo, 5.Atmosphere and Ocean Research Institute, Univ. of Tokyo)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[ACG42-06] Impacts of ammonia on gas-particle partition and AWC during the 2016 APHH-Beijing campaign: inducing effects of nitrate ammonium

*baozhu Ge[1], Xiaobin Xu[2], Zhiqiang Ma[3], Xiaole PAN[1], Zhe WANG[1,4], Weili Lin[5], Bin Ouyang[6], Danhui Xu[1], James Lee[7], Mei Zheng[8], Dongsheng Ji[1], Yele Sun[1], Huabin Dong[8], Freya Anne Squires[7], Pingqing Fu[1], Zifa Wang[1] (1.State Key Laboratory of Atmospheric Boundary Layer Physics and Atmospheric Chemistry, Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing 100029, China, 2.State Key Laboratory of Severe Weather & Key Laboratory for Atmospheric Chemistry of China Meteorological Administration, Chinese Academy of Meteorological Sciences, Beijing 100081, China, 3.Institute of Urban Meteorology, China Meteorological Administration, Beijing, China, 4.Research Institute for Applied Mechanics (RIAM), Kyushu University, Fukuoka, Japan, 5.College of Life and Environmental Sciences, Minzu University of China, Beijing 100081, China, 6.Lancaster Environment Centre,

Lancaster University, Lancaster, LA1 4YQ, UK, 7.National Centre for Atmospheric Science Department of Chemistry, University of York, York, YO10 5DD, UK, 8.State Key Joint Laboratory of Environmental Simulation and Pollution Control, College of Environmental Sciences and Engineering, Peking University, Beijing, 100871, China)

[J] Oral | H (Human Geosciences) : H-GM Geomorphology

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 101 1F

[H-GM04] Geomorphology

convener:Tsuyoshi Hattanji(Faculty of Life and Environmental Sciences, University of Tsukuba), Masayuki Seto(Fukushima Future Center for Regional Revitalization, Fukushima University), Chairperson:Tsuyoshi Hattanji

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[HGM04-01] Salt weathering in humidity-change environments: a laboratory experiment

*Masato Sato[1], Tsuyoshi Hattanji[2] (1.Graduate School of Life and environmental Sciences, University of Tsukuba, 2.Faculty of Life and Environmental Sciences, University of Tsukuba)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[HGM04-02] Verification a new control device of blown sand transport rate by wind tunnel experiments

*Yoshinori Kodama[1], Riko Saikusa[2] (1.Faculty of Agriculture, 2.Faculty of Regional Sciences)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[HGM04-03] Bedrock landslides, river blockage, and barrier-lake outburst as general geomorphic processes in high-relief mountainous landscape: an example from the Marshyangdi River, central Nepal

*Yuki Matsushi[1], Hiroshi YAGI[2], Hiroyuki Matsuzaki[3] (1.Disaster Prevention Research Institute, Kyoto University, 2.Department of Education, Art and Science, Yamagata University, 3.icro Analysis Laboratory, Tandem Accelerator, The University of Tokyo)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[HGM04-04] Influence of lithology on production and transport of soils on hillslopes underlain by granite and hornfels

*Takuma Watakabe[1], Yuki Matsushi[2], Hiroyuki Matsuzaki[3] (1.Graduate School of Science, Kyoto University, 2.Disaster Prevention Research Institute, Kyoto University, 3.The University Museum, The University of Tokyo)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[HGM04-05] Characterization of the vertical unsaturated flow for an integrated prediction of the storm runoff response and landslide initiation on a hillslope

*Makoto Tani[1], Yuki Matsushi[2], Takahiro Sayama[2], Nagahiro Kojima[3] (1.University of Human Environments, 2.Disaster Prevention Research Institute, Kyoto University, 3.Lake Biwa Environmental Research Institute)

[J] Oral | H (Human Geosciences)：H-GM Geomorphology

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 101 1F

[H-GM04] Geomorphology

convener:Tsuyoshi Hattanji(Faculty of Life and Environmental Sciences, University of Tsukuba), Masayuki Seto(Fukushima Future Center for Regional Revitalization, Fukushima University), Chairperson:Masayuki Seto, Hiroshi Shimazu

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[HGM04-06] The landform and flood characteristics of the Iron Gate on the ancient road from Samarkand to Bamian, south Uzbekistan

*Hiroshi Shimazu[1] (1.Department of Geography, Faculty of Geo-Environmental Science, Rissho University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[HGM04-07] OSL dating of sediment core in Olgoi lake, Mongolia

*Yudai Igarashi[1], Noriko Hasebe[1], Nagayoshi Katsuta[2], Hitoshi Hasegawa[3], Davaadorj Davaasuren[4], Yukiya Tanaka[5], Uyangaa Udaanjargal[1], Keisuke Fukushi[1], Ichinnorov Niiden[6] (1.Kanazawa University, 2.Gihu University, 3.Kochi University, 4.National University of Mongolia, 5.Kyunghee University, 6.Mongolian Academy of Science)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[HGM04-08] Paleo Lake level change in southern part of Mongolia

*Noriko Hasebe[1], Makoto Sambo[2], Uyangaa Udaanjargal[2,3], Shuukaaz Ganbat[3], Keisuke Fukushi[1], Yukiya Tanaka[4], Davaadorj Davaasuren[3] (1.Institute of Nature and Environmental Technology, Kanazawa University, 2.Department of Earth Sciences, Kanazawa University, 3.National University of Mongolia, 4.Kyunghee University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[HGM04-09] Numerical modeling of wave propagation on the coral reef based on high resolution 3D topography

*Kenta Minamidate[1], Kazuhisa Goto[2], Masashi Watanabe[3,4], Volker Roeber[5,6], Ken Toguchi[7], Masami Sannoh[8], Yosuke Nakashima[9], Hironobu Kan[10] (1.Graduate School of Science, Tohoku University, 2.International Research Institute of Disaster Science (IRIDeS), Tohoku University, 3.Graduate School of Engineering, Tohoku University, 4.Graduate School of Science and Engineering, Chuo University, 5.Hawaii University, 6.Université de Pau et des Pays de l'Adour, 7.Ryukyu University, 8.Mikuniya Corporation, 9.NIT, Ariake College, 10.Graduate School of Integrated Sciences for Global Society, Kyushu University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[HGM04-10] Coastal Seafloor Geomorphology: launching of a new field and perspectives

*Hironobu Kan[1], Nobuyuki Hori[2], Tatsuro Nakai[3], Yusuke Yokoyama[4], Kazuhiko Fujita[5], Hitoshi Hasegawa[3], Yosuke Nakashima[6], Kensaku Urata[1], Atsushi Suzuki[7], Masayuki Nagao[7], Kazuhisa Goto[8] (1.Graduate School of Integrated Sciences for Global Society, Kyushu University, 2.Emeritus Professor, Department of Geography, Tokyo Metropolitan University, 3.Department of Geography and Environmental Studies, Kokushikan University, 4.AORI, University of Tokyo, 5.Department of Physics and Earth Sciences, Faculty of Science, University of the Ryukyus, 6.National Institute of Technology, Ariake College, 7.Research Institute of Geology and Geoinformation, AIST, 8.IRIDeS, Tohoku University)

[J] Oral | H (Human Geosciences)：H-SC Social Earth Sciences & Civil/Urban System Sciences

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 301B 3F

[H-SC07] CCUS (Carbon Dioxide Capture, Utilization, and Storage) for Climate Mitigation

convener:Masao Sorai(Institute for Geo-Resources and Environment, National Institute of Advanced Industrial Science and Technology), Ziqiu Xue(Research Institute of Innovative Tech for the Earth), Masaatsu Aichi(Graduate School of Frontier Sciences, University of Tokyo), Chairperson:Masao Sorai(National Institute of Advanced Industrial Science and Technology)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[HSC07-01] Numerical simulation of variational pore pressure response to ocean tidal loading during CO2 injection

*Toshifumi Akaki[1], Hajime Yamamoto[1] (1.Taisei Corporation)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[HSC07-02] Relationship between rock deformation and permeability evolution during fracturing in rocks for CCUS technology

*Takashi Fujii[1], Xinglin Lei[1], Masao Sorai[1] (1.National Institute of Advanced Industrial Science and Technology)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[HSC07-03] Comparison of Optical Fiber Sensing Technique and Strain Gauge in a Measurement of Rock Deformation Caused by Chemical Osmosis

*Shogo Hirota[1], Tomochika Tokunaga[1], Ziqiu Xue[2], Hyuck Park[2] (1.Department of Environmental Systems, Graduate School of Frontier Science, the University of Tokyo, 2.Research Institute of Innovative Technology for the Earth)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[HSC07-04] Experiment of precipitation of salt for dry-out condition caused by CO_2 storage in saline aquifer

*Hayato Morigaki[1,2], Masaatsu Aichi[1] (1.University of Tokyo, 2.Toshiba Energy Systems & Solution Corporation)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[HSC07-05] Thermodynamic Approach to Wettability of CO_2/Brine/Mineral System by Augmented Young Laplace Equation

*Masashige Shiga[1,2], Masao Sorai[1], Masaatsu Aichi[2], Hiromi Honda[2] (1.AIST, 2.The University of Tokyo)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[HSC07-06] A proposal of CO2 underground storage using hydrate

*Takaomi Tobase[1] (1.Electric Power Development Co., Ltd.)

[J] Oral | H (Human Geosciences)：H-SC Social Earth Sciences & Civil/Urban System Sciences

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 301B 3F

[H-SC07] CCUS (Carbon Dioxide Capture, Utilization, and Storage) for Climate Mitigation

convener:Masao Sorai(Institute for Geo-Resources and Environment, National Institute of Advanced Industrial Science and Technology), Ziqiu Xue(Research Institute of Innovative Tech for the Earth), Masaatsu Aichi(Graduate School of Frontier Sciences, University of Tokyo), Chairperson:Ziqiu Xue(Research Institute of Innovative Technology for the Earth)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[HSC07-07] CO_2 behavior simulation using large scale geological model

*Yuuki Shigeoka[1], Haruki Nishiyama[1], Hiroshi Kinoto[1], Takaomi Tobase[2], Takahiro Nakajima[3], Ziqiu Xue[3] (1.JP Business Survice Corporation, 2.Electric Power Development Co., Ltd., 3.Research Institute of Innovative Technology for the Earth)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[HSC07-08] **Monitoring hydromechanical responses in aquifer by distributed fiber-optic strain sensing: From lab to field**

*Yi Zhang[1,2], Ziqiu Xue[1,2], Tsutomu Hashimoto[1,2], Hyuck Park[1,2] (1.Geological Carbon dioxide Storage Technology Research Association, 2.Research Institute of Innovative Tech for the Earth)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[HSC07-09] **Field Testing of Hybrid Brillouin-Rayleigh Distributed Sensing System for Subsurface Water Injection Monitoring**

*Yankun Sun[1,2], Ziqiu Xue[1,2], Tsutomu Hashimoto[1,2], Xinglin Lei[3], Yi Zhang[1,2] (1.Geological Carbon Dioxide Storage Technology Research Association, 2.Research Institute of Innovative Technology for the Earth, 3.National Institute of Advanced Industrial Science and Technology)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[HSC07-10] Gravity monitoring using superconducting gravimeters near the seashore at the Tomakomai CCS demonstration site

*Hiroki Goto[1,2], Mituhiko Sugihara[1,2], Hiroshi Ikeda[3], Yuji Nishi[1,2], Tsuneo Ishido[1,2], Masao Sorai[1,2] (1.Geological Carbon Dioxide Storage Technology Research Association, 2.National Institute of Advanced Industrial Science and Technology, 3.University of Tsukuba)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[HSC07-11] Pilot test for microbubble CO_2 injection to reservoir in oil field - Test planning and preparation -

*Kazunori Nakagawa[1], Ryo Ueda[1], Masanori Nakano[1], Ziqiu Xue[2] (1.Japan Petroleum Exploration Co., Ltd., 2.Research Institute of Innovative Technology for the Earth)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[HSC07-12] Mechanisms inducing anomalously high pCO_2 without CO_2 leakage in coastal environment

*Yuji Watanabe[1,2], Keisuke Uchimoto[1,2], Makoto Nishimura[1,2], Saeko Mito[1,2], Ziqiu Xue[1,2] (1.Geological CO2 Storage Technology Research Association, 2.RITE)

[J] Oral | H (Human Geosciences)：H-DS Disaster geosciences

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Convention Hall B 2F

[H-DS13] Tsunami and Tsunami Forecast

convener:Naotaka YAMAMOTO CHIKASADA(National Research Institute for Earth Science and Disaster Resilience), Hiroaki Tsushima(Japan Meteorological Agency), Tatsuya Kubota(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Masaaki Minami(気象研究所), Naotaka Chikasada(National Res. Inst. for Earth Science and Disaster Resilience)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[HDS13-07] Functions of Real-time Tsunami Inundation Forecast System Using S-net Pressure Data

*Wataru Suzuki[1], Naotaka YAMAMOTO CHIKASADA[1], Takayuki Miyoshi[1], Shin Aoi[1] (1.National Research Institute for Earth Science and Disaster Resilience)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[HDS13-08] Improvement of Real-time Tsunami Forecast System for Outer-rise Earthquake

*Naotaka YAMAMOTO CHIKASADA[1], Toshitaka Baba[2] (1.NIED, 2.Tokushima University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[HDS13-09] Maximum tsunami height prediction using Ocean-Bottom Pressure Values based on Gaussian Process Regression

*Kotaro Takahashi[1], Kenjiro Kashiwabara[1], Yasuhiko Igarashi[1,2], Toshitaka Baba[3], Takane Hori[4], Masato Okada[1] (1.Graduate School of Frontier Sciences, The University of Tokyo, 2.Japan Science and Technology Agency PRESTO, 3.Institute of Technology and Science, The University of Tokushima, 4.Research and Development Center for Earthquake and Tsunami, Japan Agency for Marine-Earth Science and Technology)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[HDS13-10] Improvement for Finite-Difference Formula of Non-Linear Longwave Equations to Express Tsunami Decay

*Masaaki MINAMI[1] (1.Meteorological Research Institute)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[HDS13-11] Real time tsunami inundation forecast method developed for Central America Region

*Yuichiro Tanioka[1], Ulbert Gleb Grillo[2], Greyving Jose Argrello[2], Amilcar Cabrera[2] (1.Hokkaido University, Institute of Seismology and Volcanology, 2.Nicaraguan Institute of Territorial Studies, Nicaragua)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[HDS13-12] Near-fault observations of an offshore earthquake by DONET: Comparison of ocean bottom pressure gauges and strong-motion accelerometers

*Ayumu Mizutani[1], Kiyoshi Yomogida[1] (1.Natural History Science, Graduate School of Science, Hokkaido University, Earth and Planetary Dynamics)

[J] Oral | H (Human Geosciences)：H-DS Disaster geosciences

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Convention Hall B 2F

[H-DS13] Tsunami and Tsunami Forecast

convener:Naotaka YAMAMOTO CHIKASADA(National Research Institute for Earth Science and Disaster Resilience), Hiroaki Tsushima(Japan Meteorological Agency), Tatsuya Kubota(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Kentaro Imai, Toshitaka Baba(Graduate School of Science and Technology, Tokushima University)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[HDS13-13] **Investigation of variation in multiple tsunami inundation modelling**

*Yoshinori Shigihara[1], Kentaro Imai[2], Hiroyuki Iwase[3], Koji Kawasaki[4], Makoto Nemoto[5], Toshitaka Baba[6], Naotaka YAMAMOTO CHIKASADA[7], Yu Chida[8], Taro Arikawa[9] (1.Department of Civil and Environmental Engineering, National Dedense Academy, 2.Japan Agency for Marine-Earth Science and Technology, 3.Ecoh Corporation, 4.Hydro Technology Institute, Co., Ltd., 5.OYO Corporation, 6.Graduate School of Science and Technology, Tokushima University, 7.National Research Institute for Earth Science and Disaster Resilience, 8.Port and Airport Research Institute, 9.Civil and Environmental Engineering, Faculty of Science and Engineering, Chuo University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[HDS13-14] **Numerical Modeling of Tsunami Inundation in Urban Area using Sub-Grid Scale Drag Force Model**

*Nobuki Fukui[1], Nobuhito Mori[2] (1.Graduate School of Engineering, Kyoto University, 2.Disaster Prevention Research Institute, Kyoto University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[HDS13-15] Numerical experiment of tsunami deposits related to fault parameters by sediment transport model

*Ako YAMAMOTO[1], Tomoyuki Takahashi[2], Kenji Harada[3] (1.Forest of Research and Management Organization Forestry and Forest Products Research Institute, 2.Kansai University, 3.Shizuoka University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[HDS13-16] Evaluation of potential impact of tsunami-induced sediment transport in Kochi Prefecture during the Nankai Trough megathrust earthquake and tsunami

*Kei Yamashita[1], Daisuke Sugawara[2], Shuji Seto[1], Taro Arikawa[3], Tomoyuki Takahashi[4], Fumihiko Imamura[1] (1.International Research Institute of Disaster Science, Tohoku University, 2.Museum of Natural and Environmental History, Shizuoka, 3.Faculty of Science and Engineering , Chuo University, 4.Faculty of Societal Safety Sciences, Kansai University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[HDS13-17] Tsunami damage of the Keicho Earthquake of February 3rd, 1605 on the coasts of Tokai, Shikoku, and Kyushu Districts

*Yoshinobu Tsuji[1], Kentaro Imai[2], Yuuichi Ebina[3], Hiroyuki Iwase[4], Ryoko Oobayashi[2] (1.Shimanto City, 2.JAMSTEC, 3.IRIDeS, 4.Ecoh co. LTD)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[HDS13-18] Re-examination of tsunami heights distribution during the 1854 Ansei Tokai Earthquake

*Kentaro Imai[1], ebina yuichi[2], Yoshinobu Tsuji[3], Hiroyuki Iwase[4], Takane Hori[1], Narumi Takahashi[1,5], Takashi Furumura[6] (1.Japan Agency for Marine-Earth Science and Technology, 2.International Research Institute of Disaster Science, 3.Shimanto City, 4.ECOH CORPORATION, 5.National Research Institute for Earth Science and Disaster Resilience, 6.Earthquake Research Institute The University of Tokyo)

[J] Oral | H (Human Geosciences)：H-RE Resource and Engineering Geology

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 106 1F

[H-RE16] Resource Geology

convener:Tsubasa Otake(Division of Sustainable Resources Engineering, Faculty of Engineering, Hokkaido University), Daisuke Araoka(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Ryohei Takahashi(Graduate School of International Resource Sciences, Akita University), Tatsuo Nozaki(Research and Development Center for Submarine Resources, Japan Agency for Marine-Earth Science and Technology), Chairperson:Tsubasa Otake(Faculty of Engineering, Hokkaido University), Daisuke Araoka

10:45 AM - 11:15 AM JST | 1:45 AM - 2:15 AM UTC

[HRE16-01] The role of water in the concentration of Cr

★Invited Papers

*Shoji Arai[1] (1.Department of Earth Sciences, Faculty of Science, Kanazawa University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[HRE16-02] Mineralogical Features of Silver-Bearing Minerals in Chimney Ore from Myojinsho Caldera, Myojin Knoll and Bayonnaise Knoll Seafloor Hydrothermal Area, Izu-Bonin Arc

Shinji Kawaguchi[1], *Kotaro Yonezu[1], Thomas Tindell[1], Jun-ichiro Ishibashi[2], Tatsuo Nozaki[3], Yoko Ohtomo[4], Koichiro Watanabe[1] (1.Deaprtment of Earth Resources Engineering, Faculty of Engineering, Kyushu University, 2.Department of Earth and Planetary Sciences, Faculty of Sciences, Kyushu University, 3.Research and Development Center for Submarine Resources, Japan Agency for Marine-Earth Science and Technology, 4.Faculty of Engineering, Hokkaido University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[HRE16-03] Organic matters and acid-sulfate alteration in Itomuka Mine, Hokkaido, Japan: implications for the transportation and deposition mechanisms of mercury

*Takuya Echigo[1], Mitsuyoshi Kimata[2], Masahiro Shimizu[2] (1.Graduate School of International Resource Sciences, Akita University, 2.Graduate School of Life and Environmental Sciences, University of Tsukuba)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[HRE16-04] **Significances of 12 Ma manganese ores in the Hokuroku district, Akita: unique Mn accumulation and interaction with organic matter during submarine hydrothermal activities**

*Yuya Tsukamoto[1], Takeshi Kakegawa[1] (1.Tohoku Univ.)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[HRE16-05] Microbial communities around ca. 2.7 Ga submarine hydrothermal fields at the Potterdoal deposit in Abitibi Greenstone Belt, Canada

*Takeru Osato[1], Akizumi Ishida[1], Takeshi Kakegawa[1] (1.Tohoku University)

[J] Oral | H (Human Geosciences)：H-RE Resource and Engineering Geology

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 106 1F

[H-RE16] Resource Geology

convener:Tsubasa Otake(Division of Sustainable Resources Engineering, Faculty of Engineering, Hokkaido University), Daisuke Araoka(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Ryohei Takahashi(Graduate School of International Resource Sciences, Akita University), Tatsuo Nozaki(Research and Development Center for Submarine Resources, Japan Agency for Marine-Earth Science and Technology), Chairperson:Tatsuo Nozaki(JAMSTEC), Ryohei Takahashi(Faculty of International Resource Sciences, Akita University)

1:45 PM - 2:15 PM JST | 4:45 AM - 5:15 AM UTC

[HRE16-06] Development of nano-fabrication and high-resolution electron microscopy techniques: their possible applications to resource geology

★Invited Papers

*Naotaka Tomioka[1], Satoko Motai[1], Yu Kodama[2], Motoo Ito[1] (1.Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology, 2.Marine Works Japan)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[HRE16-07] Microscopic study on rare earth elements in ion-adsorption type ore of China

*Hiroki Mukai[1], Yoshiaki Kon[1], Kenzo Sanematsu[1], Yoshio Takahashi[2], Motoo Ito[3] (1.National Institute of Advanced Industrial Science and Technology, 2.Graduate School of Science, the University of Tokyo, 3.Kochi Institute for Core Sample Research JAMSTEC)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[HRE16-08] Geochemical features of “invisible gold” in pyrites from the Akeshi and Kasuga deposits, Kagoshima, Japan

*Mizuki Ishida[1], Rurik Romeo[2,3], Mathieu Leisen[2,3], Junji Torimoto[4], Tatsuo Nozaki[4,5,6,7], Kazutaka Yasukawa[1,6], Koichiro Fujinaga[6,1], Kentaro Nakamura[1], Martin Reich[2,3], Yasuhiro Kato[1,6,5] (1.Department of Systems Innovation, School of Engineering, The University of Tokyo, 2.Department of Geology and Andean Geothermal Center of Excellence (CEGA), FCFM, 3.Millennium Nucleus for Metal Tracing Along Subduction, FCFM, Universidad de Chile, FCFM, 4.Japan Agency for Marine-Earth Science and Technology (JAMSTEC), 5.Frontier Research Center for Energy and Resources, School of Engineering, The University of Tokyo, 6.Ocean Resources Research Center for Next Generation, Chiba Institute of Technology, 7.Department of Planetology, Graduate School of Science, Kobe University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[HRE16-09] Hydrothermal Mineral Assemblage of the Southwest Prospect, in the Vicinity Sto. Tomas II (Philex) Porphyry Cu-Au Deposit, Baguio District, Philippines

*Avriel Venis Literal Cirineo[1], Akira Imai[2], Ryohei Takahashi[1], Noel C. Oliveros[3], Redempta P. Baluda[3], Victor B. Maglambayan[3], Roy Ronald C. Luis[3], Maria Lourdes M. Faustino[3] (1.Graduate School of International Resource Sciences, Akita University, 2.Faculty of Engineering, Kyushu University, 3.Philex Mining Corporation)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[HRE16-10] Characteristics and genesis of weathering REE deposits

★Invited Papers

*Kenzo Sanematsu[1] (1.Mineral Resource Research Group, Institute for Geo-Resources and Environment, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-SS09] Earthquake prediction and forecast

convener:Masayuki Obayashi(Japan Agency for Marine-Earth Science and Technology), Toshitaka Baba(Graduate School of Science and Technology, Tokushima University), Chairperson:Sumio Yoshikawa(気象研究所), Mamoru Kato(Graduate School of Human and Environmental Studies Kyoto University)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SSS09-01] **Objective evaluationof precursory seismic quiescence and activation phenomenon in wide area**

*Sumio Yoshikawa[1] (1.Meteorological Research Institute)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SSS09-02] Long-term Probability of a Great Earthquake along the Kurile Trench, Hokkaido Japan (2)

*Masajiro Imoto[1], Morilkawa Nobuyuki[1], Fujiwara Hiroyuki[1] (1.National Research Institute for Earth Science and Disaster Resilience)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SSS09-03] Parallel and Focused Increase Trends in Time Series (M-T Diagram) of Earthquake Occurrences

*Satoshi Hashimoto[1] (1.none)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SSS09-04] Revisiting a simple method for short-term earthquake probabilities derived from past Seismicity

*Mamoru Kato[1] (1.Graduate School of Human and Environmental Studies Kyoto University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SSS09-05] Recent anomalous groundwater temperature and water level changes at the frontier land zone of Nanki region for impending great earthquakes at the Nankai trough

*Tameshige Tsukuda[1] (1.none)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SSS09-06] What happen on the East Japan Megaquake; answer to sufferers

*Nobuaki Niitsuma[1] (1.Institute of Geosciences,Shizuoka University)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-SS14] Fault Rheology and Earthquake Physics

convener:Keishi Okazaki(Japan Agency for Marine-Earth Science and Technology), Hideki Mukoyoshi(Department of Geoscience Interdisciplinary Graduate School of Science and Engineering, Shimane University), Hiroyuki Noda(Kyoto University, Disaster Prevention Research Institute), Keisuke Yoshida(Tohoku University), Chairperson:Hideki Mukoyoshi, Shunya Kaneki(Osaka University)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SSS14-07] Effect of slickenside on the crustal strength

*Jun-ichi Ando[1], Takayoshi Nagaoka[1], Naotaka Tomioka[2], Hiroyuki Kagi[3], Kaushik Das[1] (1.Department of Earth and Planetary Systems Science, Hiroshima University, 2.Kochi Institute for core sample research, Japan Agency for Marine-Earth Science and Technology, 3.Geochemical Research Center, Graduate School of Science, University of Tokyo)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SSS14-08] Dehydroxylation kinetics of clay minerals and its application to friction heating along an imbricate thrust in an accretionary prism

★Invited Papers

*Hirokazu Masumoto[1], Jun Kameda[1] (1.Faculty of Science, Hokkaido University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SSS14-09] Origin of frictional melt in the Jurassic accretionary complex of the Mino Belt on the basis of trace element and isotope analysis

*Chizuru Ozawa[1], Tsuyoshi Ishikawa[2], Kohtaro Ujiie[1] (1.University of Tsukuba, 2.JAMSTEC)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SSS14-10] Geochemical constraint on the origin of albite-bearing black fault rocks in the Kodiak accretionary complex

*Tsuyoshi Ishikawa[1], Asuka Yamaguchi[2] (1.Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology, 2.AORI, The University of Tokyo)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SSS14-11] Importance of initial maturity and reaction kinetics on maturation of carbonaceous material and its implications for thermal maturity as a proxy for temperature in estimation of coseismic slip parameters

*Shunya Kaneki[1], Ichiba Tatsuya[1], Shuhei Yamashita[1], Tetsuro Hirono[1] (1.Graduate School of Science, Osaka University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SSS14-12] Experimental investigation of cumulative effect on thermal maturation of carbonaceous material as a proxy for earthquake slip

*Tetsuro Hirono[1], Yuhtaro Shimamura[1], Shunya Kaneki[2] (1.Department of Earth and Space Science, Graduate School of Science, Osaka University, 2.Disaster Prevention Research Institute, Kyoto University)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-SS14] Fault Rheology and Earthquake Physics

convener:Keishi Okazaki(Japan Agency for Marine-Earth Science and Technology), Hideki Mukoyoshi(Department of Geoscience Interdisciplinary Graduate School of Science and Engineering, Shimane University), Hiroyuki Noda(Kyoto University, Disaster Prevention Research Institute), Keisuke Yoshida(Tohoku University), Chairperson:Hiroyuki Noda(DPRI, Kyoto University), Keishi Okazaki(JAMSTEC)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SSS14-13] **Fault rheology at the depth limits of the seismogenic zone**

★Invited Papers

*Berend Antonie Verberne[1] (1.Geological Survey of Japan, National Institute of Industrial Science and Technology)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SSS14-14] Fault models revisited based on friction to flow law

*Toshihiko Shimamoto[1] (1.State Key Laboratory of Earthquake Dynamics, Institute of Geology, China Earthquake Administration)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SSS14-15] Timing of Earthquakes on Intraplate Active Faults Subjected to Stress Perturbation by Megathrust Earthquakes: Insights from Earthquake Sequence Simulation

*Hiroyuki Noda[1] (1.Kyoto University, Disaster Prevention Research Institute)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SSS14-16] Physics of earthquake triggering: effect of stress perturbation to slip acceleration

★Invited Papers

*Takahiro Hatano[1] (1.Earthquake Research Institute, University of Tokyo)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SSS14-17] Foreshock activities controlled by slip rate on a 4-meter-long laboratory fault

*Futoshi Yamashita[1], Eiichi Fukuyama[1], Shiqing Xu[1] (1.National Research Institute for Earth Science and Disaster Resilience)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SSS14-18] Supersonic propagation of slow slip rupture during rock friction experiments

*Eiichi Fukuyama[1], Futoshi Yamashita[1], Shiqing Xu[1] (1.National Research Institute for Earth Science and Disaster Resilience)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-SS14] Fault Rheology and Earthquake Physics

convener:Keishi Okazaki(Japan Agency for Marine-Earth Science and Technology), Hideki Mukoyoshi(Department of Geoscience Interdisciplinary Graduate School of Science and Engineering, Shimane University), Hiroyuki Noda(Kyoto University, Disaster Prevention Research Institute), Keisuke Yoshida(Tohoku University), Chairperson:Hiroyuki Noda(DPRI, Kyoto University), Keisuke Yoshida(東北大学大学院理学研究科 地球物理学専攻)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SSS14-19] The role of fault damage zone in the supershear rupture of the 2018 Mw 7.5 Palu earthquake

*Lingsen Meng[1], Han Bao[1], Jean-Paul Ampuero[2], Eric Fielding[3], Cunren Liang[4], Christopher Milliner [3], Tian Feng[1], Hui Huang[1] (1.University of California Los Angeles, 2.Université Côte d'Azur and IRD, 3.Jet Propulsion Laboratory , 4.California Institute of Technology)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SSS14-20] The role of curvature in earthquake mechanics

*Pierre Romanet[1], Daisuke Sato[2], Ryosuke Ando[1] (1.Earth and Planetary Science Department, University of Tokyo, 2.Disaster Prevention Research Institute, Kyoto University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SSS14-21] **Heterogeneous source modelling by the fully dynamic simulations of earthquake cycles on a strike-slip fault and scaling relations.**

*Percy Galvez[1,5], Anatoly Petukhin[2], Paul Somerville[3], Ken Miyakoshi[2], Kojiro Irikura[4] (1.KAUST University, Saudi Arabia, 2.Geo-Research Institute, Osaka Japan, 3.AECOM, Los Angeles, USA., 4.Aichi Institute of Technology, Japan, 5.ETH Zurich, Switzerland)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SSS14-22] **Strain energy released by an earthquake: Contributions of random slip fluctuations**

*Tatsuhiko Saito[1], Akemi Noda[1] (1.National Research Institute for Earth Science and Disaster Resilience)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SSS14-23] The change in the elastic strain energy due to the 1992 Landers earthquake and triggering mechanisms of aftershock activity

*Toshiko Terakawa[1], Mitsuhiro Matsu'ura[2], Akemi Noda[3] (1.Graduate School of Environmental Studies, Nagoya University, 2.Institute of Statistical Mathematics, 3.National Research Institute for Earth Science and Disaster Resilience)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SSS14-24] Toward understanding generation mechanism of crustal earthquakes based on accumulation/release of elastic strain energy

★Invited Papers

*Akemi Noda[1] (1.National Research Institute for Earth Science and Disaster Resilience)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[S-SS15] Active faults and paleoseismology

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Takashi OGAMI(National Institute of Advanced Industrial Science and Technology), Ryosuke Doke(Hot Springs Research Institute of Kanagawa Prefecture), Hisao Kondo(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Chairperson:Takashi Azuma(AIST), Mamoru KOARAI(Ibaraki University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SSS15-05] Paleoseismological survey on the Shibetsu fault zone in the eastern part of Hokkaido, Japan

*Takashi Azuma[1], Daisuke Hirouchi[2], Koji Okumura[3], Kaoru Taniguchi[4], Masashi Omata[4], Yorihide Kohriya[4] (1.National Institute of Advanced Industrial Science and Technology, 2.Shinshu University, 3.Hiroshima University, 4.Pasco CORPORATION)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SSS15-06] Deformation of marine terrace surfaces associated with active Rokkasho fault in southern Shimokita peninsula, northern Japan

*Mitsuhisa Watanabe[1] (1.Faculty of Sociology, Toyo University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SSS15-07] **Vertical crustal movement during the past 600 years in the Kikai Island, deduced from the height distribution and ages of coral microatolls**

*Masanobu Shishikura[1], Hideaki Maemoku[2], Tomoo Echigo[3], Yuichi Namegaya[1], Tatsuya Ishiyama[4], Ryo Kinjo[2], Naoto Inoue[3] (1.Institute of Earthquake and Volcano Geology, National Institute of Advanced Industrial Science and Technology, 2.Hosei University, 3.Geo-Reserch Institute, 4.Earthquake Research Institute, University of Tokyo)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SSS15-08] Variation of coseismic fault displacements on multiple seismic cycles at a site: An example from the Kamishiro fault, Itoigawa-Shizuoka Tectonic Line active fault system, central Japan

*Naoya Takahashi[1], Shinji Toda[2] (1.Graduate school of Science, Department of Earth Science, Tohoku University, 2.International Research Institute of Disaster Science, Tohoku University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SSS15-09] High-resolution shear-wave seismic reflection surveys across the Kamishiro fault, Itoigawa-Shizuoka Tectonic Line active fault system, central Japan

*Naoki IKEGUCHI[1], Nobuhisa Matsuta[2], Kyoko Kagohara[3], Shinsuke Okada[4], Daisuke Hirouchi[5], Tatsuya Ishiyama[1], Katsuya Noda[6], Hiroshi Sato[1] (1.Earthquake Resarch Institute University of Tokyo, 2.Graduate School of Education, Okayama University, 3.Faculty of Education, Yamaguchi University, 4.Graduate school of Science, Tohoku University, 5.Faculty of Education, Shinshu University, 6.GEOSYS Inc.)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[S-SS15] Active faults and paleoseismology

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Takashi OGAMI(National Institute of Advanced Industrial Science and Technology), Ryosuke Doke(Hot Springs Research Institute of Kanagawa Prefecture), Hisao Kondo(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Chairperson:HISAO KONDO(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Nobuhiko Sugito(Hosei University)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SSS15-10] Paleoseismic investigations on the un-ruptured section during the 2014 earthquake along the Kamishiro fault, ISTL active fault zone, Central Japan

*Hisao Kondo[1], Hideki Kurosawa[2], Yoko Hirakura[2], Keita Takada[3], Kohei Abe[2], Miwako Ito[2], Atsuo Igarashi[3], Tetsuya Ikeda[3], Atsushi Miwa[2] (1.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2.OYO Cooperation, 3.Fukken Co., Ltd)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SSS15-11] P-wave seismic reflection profiling across the northern central ISTL active fault system, central Japan

*Haruo Kimura[1], Hisao Kondo[2], Yasuhiko Akinaga[3], Shigeru Okamoto[3], Masaki Suehiro[3] (1.Central Research Institute of Electric Power Industry, 2.Geological Survey of Japan, AIST, 3.Hanshin Consultants Co., Ltd.)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SSS15-12] History of interplate earthquakes along the Sagami Trough from uplifted coasts in the Boso Peninsula

*Junki Komori[1], Masanobu Shishikura[2], Ryosuke Ando[1] (1.The University of Tokyo, 2.The National Institute of Advanced Industrial Science and Technology)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SSS15-13] Inferring location and activity of the Iriyamase fault, the Fujikawa-kako fault zone, based on boring core sample analyses and physical fault model

*Namiki Ryo[1], Ryosuke Ando[1], Masanobu Shishikura[2] (1.The University of Toyko, 2.National Institute of Advanced Industrial Science and Technology)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SSS15-14] **Coastal submergence events identified by fossil diatoms and plant macrofossils at Ukishima-ga-hara adjacent to the Suruga Trough (eastern Nankai Trough), central Japan**

*Yuki Sawai[1], Arata Momohara[2], DAN MATSUMOTO[1], Yumi Shimada[1,3] (1.Geological Survey of Japan, AIST, 2.Chiba University, 3.University of Tsukuba)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[S-SS15] Active faults and paleoseismology

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Takashi OGAMI(National Institute of Advanced Industrial Science and Technology), Ryosuke Doke(Hot Springs Research Institute of Kanagawa Prefecture), Hisao Kondo(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Chairperson:Takashi Ogami(AIST), Koji Okumura(Hiroshima University)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SSS15-15] Shallow structures and tectonic geomorphology of active blind thrusts imaged by new hi-resolution seismic reflection profiling, Hokkaido, Northern Japan

*Tatsuya Ishiyama[1], Naoko Kato[1], Hiroshi Sato[1], Taro Koike[2], Katsuya Noda[2] (1.Earthquake Research Institute, University of Tokyo, 2.Geosys, Inc.)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SSS15-16] Paleo-seismological survey on the Idenokuchi fault, Nishihara village, Kumamoto prefecture

*Daisuke Ishimura[1], Hiroyuki Tsutsumi[2], Naoya Takahashi[3], Ryuhei Oda[1], Jun Matsukaze[1], Heitaro Kaneda[4], Motoya Kobayashi[4], Yasuhiro Kumahara[5], Makoto Kobayashi[6], Toshihiko Ichihara[7] (1.Department of Geography, Tokyo Metropolitan University, 2.Department of Environmental Systems Science, Faculty of Science and Engineering, Doshisha University, 3.Department of EarthScience, Tohoku University, 4.Graduate School of Science, Chiba University, 5.Graduate School of Education, Hiroshima University, 6.Research Center for Volcanic Hazards and Their Mitigation, Tokyo Metropolitan University, 7.Sedimentary Environments Research)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SSS15-17] Paleoseismic investigations of the Hinagu fault zone, Kumamoto, Japan: Preliminary result of trenching survey at Yatsushiro city

*Yukari Miyashita[1], Takashi Azuma[1], Yusuke Komine[2], Masao Kametaka[2], Midori Kishiyama[2] (1.Institute of Earthquake and Volcano Geology, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2.Dia Consultants Co. Ltd.)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SSS15-18] Seismic trenching on offshore part of the Hinagu Fault Zone, Kyushu, Japan −3D structure and paleo-seismicity of offshore dextral strike-slip fault

*Takashi OGAMI[1], Shintaro Abe[2], Kenjiro Mukaiyama[3], Shigeyuki Suda[4] (1.Geological Survey of Japan, AIST, 2.ADEP, 3.Kawasaki Geological Engineering Co. Ltd., 4.JGI Inc.)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SSS15-19] Conductivity Structure models of large and small slip regions at the 2016 Kumamoto earthquake sequence

*Satoru Yamaguchi[1], Yuto Yamanaka[2], Akira Mimura[1], Kazuki Fkue[1], Daigo Furukawa[1], Tada-nori Goto[3], Hisatoshi Koji[3], Sota Kawaguchi[3], Koki Aizawa[4], Shinichi Takakura[5] (1.Department of Geosciences, Graduate School of Science, Osaka City University, 2.Faculty of Science, Osaka City University, 3.Department of Urban Management, Graduate School of Engineering, Kyoto University, 4.Institute of Seismology and Volcanology, Kyushu University, 5. Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SSS15-20] The Timing and Extent of the Last Surface Rupture Event on the Himalayan Frontal Thrust in Central Nepal around Butwal

*Koji Okumura[1], Soma Nath Sapkota[2], Prakash Pokhrel[2], Hisao Kondo[4], Takuya Furuhashi[3] (1.Graduate School of Letters, Hiroshima University, 2.Department of Mines and Geology, 3.Taiheiyo Cement Corporation, 4.Geological Survey of Japan, AIST)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[S-SS15] Active faults and paleoseismology

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Takashi OGAMI(National Institute of Advanced Industrial Science and Technology), Ryosuke Doke(Hot Springs Research Institute of Kanagawa Prefecture), Hisao Kondo(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Chairperson:Ryosuke Doke(Hot Springs Research Institute of Kanagawa Prefecture), Mamoru KOARAI(Ibaraki University)

3:30 PM - 4:00 PM JST | 6:30 AM - 7:00 AM UTC

[SSS15-21] Linear surface ruptures detected by SAR - - *the Kumamoto earthquake, the Northern Osaka earthquake and the Hokkaido Eastern Iburi earthquake*

★Invited Papers

*Satoshi Fujiwara[1], Hiroshi Une[1], Takayuki Nakano[1], Hiroshi Yarai[1], Tomokazu Kobayashi[1], Yu Morishita[1] (1.GSI of Japan)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SSS15-22] Acquisition of micro-landforms in the forest using small UAV-LiDAR: An example from surface rupture of the 2008 Iwate-Miyagi Nairiku, Japan, earthquake

*Asaka Konno[1], Taro Suzuki[2], Shinji Toda[1] (1.International Research Institute of Disaster Science, Tohoku University, 2.Waseda University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SSS15-23] **Bayesian Inference and Forecast on Renewal Processes for Recurrent Earthquakes with Uncertain Occurrence Times**

*Shunichi Nomura[1], Yosihiko Ogata[1] (1.The Institute of Statistical Mathematics)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SSS15-24] **Slip rate of the Chaman fault: estimates based on ^{10}Be exposure dating for offset geomorphic surfaces in Afghanistan**

*Zakeria Shnizai[1], Yuki Matsushi[2], Hiroyuki Tsutsumi[1] (1.Doshisha University, 2.Kyoto University)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[S-SS17] Seismic evidence of volcanic roots

convener:Naofumi Aso(Tokyo Institute of Technology), Yohei Yukutake(Hot Springs Research Institute of Kanagawa Prefecture), Chairperson:Naofumi Aso, Yohei Yukutake

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SSS17-01] Spectral characteristics of deep low frequency earthquakes at Mount Fuji

★Invited Papers

*Motoo Ukawa[1] (1.Nihon University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SSS17-02] Deep low-frequency earthquakes corresponding to the 2011 and 2018 eruptions in Kirishima volcano

*Ryo Kurihara[1], Kazushige Obara[1], Akiko Takeo[1], Yusaku Tanaka[1] (1.Earthquake Research Institute, The University of Tokyo)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SSS17-03] Origin of long-duration of deep low-frequency earthquakes and activity of shallow low-frequency earthquakes beneath northeastern Japan

*Masahiro Kosuga[1], Taichi Haruyama[1], Yuki Matsuno[2], Iori Narita[2], Takuto Maeda[1] (1.Graduate School of Science and Technology, Hirosaki University, 2.Faculty of Science and Technology, Hirosaki University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SSS17-04] Deep low-frequency earthquakes, tomography and magmatic system beneath active volcanoes

★Invited Papers

*Dapeng Zhao[1] (1.Department of Geophysics, Tohoku University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SSS17-05] Seismic imaging of deep structure beneath active volcanoes

*Junichi Nakajima[1] (1.Department of Earth and Planetary Sciences, Tokyo Institute of Technology)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SSS17-06] Deep low-frequency volcanic earthquakes and their implication for deep crustal processes in the magmatic arc

*Haruhisa Nakamichi[1] (1.Sakurajima Volcano Research Center, Disaster Prevention Research Institute, Kyoto University)

[J] Oral | S (Solid Earth Sciences)：S-MP Mineralogy & Petrology

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[S-MP32] Deformed rocks, Metamorphic rocks and Tectonics

convener:Yumiko Harigane(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Yoshihiro Nakamura(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Chairperson:Yoshihiro Nakamura(産総研), Yumiko Harigane(産総研)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SMP32-01] Argon release mechanism of deformed phengite

*Tetsumaru Itaya[1] (1.Engineering Geology Center, Hiruzen Institute for Geology and Chronology)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SMP32-02] Detrital zircons from a traverse along the Asemi River (Sanbagawa Metamorphic Belt, Shikoku, Japan): U-Pb geochronology and Hf isotopic composition

*Ulrich Knittel[1], Shigeyuki Suzuki[2], Monika Walia[3], Juan-Hsi Lee[4], Hao-Yang Lee[5] (1.RWTH Aachen University, 2.Okayama University, 3.Nat. Taiwan University , 4.Chung Cheng University, 5.Academia Sinica)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SMP32-03] Tectonic process of the Sanbagawa eclogite: zircon U–Pb and REE composition analyses

*Shogo Aoki[1], Kazumasa Aoki[2], Tatsuki Tsujimori[3], Yuta Tsuchiya[1], Daichi Kato[2] (1.Department of Biosphere-Geosphere Science, Okayama University of Science, 2.Department of Applied Science, Okayama University of Science, 3.Center for Northeast Asian Studies, Tohoku University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SMP32-04] Petrological implications of a new occurrence of retrogressed eclogite from the Sanbagawa belt of southwest Japan

*Tomoki Taguchi[1], Shunsuke Endo[2], Yohei Igami[1,3], Akira Miyake[1] (1.Graduate School of Science, Kyoto University, 2.Interdisciplinary Faculty of Science and Engineering, Shimane University, 3.Institute of Materials and Systems for Sustainability, Nagoya University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SMP32-05] *P-T* estimations of Kashio mylonite in Oshika, Nagano, Japan: Constraints on the amalgamation of Ryoke and Sambagawa belts

*Yoshihiro Nakamura[1], Yutaka Takahasi[1], Tohru Danhara[2], Hideki Iwano[2], Takehumi Hirata[3] (1.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2.Kyoto Fission-Track Co., Ltd., 3.Geochemical Research Center, The University of Tokyo)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SMP32-06] **Static phenomena retained by garnet during exhumation of metamorphic rocks**

*Masaki Enami[1], Yui Kouketsu[2] (1.Institute for Space–Earth Environmental Research, Nagoya University, 2. Nagoya University)

[J] Oral | S (Solid Earth Sciences)：S-MP Mineralogy & Petrology

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[S-MP32] Deformed rocks, Metamorphic rocks and Tectonics

convener:Yumiko Harigane(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Yoshihiro Nakamura(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Chairperson:Tomoki Taguchi(京都大学　大学院理学研究科), Kenta Yoshida(JAMSTEC)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SMP32-07] Garnet zoning suggesting the correlation between the Higo and Abukuma metamorphic rocks

*Tadao Nishiyama[1], Yuto Wakida[1] (1.Department of Earth and Environmental Sciences, School of Science, Graduate School of Science and Technology, Kumamoto University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SMP32-08] $FeAlO_3$ phase at ultrahigh-temperature metamorphic conditions: Evidences from the sillimanite—Fe_2O_3 and sillimanite—Fe_3O_4 systems at 9 kbar and 1050 °C

*Toshisuke Kawasaki[1], Tatsuro Adachi[2], Hiroaki Ohfuji[1], Yasuhito Osanai[2] (1.Ehime University, 2.Kyushu University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SMP32-09] **Halogens in nanogranitoids entrapped during granulite facies to ultrahigh-temperature metamorphism in the lower crust**

*Fumiko Higashino[1], Tetsuo Kawakami[2] (1. Graduate School of Environmental Studies, Tohoku University, 2.Graduate School of Science, Kyoto University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SMP32-10] Significance of high-Ti biotite and anatectic conditions of paragneiss in the Oki-Dogo Island, Japan

Hiroshi Yoshida[1], *Shunsuke Endo[1], Mai Fujiwara[1], Atsushi Kamei[1] (1.Department of Earth Science, Interdisciplinary Faculty of Science and Engineering, Shimane University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SMP32-11] Eclogite-to-granulite transition in the Ufipa Complex (Tanzania): the time-lag between collision and the granulitization

*Morita Isamu[1], Tatsuki Tsujimori[1], Nelson Boniface[2], Shogo Aoki[3], Kazumasa Aoki[3] (1.Tohoku University, 2.University of Dar es Salaam, 3.Okayama University of Science)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SMP32-12] **Switching of metamorphic growth kinetics due to volume fraction of metamorphic fluid**

*Kazuhiro Miyazaki[1] (1.Orogenic Processes Research Group, Institute of Geology and Geoinformation, Geological Survey of Japan/National Institute of Advanced Industrial Science and Technology)

[J] Oral | S (Solid Earth Sciences)：S-MP Mineralogy & Petrology

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[S-MP32] Deformed rocks, Metamorphic rocks and Tectonics

convener:Yumiko Harigane(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Yoshihiro Nakamura(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Chairperson:Shunsuke Endo(島根大学 総合理工学部 地球科学科), Ryosuke Oyanagi(国立研究開発法人 海洋研究開発機構 地球内部物質循環研究分野)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SMP32-13] Early Paleozoic subduction-zone metamorphism in Japan: A geochronological reappraisal of Kitomyo Schists

*Shota Matsunaga [1], Tatsuki Tsujimori[1], Atsushi MIYASHITA[2], Shogo Aoki[3], Kazumasa Aoki[3] (1.Tohoku University, 2.Seikei University, 3. Okayama University of Science)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SMP32-14] Dating a 'princess': U–Pb age determination of 'nunakawaite' (strontio-orthojoaquinite)

*Tatsuki Tsujimori[1], Tomomi Hara[1], Yuzuki Shinji[1], Tomohiro Ishizaka[1], Hiroshi Miyajima[2], Jun-Ichi Kimura[3], Shogo Aoki[4], Kazumasa Aoki[4] (1.Tohoku University, 2.Fossa Magna Museum, 3.JAMSTEC, 4.Okayama University of Science)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SMP32-15] Modeling of the progressive evolution of subducting slab composition by sparse modeling

*Kenta Yoshida[1], Tatsu Kuwatani[1,2], Kenta Ueki[1], Ryosuke Oyanagi[1], Shotaro Akaho[3] (1.Japan Agency for Marine-earth Science and Technology (JAMSTEC), 2.PRESTO, Japan Science and Technology Agency, 3.National Institute of Advanced Industrial Science and Technology (AIST))

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SMP32-16] Bayesian statistical evaluation method for detrital zircon geochronology: Applications

*Tan Furukawa[1], Tatsuki Tsujimori[2], Shogo Aoki[3], Kazumasa Aoki[4] (1.Tohoku University, Department of Earth Science, 2.Tohoku University, 3.Faculty of Biosphere-Geosphere Science, Okayama University of Science, 4.Department of Applied Science Okayama University of Science)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SMP32-17] 3D structural analysis using X-ray Computed Tomography technique: a case study for fault rocks from the Nojima Fault, southwest Japan

*Takafumi Nishiwaki[1], Aiming Lin[1], Bingcheng Liu[1] (1.Kyoto University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SMP32-18] High- and low-stress subduction zones recognized in the rock record

*Kazuhiko Ishii[1], Simon Richard Wallis[2] (1.Department of Physical Science, Graduate School of Sciences, Osaka Prefecture University, 2.Department of Earth and Planetary Science, Faculty of Science, The University of Tokyo)

[J] Oral | S (Solid Earth Sciences)：S-MP Mineralogy & Petrology

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-MP33] Physics and Chemistry of Minerals

convener:Seiji Kamada(Frontier Research Institute for Interdisciplinary Sciences, Tohoku University), Masahiro KAYAMA(Department of Earth and Planetary Material Sciences, Faculty of Science, Tohoku University), Chairperson:Seiji Kamada(FRIS, Tohoku Univ.)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SMP33-01] High-temperature Raman spectroscopic study of CO_2-containing melanophlogite

*Masami Kanzaki[1] (1.Institute for Planetary Matereials, Okayama University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SMP33-02] Synthesis of barium carbonate with calcite structure and rotational disorder of carbonate ions

*Hiroyuki Kagi[1], Ayaka Saito[1], Kazuki Komatsu[1], Jun Kawano[2] (1.Geochemical Research Center, Graduate School of Science, University of Tokyo, 2.Fuculty of Science, Hokkaido University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SMP33-03] In-situ Raman spectroscopy of ε-FeOOH under high pressures

*Osamu Ikeda[1], Tatsuya Sakamaki[1], Akio Suzuki[1] (1.Department of Earth Science, Graduate School of Science, Tohoku University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SMP33-04] **Strong hydrogen-bond generation in dense hydrous magnesium silicate phase E observed by single-crystal neutron diffraction**

*Narangoo Purevjav[1], Takuo Okuchi[1], Christina Hoffmann[2] (1.Institute for Planetary Materials, Okayama University, 2.Neutron Scattering Division, Neutron Sciences Directorate, Oak Ridge National Laboratory)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SMP33-05] **Water partitioning between upper mantle minerals and melts**

*Dmitry Bondar[1], Hongzhan Fei[1], Tony Withers[1], Tomoo Katsura[1] (1.Bayerisches Geoinstitut, University of Bayreuth, 95440 Bayreuth, Germany)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SMP33-06] Drop-solution enthalpy measurement of $MgSiO_3$ majorite

*Hiroshi Kojitani[1], Masamichi Noda[2], Toru Inoue[2,3], Masaki Akaogi[1] (1.Department of Chemistry, Faculty of Science, Gakushuin University, 2.GRC, Ehime University, 3.Dept. of Earth and Planetary systems Science, Hiroshima University)

[J] Oral | S (Solid Earth Sciences)：S-MP Mineralogy & Petrology

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-MP33] Physics and Chemistry of Minerals

convener:Seiji Kamada(Frontier Research Institute for Interdisciplinary Sciences, Tohoku University), Masahiro KAYAMA(Department of Earth and Planetary Material Sciences, Faculty of Science, Tohoku University), Chairperson:Masahiro Kayama(東北大学)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SMP33-07] High-pressure phase transitions of minerals in the system MgO-TiO_2

*Masaki Akaogi[1], Tetsuya Fujimura[1], Shunto Arai[1], Masaki Okano[1], Hiroshi Kojitani[1] (1.Department of Chemistry, Faculty of Science, Gakushuin University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SMP33-08] Phase change process of iron sulfide nanoparticle from amorphous to crystalline with grain growth

*Yoshinari Sano[1], Atsushi Kyono[2], Yasuhiro Yoneda[3], Gen-ichiro Yamamoto[1] (1.Graduate School of Life and Environmental Sciences, University of Tsukuba, 2.Faculty of Life and Environmental Sciences, University of Tsukuba, 3.Japan Atomic Energy Agency)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SMP33-09] Texture formation in quenching of Fe-S-O micro melt spherules

*Hiroshi Isobe[1] (1.Department of Earth and Environmental Sciences, Faculty of Advanced Science and Technology, Kumamoto University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SMP33-10] Development of a software for electron diffraction simulation based on dynamical theory and its application to mineralogy

*Yusuke Seto[1], Masahiro Ohtuka[3], Akira Miyake[2] (1.Graduate School of Science, Kobe University, 2.Graduate School of Science, Kyoto University, 3.Graduate School of Technology, Nagoya University)

11:45 AM - 12:15 PM JST | 2:45 AM - 3:15 AM UTC

[SMP33-11] Site occupation analysis for cation in minerals by analytical electron microscopy: application of TEM-ALCHEMI for earth and planetary science

★Invited Papers

*Yohei Igami[1], Shunsuke Muto[1], Masahiro Ohtsuka[3], Akira Miyake[2], Takahiro Kuribayashi[4], Shoichi Toh[5] (1.Institute of Materials and Systems for Sustainability, Nagoya University, 2.Graduate School of Science, Kyoto University, 3.Graduate School of Engineering, Nagoya University, 4.Graduate School of Science, Tohoku University, 5.Faculty of Science, Fukuoka University)

[J] Oral | S (Solid Earth Sciences)：S-MP Mineralogy & Petrology

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-MP33] Physics and Chemistry of Minerals

convener:Seiji Kamada(Frontier Research Institute for Interdisciplinary Sciences, Tohoku University), Masahiro KAYAMA(Department of Earth and Planetary Material Sciences, Faculty of Science, Tohoku University), Chairperson:Fumiya Noritake(Materials Science, Faculty of Engineering, Graduate Faculty of Interdisciplinary Research, UNIVERSITY OF YAMANASHI), Seiji Kamada(FRIS, Tohoku Univ.)

1:45 PM - 2:15 PM JST | 4:45 AM - 5:15 AM UTC

[SMP33-12] Molecular Dynamics Study of Soret Effect in Silicate Liquids

★Invited Papers

*Fumiya Noritake[1] (1.Graduate Faculty of interdisciplinary Research, University of Yamanashi)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SMP33-13] Seebeck coefficient of olivine: Implausible Mercury's thermoelectric dynamo

*Hitoshi Gomi[1], Takashi Yoshino[1], Akira Yoneda[1] (1.Okayama University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SMP33-14] Density measurement of liquid gallium using externally heated diamond anvil cell

*Ryo Tsuruoka[1], Hidenori Terasaki[1], Seiji Kamada[2], Iori Yamada[1], Fumiya Maeda[3], Tadashi Kondo[1], Satoru Urakawa[4], Naohisa Hirao[5], Akihiko Machida[6] (1.Department of Earth and Space Science, Graduate School of Science Osaka University, 2.Frontier Research Institute for Interdisciplinary Sciences, Tohoku University, 3.Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University, 4.Department of Earth Science, Okayama University, 5.Japan Synchrotron Radiation Research Institute, 6.National Institutes for Quantum and Radiological Science and Technology)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SMP33-15] Density measurements of crystalline Fe and amorphous materials at high pressure

*Seiji Kamada[1,2], Hidenori Terasaki[3], Yusaku Takubo[3], Ryo Tsuruoka[3], Fumiya Maeda[2], Rui Yamada[1], Saori Kawaguchi[4], Naohisa Hirao[4], Akihiko Machida[5] (1.Frontier Research Institute for Interdisciplinary Sciences, Tohoku University, 2.Department of Earth Science, Graduate School of Science, Tohoku University, 3.Department of Earth and Space Science, Graduate School of Science, Osaka University, 4.JASRI, 5.QST)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SMP33-16] DAC-GHz ultrasonic P wave velocity measurement on KCl and natural olivine

*Akira Yoneda[1], Shinichiro Kobayashi[2], Seiji Kamada[3] (1.Institute for planetary materials, Okayama University, 2.Department of Earth Science, Graduate school of Science, Tohoku Univ., 3.Frontier Research Institute for Interdisciplinary Sciences, Tohoku Univ.)

[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | IC 2F

[S-VC38] Active Volcanism

convener:Yuta Maeda(Nagoya University), Takahiro Miwa(National research institute for earth science and disaster prevention), Takeshi Nishimura(Department of Geophysics, Graduate School of Science, Tohoku University), Chairperson:Nobukazu Seama, Tetsuo Matsuno

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SVC38-30] Summary of Kikai submarine caldera researches conducted by KOBEC (Kobe Ocean-Bottom Exploration Center)

*Nobukazu Seama[1,2], Tetsuo Matsuno[2,1], Koji Kiyosugi[3,2], Satoshi Shimizu[2], Reina Nakaoka[2], Keiko Suzuki-Kamata[2,1], Yasutomo Seto[1], Mamoru Sano[2], Yuiko Morita[4], Hikaru Iwamaru[2], Haruhisa Morozumi[2], Misaki Horiuchi[1], Kimihiro Nishimura[1], Hiroshi Ichihara[5], Kazuki Hayashi[1], Toki Hirose[1], Katsuya Kaneko[1,2], Hiroto Yamaguchi[4], Yuki Okizono[4], Hiroko Sugioka[1,2], Kazuo Nakahigashi[6,2], Yojiro Yamamoto[7], Tatsuya KODA[2], Shuichi Kodaira[7,2], Yoshiyuki Tatsumi[2,1], Scientific party of T/S Fukae-maru Kikai caldera research cruises (1.Department of Planetology, Graduate School of Science, Kobe University, 2.Kobe Ocean Bottom Exploration Center, Kobe University, 3.Organization of Advanced Science and Technology, Kobe University, 4.Department of Planetology, Faculty of Science, Kobe University, 5.Graduate school of environmental studies, Nagoya University, 6.Tokyo University of Marine Science and Technology, 7.Japan Agency for Marine-Earth Science and Technology)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SVC38-31] Distribution of submarine pyroclastic-flow deposits of Akahoya eruption, Kikai caldera

*Satoshi Shimizu[1,2], Nobukazu Seama[3,1], Reina NAKAOKA[1], Tetsuo Matsuno[1,3], Koji Kiyosugi[5], Hikaru Iwamaru[1,2], Mamoru Sano[1,2], Kimihiro Nishimura[3], Keiko Suzuki-Kamata[1,3], Katsuya Kaneko[3], hiroto yamaguchi[4], Misaki Horiuchi[3], Toki Hirose[3], Kazuki Hayashi[3], Yoshiyuki Tatsumi[1,3] (1.Ocean Bottom Exploraiton Center, Kobe University, 2.Nippon Marine Enterprises, Ltd., 3.Department of Planetology, Graduate School of Science, Kobe University, 4.Department of Planetology, Faculty of Science, Kobe University, 5.Organization of Advanced Science and Technology, Kobe University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SVC38-32] Identification of submarine volcanic ash around the Kikai caldera with the Koya pyroclastic flow deposit inferred from glass composition

*Reina NAKAOKA[1], Keiko Suzuki-Kamata[1,2], Satoshi Shimizu[1], Yoshiyuki Tatsumi[1,2], Katsuya Kaneko[2,1], Koji Kiyosugi[3,1], Nobukazu Seama[2,1], Tetsuo Matsuno[1,2], Kimihiro Nishimura[2], Kazuki Hayashi[2] (1.Kobe Ocean-Bottom Exploration Center, Kobe University, 2.Department of Planetology, Graduate School ofScience, Kobe University, 3.Organization of Advanced Science and Technology, Kobe University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SVC38-33] Preliminary report of the sea floor survey by a remotely operated vehicle (ROV) at the Kikai caldera, SW Japan

*Koji Kiyosugi[1], Keiko Suzuki-Kamata[2], Haruhisa Morozumi[2,4], Yoshiyuki Tatsumi[2], Katsuya Kaneko[3], Reina NAKAOKA[2], Mamoru Sano[2], Satoshi Shimizu[2], Hikaru Iwamaru[2], Nobukazu Seama[3], Tetsuo Matsuno[2], Kimihiro Nishimura[3], Kazuki Hayashi[3], Misaki Horiuchi[3] (1.Organization for Advanced and Integrated Research, Kobe University, 2.Kobe Ocean-Bottom Exploration Center, Kobe University, 3.Department of Planetology, Graduate School of Science, Kobe University, 4.Japan Oil, Gas and Metals National Corporation)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SVC38-34] Seismic activity beneath Kikai Caldera by using Ocean Bottom Observation

*Yasutomo Seto[1], Hiroko Sugioka[2], Yojiro Yamamoto[3], Tsutomu Takahashi[4] (1.Department of Planetology, Graduate School of Science, Kobe University, 2.Department of Planetology, Kobe University, 3.Japan Agency for Marine-Earth Science and Technology, 4.Research and Developement Center for Earthquake and Tsunami, Japan Agency for Marine-Earth Science and Technology)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SVC38-35] An investigation of three-dimensional electrical resistivity structure under Kikai Caldera

*Tetsuo Matsuno[1,2], Toki Hirose[2], Yuuki Okizono[3], Nobukazu Seama[2,1], Hiroshi Ichihara[4], Hiroko Sugioka[2,1], Yoshiyuki Tatsumi[1,2] (1.Kobe Ocean Bottom Exploration Center, Kobe University, 2.Department of Planetology, Graduate School of Science, Kobe University, 3.Department of Planetology, Faculty of Science, Kobe University, 4.Graduate school of environmental studies, Nagoya University)

[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | IC 2F

[S-VC38] Active Volcanism

convener:Yuta Maeda(Nagoya University), Takahiro Miwa(National research institute for earth science and disaster prevention), Takeshi Nishimura(Department of Geophysics, Graduate School of Science, Tohoku University), Chairperson:Takeshi Ohba, Akihiko Terada

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SVC38-36] Time variation in the chemical and isotopic composition of fumarolic gases at Hakone volcano Japan

*Takeshi Ohba[1], Muga Yaguchi[2], Kana NISHINO[1], Nozomi Numanami[1], Yasushi DAITA[3], Urumu Tsunogai[4], Masanori Ito[4], Chiho Sukigara[4] (1.Department of chemistry, School of Science, Tokia University, 2.Meteorological Research Institute, JMA, 3.Kanagawa Environmental Research Center, 4.Nagoya University Graduate School of Environmental Studies)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SVC38-37] Chemical and isotopic composition of volcanic gases at Mt Kirishima Iwoyama, Japan

*Takeshi Ohba[1], Muga Yaguchi[2], Kotaro Toyama[3], Hirochika Sumino[3], Urumu Tsunogai[4], Masanori Ito[4], Ryo Shingubara[4] (1.Department of chemistry, School of Science, Tokia University, 2.Meteorological Research Institute, 3.The University of Tokyo Graduate School of Arts and Sciences Department of Basic Science, 4.Nagoya University Graduate School of Environmental Studies)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SVC38-38] Temporal and spatial variations of helium isotope ratios in volcanic gases in Kirishima volcanic group, Japan

*Kotaro Toyama[1], Hirochika Sumino[1], Kaori Kawana[1], Takeshi Ohba[2], Muga Yaguchi[3], Yoshihide Akiyama[1], Koki Aizawa[4], Kaori Tsukamoto[4] (1.Department of Basic Science, Graduate School of Arts and Sciences, The University of Tokyo, 2.Department of chemistry, School of Science, Tokia University, 3.Meteorological Research Institute, 4.Institute of Seismology and Volcanology, Faculty of Science, Kyushu University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SVC38-39] Emission regions of gaseous elemental mercury around Yugama crater lake at Kusatsu-Shirane volcano, Japan

*Akihiko Terada[1], Noriaki Mizutani[1] (1.Volcanic Fluid Research Center, Faculty of Science, Tokyo Institute of Technology)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SVC38-40] Magnetotelluric images of Kusatsu-Shirane volcano, revisited by 3-D modeling with tetrahedral elements considered topography effect

*Kuo Hsuan Tseng[1], Yasuo Ogawa[1], Nurhassan .[2], Sabri Bulent Tank[3], Akihiko Terada[1], Wataru Kanda[1], Masato Fukai[1] (1.Tokyo Institute of Technology, 2.Bandung Institute of Technology, Indonesia, 3.Bogazici University, Turkey)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SVC38-41] Magma conduit and associated hydrothermal systems of Aso volcano as revealed by broadband magnetotelluric data

*Nobuo Matsushima[1], Mitsuru Utsugi[2], Shinichi Takakura[1], Tadashi Yamasaki[1], Maki Hata[3], Takeshi Hashimoto[4], Makoto Uyeshima[3] (1.Geological Survey of Japan,AIST, 2.Kyoto University, 3.The University of Tokyo, 4.Hokkaido University)

[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-CG57] Structure and evolution of Japanese islands - Formation of island arc systems and earthquake cycles

convener:Hiroshi Sato(Earthquake Prediction Research Center, Earthquake Research Institute, The University of Tokyo), Masanao Shinohara(Earthquake Research Institute, University of Tokyo), Masahiro Ishikawa(Graduate School of Environment and Information Sciences Yokohama National University), Makoto MATSUBARA(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Masanao Shinohara(Earthquake Research Institute, The University of Tokyo), Tatsuya Ishiyama(Earthquake Research Institute, University of Tokyo)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SCG57-01] Recent Earthquake Activity in Northern Hokkaido, Japan

Cancelled

*Tetsuo Takanami[1,2] (1.Carnegie Institution for Science, 2.Hokkaido Research Center of Geology)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SCG57-02] Seismic constraints on the crustal structure off the southwestern coast of Hokkaido, Japan Sea

*Tetsuo No[1], Takeshi Sato[1], Shuichi Kodaira[1], Hiroshi Sato[2], Tatsuya Ishiyama[2] (1.JAMSTEC, 2.ERI, University of Tokyo)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SCG57-03] Deep seismic reflection profiling across the Oshima Peninsula, SW Hokkaido, Japan

*Hiroshi Sato[1], Tatsuya Ishiyama[1], Naoko Kato[1], Hidehiko Shimizu[2], Takeshi Sato[3], Shinji Kawasaki[2], Tetsuo No[3], Shuichi Kodaira[3], Seiichi Miura[3] (1.Earthquake Research Institute, The University of Tokyo, 2.JGI Inc, 3.Japan Agency for Marine-Earth Acience and Technology)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SCG57-04] Crustal deformation and stress accumulation on source faults around Hokkaido, Japan, due to coupling at the Kuril trench

*Akinori Hashima[1], Hiroshi Sato[1], Tatsuya Ishiyama[1], Andrew M. Freed[2] (1.Earthquake Research Institute, The University of Tokyo, 2.Purdue University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SCG57-05] Structural Heterogeneity in and around the Source Region of the 2018 Hokkaido Eastern Iburi Earthquake, Central Hokkaido, Japan

*Takaya Iwasaki[1], Noriko Tsumura[2], Tanio Ito[3], Kazunori Arita[4], Makoto Matsubara[5], Hiroshi Sato[1], Eiji Kurashimo[1], Naoshi Hirata[1], Susumu Abe[6], Katsuya Noda[7], Akira Fujiwara[8], Shinsuke Kikuchi[9], Kazuko Suzuki[10] (1.Eathquake Research Institute, the University of Tokyo, 2.Graduate School of Science, Chiba University, 3.Association for the Development of Earthquake Prediction, 4.Hokkaido Research Center of Geology, 5.National Research Institute for Earth Science and Disaster Resilience, 6.JAPEX, 7.GEOSYS Inc., 8.JOGMEC, 9.JGI Inc., 10.Schlumberger Ltd.)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SCG57-06] Electrical resistivity distribution around the middle axis of Hokkaido Island: constraint for tectonics of ultra-mafic rocks

*Hiroshi Ichihara[1], Toru Mogi[1], Yusuke Yamaya[2] (1.Earthquake and Volcano Research Center, Nagoya University, 2.AIST)

[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-CG57] Structure and evolution of Japanese islands - Formation of island arc systems and earthquake cycles

convener:Hiroshi Sato(Earthquake Prediction Research Center, Earthquake Research Institute, The University of Tokyo), Masanao Shinohara(Earthquake Research Institute, University of Tokyo), Masahiro Ishikawa(Graduate School of Environment and Information Sciences Yokohama National University), Makoto MATSUBARA(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Hiroshi Sato(Earthquake Research Institute, Tokyo University), Masahiro Ishikawa(Yokohama National University)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SCG57-07] Three-dimensional seismic velocity structure beneath and around Japanese Islands including beneath the Pacific Ocean using NIED S-net data

*Makoto MATSUBARA[1], Hiroshi Sato[2], Kenji Uehira[1], Masashi Mochizuki[4], Toshihiko Kanazawa[5], Narumi Takahashi[1], Kensuke Suzuki[3], Shinichiro Kamiya[1] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Earthquake Research Institute, the University of Tokyo, 3.Japan Agency for Marine-Earth Science and Technology, 4.Ministry of Education, Culture, Sports, Science and Technology, Japan , 5.Association for the Development of Earthquake Prediction)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SCG57-08] Spatio-temporal extent of Cretaceous fore-arc basin in Japan

*Yukio Isozaki[1], Ryo Hasegawa[1], Yukiyasu Tsutsumi[1] (1.Department of Earth Science and Astronomy, Multi-disciplinary Sciences - General Systems Studies, Graduate School of Arts and Sciences, The University of Tokyo)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SCG57-09] Geotectonic identities of dismembered ancient fore-arc clastics: U-Pb dating of detrital zircons in Cretaceous-Paleogene shallow marine/fluvial sandstones sporadically found in Kanto, central Japan

*Ryo Hasegawa[1], Yukio Isozaki[1], Yukiyasu Tsutsumi[2] (1.Department of Earth Science and Astronomy, The University of Tokyo, 2.Department of Geology and Paleontology, National Museum of Nature and Science)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SCG57-10] Laboratory Measurements of Vp, Vs and Vp/Vs for polycrystalline labradorite up to 800°C and 1GPa

*Satoko Honda[1], Masahiro Ishikawa[1] (1.Graduate School of Environment and Information Sciences, Yokohama National University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SCG57-11] Shallow to deeper structures of the Median Tectonic Line active fault system in Shikoku illuminated by new hi-resolution seismic reflection profiling, southwest Japan

*Tatsuya Ishiyama[1], Naoko Kato[1], Shin Koshiya[2], Hiroshi Sato[1], Makoto MATSUBARA[3], Tomoko Elizabeth Yano[3], Taro Koike[4], Katsuya Noda[4] (1.Earthquake Research Institute, University of Tokyo, 2.Department of Civil and Environmental Engineering, Faculty of Science and Engineering, Iwate University, 3.National Research Institute for Earth Science and Disaster Resilience, 4.Geosys, Inc.)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SCG57-12] **Cenozoic evolution of the Tsushima Strait and the Fukue Basin, southern Sea of Japan: an interplay of tectonics, palaeo-environment, and volcanism**

*Johan S. Claringbould[1], Hiroshi Sato[1], Tatsuya Ishiyama[1], Anne Van Horne[1,2], Shinji Kawasaki[3], Susume Abe[4] (1.Earthquake Research Institute, The University of Tokyo, 2.Department of Geology and Geophysics, University of Wyoming, 3.JGI, Inc., 4.JAPEX)

[J] Oral | B (Biogeosciences)：B-CG Complex & General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 201A 2F

[B-CG07] Decoding the history of Earth: From Hadean to the present

convener:Tsuyoshi Komiya(Department of Earth Science & Astronomy Graduate School of Arts and Sciences The University of Tokyo), Yasuhiro Kato(Department of Systems Innovation, Graduate School of Engineering, University of Tokyo), Katsuhiko Suzuki(Research and Development Center for Submarine Resources, Japan Agency for Marine-Earth Science and Technology), Chairperson:Tomohiko Sato(Earth-Life Science Institute, Tokyo Institute of Technology)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[BCG07-01] Iron-oxidizing bacteria and stromatolites in the Ediacaran hydrothermal carbonate

*Akihiro Kano[1], Aya Miyazaki[1], Jumpei Yoshioka[1], Ibtissam Chraiki[2], Abdelhafed Barzouk[2], Nasrrddine Youbi[2,3], Hassan Admou[2], Moulay Ahmed Boumehdi[2,3], Lhou Maacha[4], Hsaine Baoutoul[4], Ismail Bouskri[4] (1.Graduate School of Science, The University of Tokyo, 2.Department of Geology, Faculty of Sciences-Semlalia, Cadi Ayyad University, 3.Instituto Dom Luiz, Faculdade de Ciências, Universidade de Lisboa, 4.Managem-ONA Group)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[BCG07-02] Carbonate carbon isotope stratigraphy of the Paleoproterozoic Francevillian Group in Gabon

★Invited Papers

*Tomohiko Sato[1], Yusuke Sawaki[2], Hisashi Asanuma[2], Hisahiro Ueda[1], Shigenori Maruyama[1] (1.Tokyo Institute of Technology, 2.The University of Tokyo)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[BCG07-03] The redox condition of late Paleoproterozoic shallow marine environment: The Cape Smith Belt, Canada

*Kento Motomura[1], Shoichi Kiyokawa[1], Minoru Ikehara[2], Takashi Sano[4], Kentaro Tanaka[3], Tsubasa Miki[3], Yuji Sano[3] (1.Kyushu University, 2.Kochi University, 3.University of Tokyo, 4.National Museum of Nature and Science)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[BCG07-04] Paleovegetation changes reconstructed by terrestrial plant biomarker analyses in the sediments deposited across the Cenomanian/Turonian boundary in the Tomamae area, Hokkaido, Japan

*Masashi A. Ikeda[1], Ken Sawada[2], Takuto Ando[3], Hideto Nakamura[4], Reishi Takashima[5], Hiroshi Nishi[5] (1.Graduate School of Science, Hokkaido University, 2.Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University, 3.Arctic Research Center, Hokkaido University, 4.Faculty of Science, Osaka City University, 5.The Center for Academic Resources and Archives, The Tohoku University Museum, Tohoku University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[BCG07-05] A general overview of the research progress on REY-rich mud

*Yasuhiro Kato[1,2], Kentaro Nakamura[1], Koichiro Fujinaga[2,1], Kazutaka Yasukawa[1,2], Yutaro Takaya[3,1,2], Junichiro Ohta[2,1], Erika Tanaka[1], Kazuhide Mimura[1], Koichi Iijima[4,1], Shiki Machida[2,1], Tatsuo Nozaki[4,1,2,5], Jun-Ichi Kimura[4], Hikaru Iwamori[1,4,6] (1.The University of Tokyo, 2.ORCeNG, Chiba Institute of Technology, 3.Waseda University, 4.JAMSTEC, 5.Kobe University, 6.Tokyo Institute of Technology)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[BCG07-06] A cold and alkaline Hadean ocean caused by impact ejecta weathering

*Shintaro Kadoya[1], David C Catling[1] (1.University of Washington)

[J] Oral | B (Biogeosciences) : B-CG Complex & General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 201A 2F

[B-CG07] Decoding the history of Earth: From Hadean to the present

convener:Tsuyoshi Komiya(Department of Earth Science & Astronomy Graduate School of Arts and Sciences The University of Tokyo), Yasuhiro Kato(Department of Systems Innovation, Graduate School of Engineering, University of Tokyo), Katsuhiko Suzuki(Research and Development Center for Submarine Resources, Japan Agency for Marine-Earth Science and Technology), Chairperson:Satoshi Yoshida(Department of Earth Science & Astronomy, Graduate School of Arts and Sciences, The University of Tokyo)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[BCG07-07] **Impact-induced magmatism on early Earth**

*Hiroshi Ohmoto[1], Uschi M. Graham[2], Yuya Tsukamoto[3], Yumiko Watanabe[3], Takeshi Kakegawa[3], Hiroshi Hamasaki[4], Andrew Chorney[5], Katherine Crispin[1], Zi-Kui Liu[1] (1.The Pennsylvania State University, 2.Univ. of Kentucky, 3.Tohoku Univ., 4.Tokyo Gas, 5.Temple Univ.)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[BCG07-08] An evaluation of impact dating for shocked zircons with planar features (PFs) in the Vredefort dome by LA-ICP-MS multi-spot analysis

*Shinji Yamamoto[1], Taiga Kato[1] (1.Graduate School of Environment and Information Sciences, Yohohama National University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[BCG07-09] **Application of acid-washing to trace element and tungsten isotope analyses of Eoarchean rocks from the Isua Supracrustal Belt**

★Invited Papers

*Hatsuki Enomoto[1], Tsuyoshi Iizuka[1], Yoshitaka Homma[1] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[BCG07-10] Limited primary production in the early Archean oceans and its biogeochemical consequenses

★Invited Papers

*Kazumi Ozaki[1] (1.Toho University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[BCG07-11] Behaviors of carbon cycle system and inevitability of the hot climate in the Archean Earth

★Invited Papers

*Yasuto Watanabe[1], Eiichi Tajika[1], Kazumi Ozaki[2], Peng Hong[3] (1.The University of Tokyo, 2.Toho University, 3.Chiba Institute of Technology)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[BCG07-12] Occurrence and chemical composition of metamorphic carbonate rocks in the Isua supracrustal belt, West Greenland: Implications for the origin of carbonate rocks and compositions of the Eoarchean seawater.

*Yoshida Satoshi[1], Kazutaka Yasukawa[2], Yasuhiro Kato[2], Yusuke Sawaki[3], Tsuyoshi Komiya[3] (1.Department of Earth & Planetary Science, Graduate School of Science, The University of Tokyo, 2.Department of Systems Innovation, Graduate School of Engineering, University of Tokyo, 3.Department of Earth Science & Astronomy Graduate School of Arts and Sciences, The University of Tokyo)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 304 3F

[M-IS19] Paleoclimatology and paleoceanography

convener:Yusuke Okazaki(Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University), Akira Oka(Atmosphere and Ocean Research Institute, The University of Tokyo), Michinobu Kuwae(Center for Marine Environmental Studies), Hitoshi Hasegawa(Faculty of Science and Technology, Kochi University), Chairperson:Yusuke Okazaki

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MIS19-01] Development of Longitudinal dunes under the Pangean atmospheric circulation

*Hiroki Shozaki[1], Hitoshi Hasegawa[2] (1.Faculty of Science, Kochi University, 2.Faculty of Science and Technology, Kochi University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MIS19-02] Response of primary producers in the ocean anoxic events during the Cretaceous

*Haga Mayuko[1], Eiichi Tajika[1], Kazumi Ozaki[2] (1.The University of Tokyo, 2.Toho University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MIS19-03] The linkage between desertification and tectonism inferred from the provenance change of the terrestrial sediments in the Tarim basin

*Aki Sakuma[1], Ryuji Tada[1], Tomohiro Yoshida[1], Hitoshi Hasegawa[2], Naomi Sugiura[1], Akinori Karasuda[1], Ke WANG[1], Hongbo Zheng[3] (1.Department of Earth and Planetary Science, School of Science, the University of Tokyo, 2.Faculty of Science and Technology, Kochi University, 3.School of Resource Environment and Earth Science, Yunnan University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MIS19-04] Paleoceanographic reconstruction in the northwestern Pacific during MIS 19 using ultra-high temporal resolution oxygen isotope profiles and planktonic foraminiferal assemblage

*Yuki Haneda[1], Nanako Yokokawa[1], Makoto Okada[1], Hiroki Hayashi[2], Yoshimi Kubota[3], Yusuke Suganuma[4] (1.College of Science, Ibaraki University, 2.Interdisciplinary Factulty of Science and Engineering, Shimane University, 3.National Museum of Nature and Science, 4.National Institute of Polar Research)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MIS19-05] Paleoclimate reconstruction using fossil pollen analyses from a sedimentary sequence around the Matuyama-Brunhes polarity transition in the Chiba composite section

*Makoto Okada[1], Hitomi Takizawa[1], Yuki Haneda[2], Yusuke Suganuma[3,4], Quentin Simon[5] (1.Department of Earth Sciences, College of Science, Ibaraki University, 2.Graduate school of Science and Technology, Ibaraki University, 3.National Institute of Polar Research, 4.Graduate University for Advanced Studies, 5.Aix-Marseille University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[MIS19-06] Reconstruction of vertical thermal structure in the western Pacific warm pool over the last 1 Myr

*Fumito Mizuno[1], Takuya Sagawa[2], Keisuke Mukaida[3], Yoshimi Kubota[4], Toshitsugu Yamazaki[5], Junichiro Kuroda[5] (1.Graduate School of Natural Science and Technology. Kanazawa University, 2.Institute of Science & Engineering. Kanazawa University, 3.Collage of Science & Engineering. Kanazawa University, 4.National Museum of Nature & Science, 5.Atmosphere and Ocean Research Institute. The University of Tokyo)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 304 3F

[M-IS19] Paleoclimatology and paleoceanography

convener:Yusuke Okazaki(Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University), Akira Oka(Atmosphere and Ocean Research Institute, The University of Tokyo), Michinobu Kuwae(Center for Marine Environmental Studies), Hitoshi Hasegawa(Faculty of Science and Technology, Kochi University), Chairperson:Michinobu Kuwae(愛媛大学沿岸環境科学研究センター)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MIS19-07] Future perspective on the response of marine calcifiers to “evil twins” of climate change due to increased PCO2

*Hodaka Kawahata[1] (1.Atmosphere Ocean Research Institute, the University of Tokyo)

2:00 PM - 2:22 PM JST | 5:00 AM - 5:22 AM UTC

[MIS19-08] Reconstruction of seawater pH and atmospheric CO_2 concentration based on boron isotopic composition of biogenic calcium carbonate

★Invited Papers

*Kaoru Kubota[1] (1.Kochi Institute for Core Sample Research, JAMSTEC)

2:22 PM - 2:37 PM JST | 5:22 AM - 5:37 AM UTC

[MIS19-09] A 70 years changes of the Java Sea surface condition based on geochemical analyses of a coral core

*Ai Genda[1], Atsushi Suzuki[2], Toyoho Ishimura[3], Minoru Ikehara[4], Mayuri Inoue[1] (1.Graduate School of National Science and Technology, Okayama University, 2.Geological Survey of Japan Natinal Institute of Advanced Industrial Science and Technology, 3.National Institute of Technology, Ibaraki College, 4.Center for Advanced Marine Core Research, Kochi University)

2:37 PM - 2:52 PM JST | 5:37 AM - 5:52 AM UTC

[MIS19-10] Reconstruction of paleoenvironments in the western Pacific for the last 220 years

Mutsumi Chihara[1], Ayaka Fukushima[2], Minoru Ikehara[3], Hodaka Kawahata[2], Atsushi Suzuki[4], *Mayuri Inoue[1] (1.Department of Earth Sciences, Okayama University, 2.Atmosphere and Ocean Research Institute, the University of Tokyo, 3.Center for Advanced Marine Core Research, Kochi University, 4.Geological Survey of Japan, AIST)

2:52 PM - 3:15 PM JST | 5:52 AM - 6:15 AM UTC

[MIS19-11] Ocean deoxygenation from the Last Glacial Maximum to the future global warming: inshight from model simulations

★Invited Papers

*Akitomo Yamamoto[1], Ayako Abe-Ouchi[2,1], Rumi Ohgaito[1], Akinori Ito[1], Masahito Shigemitsu[1], Yasuhiro Yamanaka[3], Akira Oka[2] (1.Japan Agency for Marine-Earth Science and TechnologyAtmosphere and Ocean Research Institute, 2.Atmosphere and Ocean Research Institute, The University of Tokyo, 3. Faculty of Environmental Earth Science, Hokkaido University)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 304 3F

[M-IS19] Paleoclimatology and paleoceanography

convener:Yusuke Okazaki(Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University), Akira Oka(Atmosphere and Ocean Research Institute, The University of Tokyo), Michinobu Kuwae(Center for Marine Environmental Studies), Hitoshi Hasegawa(Faculty of Science and Technology, Kochi University), Chairperson:Akira Oka

3:30 PM - 3:52 PM JST | 6:30 AM - 6:52 AM UTC

[MIS19-12] Extraction of high-quality ^{14}C data from terrestrial sediments containing pollen fossils

★Invited Papers

*Takayuki Omori[1], Keitaro Yamada[2], Ikuko Kitaba[2], Takeshi Nakagawa[2] (1.The University Museum, The University of Tokyo, 2.Research Centre for Palaeoclimatology, Ritsumeikan University)

3:52 PM - 4:07 PM JST | 6:52 AM - 7:07 AM UTC

[MIS19-13] Oxygen isotope fluctuations of pollen fossils from Lake Suigetsu, Japan

*Keitaro Yamada[1], Takayuki Omori[2], Ikuko Kitaba[1], Takeshi Nakagawa[1] (1.Research Organization of Science and Technology, Ritsumeikan University, 2.The University museum, The University of Tokyo)

4:07 PM - 4:22 PM JST | 7:07 AM - 7:22 AM UTC

[MIS19-14] Reconstruction of lake-level changes during the last glaciation based on fossil diatom record in Lake Biwa

*Takashi Suzuki[1], Yoshio Inouchi[2], Keisuke Otsuka[1], Kaoru Kawakami[3] (1.Graduate School of Human Science, Waseda University, 2.Faculty of Human Sciences, Waseda University, 3.Graduate School of Environmental Science, Hokkaido University)

4:22 PM - 4:45 PM JST | 7:22 AM - 7:45 AM UTC

[MIS19-15] An estimation of microplatcis sedimentation flux in a coastal sea

★Invited Papers

*Hirofumi Hinata[1], Michinobu Kuwae[1], Issei Masumoto[1], Hayato Kawamata[1] (1.Ehime University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MIS19-16] Beppu Bay sediments: Potential palaeoenvironmental archives for a candidate auxiliary stratotype for Anthropocene-Holocene boundary

*Michinobu Kuwae[1], Yoshiaki Suzuki[2] (1.Center for Marine Environmental Studies, Ehime Univ., 2.Department of Eearth Scieces, Fuculty of Education and Integrated Arts and Sciences, Waseda Univ.)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[M-IS22] Electromagnetic phenomena associated with seismic and volcanic activities

convener:Tetsuya Kodama(Research Unit I, Research and Development Directorate, Japan Space Exploration Agency), Toshiyasu Nagao(Institute of Oceanic Research and development, Tokai University), Chairperson:Tetsuya Kodama, Toshiyasu Nagao

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MIS22-01] Stress-induced charges in gabbro at high temperature

*Chihiro Yamanaka[1], Daiki Maezono[1] (1.Graduate School of Science, Osaka University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MIS22-02] Evaluation of ULF seismo-magnetic precursor phenomena at Kakioka, Japan over 1983 – 2018 by using SEA and Molchan's error diagram

*Katsumi Hattori[1], Kei Takahashi[2], Peng Han[3] (1.Department of Earth Sciences, Graduate School of Science, Chiba University, 2.Department of Earth Sciences, Faculty of Science, Chiba University, 3.Southern University of Science and Technology, China)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MIS22-03] On the tsunami and electromagnetic pulses appeared abound 10min. after the 2011 Tohoku earthquake

*Yuji Enomoto[1], Tsuneaki Yamabe[1], Shigeki Sugiura[2], Hitoshi Kondo[2] (1.Shinshu Univeristy, Ueda Campus Fii, 2.Genesis Reserach Institute, Inc.)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MIS22-04] Reinvestigation of correlation between groundwater anomalies and earthquakes carried out by an amateur network in Japan

*Yoshiaki Orihara[1], Masashi Kamogawa[2], Toshiyasu Nagao[1] (1.Institute of Oceanic Research and Development, Tokai University, 2.Dpt. of Phys., Tokyo Gakugei Univ.)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MIS22-05] Participation Report of S-Booster 2018

*Tetsuya Kodama[1] (1.Research Unit I, Research and Development Directorate, Japan Space Exploration Agency)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MIS22-06] The future direction of EMSEV, IUGG International Working Group

*Toshiyasu Nagao[1] (1.Institute of Oceanic Research and development, Tokai University)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-SD Space Development & Earth Observation from Space

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 302 3F

[M-SD44] Future Missions of Satellite Earth Observation

convener:Yoshiaki HONDA(Center for Environmental Remote Sensing, Chiba University), Yukari Takayabu(Atmosphere and Ocean Research Institute, the University of Tokyo), Shinichi Sobue(Japan Aerospace Exploration Agency), Yuki Kaneko(Japan Aerospace Exploration Agency), Chairperson:Yoshiaki Honda

9:05 AM - 9:20 AM JST | 12:05 AM - 12:20 AM UTC

[MSD44-01] Experimental platform for design and advance evaluation of frequent satellite observations to innovate weather, ocean and land surface predictions

*Takemasa Miyoshi[1], Shunji Kotsuki[1], Koji Terasaki[1], Shigenori Otsuka[1], Takumi Honda[1], Atsushi Okazaki[1], Kohei Takatama[1] (1.RIKEN)

9:20 AM - 9:35 AM JST | 12:20 AM - 12:35 AM UTC

[MSD44-02] Technology demonstration mission for next generation precipitation observation radars

*Tomoo Ushio[1], Toshio Iguchi[2], Kenji Nakamura[4], Kinji Furukawa[3], Riko Oki[3], Daisuke Jodoi[3] (1.Tokyo Metropolitan University, 2.NICT, 3.JAXA, 4.Dokkyo University)

9:35 AM - 9:50 AM JST | 12:35 AM - 12:50 AM UTC

[MSD44-03] Mission of creating base maps as public infrastructures for disaster and monitoring

*ISHITSUKA Naoki[1] (1.The Remote Sensing Society of Japan)

9:50 AM - 10:05 AM JST | 12:50 AM - 1:05 AM UTC

[MSD44-04] Aerosol monitoring, forecasting and estimate of its impacts with multispectral imager data

*Keiya Yumimoto[1,2], Takashi Maki[2], Taichu Y Tanaka[2], Thomas Sekiyama[2], Toshihiko Takemura[1] (1.Kyushu University, 2.Meteorological Research Institute)

10:05 AM - 10:20 AM JST | 1:05 AM - 1:20 AM UTC

[MSD44-05] Global aerosol and cloud observation by space-borne multi-wavelength polarization high-spectral-resolution lidar

*Tomoaki Nishizawa[1], Hajime Okamoto[2], Syoken Ishii[3], Yoshitaka Jin[1] (1.National Institute for Environmental Studies, 2.Kyushu University, 3.National Institute of Information and Communication Technology)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-SD Space Development & Earth Observation from Space

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 302 3F

[M-SD44] Future Missions of Satellite Earth Observation

convener:Yoshiaki HONDA(Center for Environmental Remote Sensing, Chiba University), Yukari Takayabu(Atmosphere and Ocean Research Institute, the University of Tokyo), Shinichi Sobue(Japan Aerospace Exploration Agency), Yuki Kaneko(Japan Aerospace Exploration Agency), Chairperson:Kazuhiro Asai(東北工業大学), Toshiyoshi Kimura(宇宙航空研究開発機構)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MSD44-06] Dual-Doppler-velocity-mission using cloud radar and lidar

*Okamoto Hajime[1], Kentaroh Suzuki[2], Tomoaki Nishizawa[3], Shoken Ishii[4] (1.Kyushu University, 2.The university of Tokyo, 3.National Instuitute for Environmental Studies, 4.National Institute of Information and Communications Technology)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MSD44-07] Global wind profiling with space-based Doppler wind lidar for improvement of numerical weather prediction

*Shoken Ishii[1], Kozo Okaoto[2,1], Takuji Kubota[3], Atsushi Sato[4,1], Daisuke Sakaizaw[3], Tomoaki Nishizawa[5], Ayako Matsumoto[6], Tetsuya Tugami[6], Toshiyuki Ishibashi[2], Taichu Y Tanaka[2], Philippe Baron[1], Makoto Aoki[1], Riko Oki[3], Masaki Satoh[7], Toshiki Iwasaki[8] (1.National Institute of Information and Communications Technology, 2.JMA/MRI, 3.JAXA, 4.TIT, 5.NIES, 6.ANA, 7.University of Tokyo, 8.Tohoku University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MSD44-08] Technology demonstration of space-borne water vapor DIAL

*Makoto Abo[1], Chikao Nagasawa[1], Yasukuni Shibata[1], Osamu Uchino[2], Takashi Shibata[3] (1.Graduate School of System Design, Tokyo Metropolitan University, 2.National Institute for Environmental Studies, 3.Nagoya University)

11:30 AM - 12:00 PM JST | 2:30 AM - 3:00 AM UTC

[MSD44-09] Short presentation of poster session

*Yoshiaki HONDA[1] (1.Center for Environmental Remote Sensing, Chiba University)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-SD Space Development & Earth Observation from Space

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 302 3F

[M-SD44] Future Missions of Satellite Earth Observation

convener:Yoshiaki HONDA(Center for Environmental Remote Sensing, Chiba University), Yukari Takayabu(Atmosphere and Ocean Research Institute, the University of Tokyo), Shinichi Sobue(Japan Aerospace Exploration Agency), Yuki Kaneko(Japan Aerospace Exploration Agency), Chairperson:Riko Oki(宇宙航空研究開発機構)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MSD44-10] **Himawari-8/9 follow-on satellites program**

*BESSHO Kotaro[1] (1.Japan Meteorological Agency)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MSD44-11] Impact assessment of hyperspectral infrared sounders toward Himawari-8/9 follow-on satellites

*Kozo OKAMOTO[1], Hiromi Owada[2], Masahiro Kazumori[2], Michiko Otsuka[1], Yoshifumi Ota[2], Naotaka Uekiyo[1], Hiromu Seko[1], Akiyoshi Ando[2], Ryo Yoshida[2], Hiroshi Ishimoto[1], Masahiro Hayashi[1], Haruma Ishida[3], Yoshiaki Sato[2], Hiroshi Kunimatsu[2], Kotaro Bessho[2], Hironobu Yokota[2] (1.Meteorological Research Institute, 2.Japan Meteolological Agency, 3.Meteorological Satellite Center)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MSD44-12] Observation system simulation experiments for a hyperspectral infrared sounder onboard geostationary satellite

*HIROMI OWADA[1], Kozo OKAMOTO[2], Masahiro Kazumori[1], NAOTAKA UEKIYO[2], Hiroshi Ishimoto[2], Masahiro Hayashi[2] (1.Japan Meteorological Agency, 2.Meteorological Research Institute)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MSD44-13] Realization of pseudo high frequency high resolution observation by geostationary satellite and orbiting satellite combined observation

*Yoshiaki HONDA[1] (1.Center for Environmental Remote Sensing, Chiba University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MSD44-14] **Geostationary Optical Earth Observation Satellite**

*Kazuo Oki[1], Toshiyoshi Kimura[2], Tadahito Mizutani[2], Takeo Tadono[2] (1.The University of Tokyo, 2.JAXA)

Thu. May 30, 2019

[J] Oral | U (Union)：Union

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | IC 2F

[U-06] Japan's contribution to IUGG celebrating 100th anniversary

convener:Setsuya Nakada(National Research Institute for Earth Science and Disaster Resilience), Kenji Satake(Earthquake Research Institute, University of Tokyo), Kumiko Goto-Azuma(National Institute of Polar Research), Chairperson:Kumiko Goto-Azuma(National Institute of Polar Research), Setsuya Nakada(NIED)

9:00 AM - 9:20 AM JST | 12:00 AM - 12:20 AM UTC

[U06-01] **Centennial of the International Cooperation in Earth and Space Sciences**

★Invited Papers

*Alik Ismail-Zadeh[1,2,3] (1.Karlsruhe Institute of Technology, 2.International Union of Geodesy and Geophysics, 3.International Science Council)

9:20 AM - 9:40 AM JST | 12:20 AM - 12:40 AM UTC

[U06-02] IUGG and Japan: the past, the present, and the way to go from now

★Invited Papers

*Masaru Kono[1] (1.Tokyo Institute of Technology)

9:40 AM - 9:55 AM JST | 12:40 AM - 12:55 AM UTC

[U06-03] **Contributions from the Science Council of Japan to international cooperation in the field of Earth and planetary science**

*Hisashi Nakamura[1] (1.Research Center for Advanced Science and Technology, University of Tokyo)

9:55 AM - 10:15 AM JST | 12:55 AM - 1:15 AM UTC

[U06-04] History and Japanese contribution to the International Association of Cryospheric Sciences IACS

★Invited Papers

*Ralf Greve[1] (1.Institute of Low Temperature Science, Hokkaido University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[U06-05] **Japan's Contributions to IAG**

*Yoichi Fukuda[1] (1.Department of Geophysics, Graduate School of Science, Kyoto University)

[J] Oral | U (Union)：Union

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | IC 2F

[U-06] Japan's contribution to IUGG celebrating 100th anniversary

convener:Setsuya Nakada(National Research Institute for Earth Science and Disaster Resilience), Kenji Satake(Earthquake Research Institute, University of Tokyo), Kumiko Goto-Azuma(National Institute of Polar Research), Chairperson:Kumiko Goto-Azuma(National Institute of Polar Research), Kenji Satake(Earthquake Research Institute, the University of Tokyo)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[U06-06] IAGA activities in the era of too many international conferences

*Toshihiko Iyemori[1] (1.Kyoto University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[U06-07] The role of IAHS in education, research, social issues concerning water and future perspective

*Maki Tsujimura[1] (1.Faculty of Life and Environmental Sciences, University of Tsukuba)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[U06-08] Centenary of the atmospheric sciences: Its progress and future issues

*Teruyuki Nakajima[1] (1.Japan Aerospace Exploration Agency)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[U06-09] Contributuins of Japan to IAPSO

*Yukio Masumoto[1] (1.Graduate School of Science, The University of Tokyo)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[U06-10] IASPEI- activities, history and Japan’s contribution

*Kenji Satake[1], Thorne Lay[2], Johannes Schweitzer[3] (1.Earthquake Research Institute, University of Tokyo, 2.IASPEI President , 3.IASPEI Secretary General)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[U06-11] Recent history of IAVCEI in Japan and young researchers’ response to IUGG and IAVCEI

*Setsuya Nakada[1] (1.National Research Institute for Earth Science and Disaster Resilience)

[J] Oral | U (Union)：Union

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 101 1F

[U-08] Opinions and recommendations from meeting participants to the future of the Japan Geoscience Union

convener:Yozo Hamano(KOBE Ocean-Bottom Exploration Center, Kobe University), Eiichi Tajika(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Koji Wada(Planetary Exploration Research Center, Chiba Institute of Technology), Ikuro Sumita(Geosciences and Civil Engineering, Institute of Science and Engineering, Kanazawa University), Chairperson:Koji Wada(Planetary Exploration Research Center, Chiba Institute of Technology), Ikuro Sumita

1:51 PM - 2:03 PM JST | 4:51 AM - 5:03 AM UTC

[U08-01] Request and proposal from the Committee on Earth and Planetary Sciences of the Science Council of Japan to JpGU

*Ryoichi Fujii[1] (1.Research Organization of Information and Systems)

2:03 PM - 2:15 PM JST | 5:03 AM - 5:15 AM UTC

[U08-02] Geography in JpGU: current status and future perspectives

*Takashi Oguchi[1], Ikuho Yamada[2], Yuichi S. Hayakawa[3], Daichi Kohmoto[4], Hitoshi Saito[5] (1.Center for Spatial Information Science, The University of Tokyo, 2.Faculty of Science and Engineering, Chuo University, 3.Graduate School of Env.Science, Hokkaido University , 4.Nara University of Education, 5.College of Economics, Kanto Gakuin University)

2:15 PM - 2:27 PM JST | 5:15 AM - 5:27 AM UTC

[U08-03] Biogeoscineces will connect everthing together

*Takeshi Kakegawa[1] (1.Graduate School of Science, Tohoku University)

2:27 PM - 2:39 PM JST | 5:27 AM - 5:39 AM UTC

[U08-04] Coverage of JpGU

*Yukihiro Takahashi[1] (1.Department of Cosmosciences, Graduate School of Science, Hokkaido University)

2:39 PM - 2:51 PM JST | 5:39 AM - 5:51 AM UTC

[U08-05] Is he a bit overkill for English?

*Yoshi-Yuki Hayashi[1] (1.Department of Planetology/CPS, Graduate School of Science, Kobe University)

2:51 PM - 3:03 PM JST | 5:51 AM - 6:03 AM UTC

[U08-06] Globalization of Japan Geoscience Union

*Hirokuni Oda[1] (1.Institute of Geology and Geoinformation, Geological Survey of Japan, AIST)

3:03 PM - 3:15 PM JST | 6:03 AM - 6:15 AM UTC

[U08-07] A proposal for JpGU based on the questionaires to SSJ members

*Koshun Yamaoka[1] (1.Earthquake and Volcano Research Center, Graduate School of Environmental Studies, Nagoya University)

[J] Oral | U (Union)：Union

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 101 1F

[U-08] Opinions and recommendations from meeting participants to the future of the Japan Geoscience Union

convener:Yozo Hamano(KOBE Ocean-Bottom Exploration Center, Kobe University), Eiichi Tajika(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Koji Wada(Planetary Exploration Research Center, Chiba Institute of Technology), Ikuro Sumita(Geosciences and Civil Engineering, Institute of Science and Engineering, Kanazawa University), Chairperson:Koji Wada(Planetary Exploration Research Center, Chiba Institute of Technology), Ikuro Sumita

3:30 PM - 3:42 PM JST | 6:30 AM - 6:42 AM UTC

[U08-08] Opinions and recommendations to the Japan Geoscience Union from Society of Geomagnetism and Earth, Planetary and Space Sciences

Yoshiharu Omura[2], Shigeto Watanabe[3], *Yuto Katoh[1], Takuya Tsugawa[4], Yuichi Otsuka[5], SGEPSS steering committee (1.Graduate School of Science, Tohoku University, 2.Research Institute for Sustainable Humanosphere, Kyoto University, 3.Hokkaido Information University, 4.National Institute of Information and Communications Technology, 5.Institute for Space–Earth Environmental Research, Nagoya University)

3:42 PM - 3:54 PM JST | 6:42 AM - 6:54 AM UTC

[U08-09] Collaboration between Earth & Planetary Science and Information Science ~A trial of mutual benefit in the interdisciplinary field~

*Hirohide Demura[1] (1.The University of Aizu)

3:54 PM - 4:06 PM JST | 6:54 AM - 7:06 AM UTC

[U08-10] Comments from young planetary scientists

*Shunichi Kamata[1], Keiko Hamano[2], Go Murakami[3], Ryuki Hyodo[2], Yusuke Nakauchi[3] (1.Hokkaido University, 2.Tokyo Institute of Technology, 3.JAXA/ISAS)

4:06 PM - 4:18 PM JST | 7:06 AM - 7:18 AM UTC

[U08-11] Japan Geoscience Union should operate based on the perspective of individual academic society and fulfill accountability

*Naoji Koizumi[1] (1.School of Environmental Science,the University of Shiga Prefecture)

4:18 PM - 4:30 PM JST | 7:18 AM - 7:30 AM UTC

[U08-12] A proposal from a representative of General Geoscience Sector on a possible direction to future JpGU: actions for domestic activities could be weighted

*Hidenori Kumagai[1] (1.Japan Agency for Marine-Earth Science and Technology)

4:30 PM - 4:42 PM JST | 7:30 AM - 7:42 AM UTC

[U08-13] Fifteen years of Japan Geoscience Letters and its future

*Shogo Tachibana[1], Eiichi Tajika[2] (1.UTokyo Organization for Planetary and Space Science, University of Tokyo , 2.Dept. Earth and Planetary Science, University of Tokyo)

[J] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 103 1F

[P-PS08] Lunar science and exploration

convener:Hiroshi Nagaoka(Japan Aerospace Exploration Agency), Masahiro KAYAMA(Department of Earth and Planetary Material Sciences, Faculty of Science, Tohoku University), Masaki N Nishino(Japan Aerospace Exploration Agency, Institute of Space and Astronautical Science), Tomokatsu Morota(Graduate School of Environmental Studies, Nagoya University), Chairperson:Satoshi Tanaka, Masaki Nishino(名古屋大学宇宙地球環境研究所)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[PPS08-01] Observing simulations of impact-induced moonquakes combined with the lunar impact flash observation data for future lunar seismic explorations

*Keisuke Onodera[1,2], Taichi Kawamura[3], Satoshi Tanaka[2], Yoshiaki Ishihara[4], Takuto Maeda[5], Masahisa Yanagisawa[6], Yuki Uchida[6], Shinsuke Abe[7], Ryuhei Yamada[8], Takaya Okamoto[2] (1.SOKENDAI (The Graduate University for Advanced Studies), 2.Institute of Space and Astronautical Science / Japan Aerospace Exploration Agency, 3.Insitut de Physique du Globe de Paris, 4.National Institute for Environmental Studies, 5.Hirosaki University, 6.The University of Electro-Communications, 7.Nihon University, 8.University of Aizu)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[PPS08-02] New Results from Restored Apollo Magnetic Field Records

*Peter J Chi[1] (1.University of California Los Angeles)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[PPS08-03] Analysis of the High Latitude Region of the Moon with Spectral Profiler Data: Possible Presence of Water Ice

Haramitsu Kyoda[3], *Satoshi Tanaka[1], Makiko Ohtake[1], Hiroshi Nagaoka[2], Yusuke Nakauchi[2], Keisuke Onodera[4] (1.Department of Solid Planetary Sciences Institute of Space and Astronautical Science, 2.Japan Aerospace Exploration Agency, 3.Department of Complexity Science and Enginnering, the University of Tokyo, 4.Department of Space and Astronautical Science, SOKENDAI)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[PPS08-04] **Detection of Dark Regions on the Lunar Surface with Shadow Masked Multiband Imager Data**

*Riho Ito[1], Hiroka Inoue[2], Makiko Ohtake[2], Hisashi Otake[2], Ryosuke Nakamura[1] (1.National Institute of Advanced Industrial Science and Technology, 2.Japan Aerospace Exploration Agency)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[PPS08-05] Estimation of Moho depth under lunar basins by using only the GRAIL gravity data

*Gaku Nishiyama[1], Noriyuki Namiki[2] (1.Department of Earth and Planetary Science, The University of Tokyo, 2.RISE Project, National Astronomical Observatory of Japan)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[PPS08-06] Ejecta Thickness Distribution of Lunar Schrödinger Basin

*Luyuan Xu[1], Minggang Xie[1] (1.State Key Laboratory of Lunar and Planetary Sciences, Macau University of Science and Technology)

[J] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 103 1F

[P-PS08] Lunar science and exploration

convener:Hiroshi Nagaoka(Japan Aerospace Exploration Agency), Masahiro KAYAMA(Department of Earth and Planetary Material Sciences, Faculty of Science, Tohoku University), Masaki N Nishino(Japan Aerospace Exploration Agency, Institute of Space and Astronautical Science), Tomokatsu Morota(Graduate School of Environmental Studies, Nagoya University), Chairperson:Ko Hashizume, Hiroshi Nagaoka

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[PPS08-07] Possible evolution paths of the lunar orbit based on tidal response in the global ocean model of the early Earth

*Mai Motoyama[1], Hideo Tsunakawa[1], Futoshi Takahashi[2] (1.Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology, 2.Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[PPS08-08] Geochemical and Petrological Investigations of Lunar Feldspathic Crust by Lunar Sample Studies and Remote Sensing Data

*Hiroshi Nagaoka[1], Yuzuru Karouji[1], Makiko Ohtake[1] (1.Japan Aerospace Exploration Agency)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[PPS08-09] Development of frosting system for lunar simulant and the detectability of ice growing on the simulant by NIR measurement

*Aoi Ogishima[1], Kazuto Saiki[1] (1.Department of Earth and Space Science, Graduate School of Science, Osaka University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[PPS08-10] Volatile studies on Moon - A review toward future exploration programs

*Ko Hashizume[1] (1.Faculty of Science, Ibaraki University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[PPS08-11] Scientific approach for the promotion of lunar polar exploration mission

*Masahiro KAYAMA[1], Ko Hashizume[2], Hiroshi Nagaoka[3], Kazuto Saiki[4], Chihiro Yamanaka[4], Makoto Hareyama[5], Makiko Ohtake[3] (1.Tohoku University, 2.Ibaraki University, 3.Japan Aerospace Exploration Agency, 4.Osaka University, 5.St. Marianna University School of Medicine)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[PPS08-12] Feasibility study of detection of the lunar subsurface ice with UHF-band GPR based on FDTD electromagnetic simulation

*Atsushi Kumamoto[1], Hideaki Miyamoto[2], Toshifumi Nishibori[3], Takafumi Niihara[2], Fuminori Tsuchiya[1], Ken Ishiyama[3] (1.Tohoku University, 2.University of Tokyo, 3.JAXA)

[J] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 103 1F

[P-PS08] Lunar science and exploration

convener:Hiroshi Nagaoka(Japan Aerospace Exploration Agency), Masahiro KAYAMA(Department of Earth and Planetary Material Sciences, Faculty of Science, Tohoku University), Masaki N Nishino(Japan Aerospace Exploration Agency, Institute of Space and Astronautical Science), Tomokatsu Morota(Graduate School of Environmental Studies, Nagoya University), Chairperson:Masahiro Kayama(東北大学), Yusuke Nakauchi(JAXA/ISAS)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[PPS08-13] **Geology of the SLIM landing site on the Moon**

★Invited Papers

*Makiko Ohtake[1], Kazuto Saiki[2], Yusuke Nakauchi[1], Hiroaki Shiraishi[1], Yoshiaki Ishihara[3], Hiroyuki Sato[1], Chikatoshi Honda[4] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.Osaka University, 3.National Institute for Environmental Studies, 4.University of Aizu)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[PPS08-14] Observing scenario for the Multi-Band Camera onboard SLIM

*Kazuto Saiki[1], Yuya Igarashi[1], Yusuke Nakauchi[2], Chikatoshi Honda[3], Makiko Ohtake[2], Hiroaki Shiraishi[2], Hiroyuki Satoh[2], Yoshiaki Ishihara[4], Takao Maeda[5], Chihiro Yamanaka[1] (1.Osaka Univ., 2.JAXA, 3.Univ. Aizu, 4.National Institute for Environmental Studies, 5.Chuo Univ.)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[PPS08-15] **Current status of a Japanese lunar polar exploration mission**

*Takeshi Hoshino[1], Makiko Ohtake[1], Yuzuru Karouji[1], Hiroaki Shiraishi[1] (1.Japan Aerospace Exploration Agency)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[PPS08-16] HERACLES mission: Returning to the Moon by an ESA-JAXA-CSA Joint Study

*Yuzuru Karouji[1], Hiroshi Nagaoka[1], Yoshiaki Ishihara[2], Masahiro KAYAMA[3], Satoru Yamamoto[4], Nobuyuki Hasebe[5], Ko Hashizume[6], Yoshiko Ogawa[7], Toru Yada[1], Junichi Haruyama[1], Masanao Abe[1], Makiko Ohtake[1], HERACLES Science Working Group, HERACLES International Science Definition Team (1.Japan Aerospace Exploration Agency, 2.National Institute for Environmental Studies, 3.Faculty of Science, Tohoku University, 4.J-spacesystems, 5.Advanced Research Institute for Science and Engineering, Waseda University, 6.Faculty of Science, Ibaraki University, 7.The University of Aizu)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[PPS08-17] **Lunar Science for Landed Missions – High-Priority Landing Sites Visualized with NASA's Moon Trek**

*Brian Hamilton Day[1], Emily Law[2] (1.NASA Solar System Exploration Research Virtual Institute, NASA Ames Research Center, 2.NASA Jet Propulsion Laboratory, California Institute of Technology)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[PPS08-18] NASA SSERVI: Merging Science and Human Exploration

*Brad Eugene Bailey[1], Kristina Gibbs[1], Gregory Schmidt[1] (1.NASA)

[J] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[P-EM17] Space Plasma Physics: Theory and Simulation

convener:Takayuki Umeda(Institute for Space-Earth Environmental Research, Nagoya University), Takanobu Amano(Department of Earth and Planetary Science, University of Tokyo), Yasuhiro Nariyuki(Faculty of Human Development, University of Toyama), Tadas Nakamura(Fukui Prefectural University), Chairperson:Takayuki Umeda(Institute for Space-Earth Environmental Research, Nagoya University), Takanobu Amano(Department of Earth and Planetary Science, University of Tokyo)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[PEM17-01] Prediction of the high-resolution numerical flux by using a deep neural network

*Yosuke Matsumoto[1] (1.Graduate School of Science, Chiba University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[PEM17-02] Multiple Boris integrators for particle-in-cell simulation

*Seiji Zenitani[1], Tsunehiko N Kato[2] (1.Kyoto University, 2.National Astronomical Observatory of Japan)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[PEM17-03] Contour Dynamics for Vlasov–Poisson Plasma with the Periodic Boundary

*Hiroki Sato[1], Tomo-Hiko Watanabe[1], Shinya Maeyama[1] (1.Nagoya University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[PEM17-04] Simulation methods and visualization tools for MHD simulations in a sphere

*Akira Kageyama[1], Kumiko Hori[1], Naohisa Sakamoto[1] (1.Graduate School of System Informatics, Kobe University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[PEM17-05] Kármán Vortex Street, Strouhal Number, Hairpin Vortex in 3D global Magnetohydrodynamic MHD simulations in Northward IMF

*DongSheng CAI[1] (1.University of Tsukuba)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[PEM17-06] Correlations between plasma density and magnetic field strength in MHD turbulence in space

*Tohru Hada[1], Yasuhito Narita[2], Yasuhiro Nariyuki[3] (1.Interdisciplinary Graduate School of Engineering Sciences, Kyushu University, 2.Space Research Institute, Austrian Academy of Sciences, 3.Faculty of Human Development, University of Toyama)

[J] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[P-EM17] Space Plasma Physics: Theory and Simulation

convener:Takayuki Umeda(Institute for Space-Earth Environmental Research, Nagoya University), Takanobu Amano(Department of Earth and Planetary Science, University of Tokyo), Yasuhiro Nariyuki(Faculty of Human Development, University of Toyama), Tadas Nakamura(Fukui Prefectural University), Chairperson:Tadas Nakamura(Fukui Prefectural University), Yasuhiro Nariyuki

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[PEM17-07] Stochastic models of phase space diffusion via wave-particle interaction with parallel propagating electromagnetic waves

*Yasuhiro Nariyuki[1] (1.Faculty of Human Development, University of Toyama)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[PEM17-08] Electron beam instability in collisionless magnetic reconnection with a strong guide field

*Kazuya Shimomura[1], Tomo-Hiko Watanabe[1], Shinya Maeyama[1], Akihiro Ishizawa[2] (1.Nagoya Univertsity, 2.Kyoto University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[PEM17-09] Particle acceleration with precursor wave driven wakefield in relativistic shocks

*Masanori Iwamoto[1], Takanobu Amano[1], Masahiro Hoshino[1], Yosuke Matsumoto[2] (1.Graduate School of Science,The University of Tokyo, 2.Graduate School of Science, Chiba University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[PEM17-10] Stochastic Shock Drift Acceleration in the Shock Transition Region with Finite Pitch-Angle Anisotropy

*Takuma Katou[1], Takanobu Amano[1] (1.The University of Tokyo)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[PEM17-11] Near-fields and its Applications in Space Plasmas

*Tadas Nakamura[1] (1.Fukui Prefectural University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[PEM17-12] Problems of Gravitational Waves and Origin of Gravitational Fields Raised by Studies on Binary Black Hole

*Hiroshi Oya[1] (1.Department of Geophysics Graduate School for Science Tohoku University)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 102 1F

[A-AS04] Atmospheric Chemistry

convener:Tomoki Nakayama(Graduate School of Fisheries and Environmental Sciences, Nagasaki University), Yoko Iwamoto(Graduate School of Biosphere Science, Hiroshima University), Sakae Toyoda(Department of Chemical Science and Engineering, Tokyo Institute of Technology), Nawo Eguchi(Kyushu University), Chairperson:Hisahiro Takashima(福岡大学)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[AAS04-16] Toward the Reduction of Radiative Forcing of Methane and Tropospheric Ozone: Aiming at the Emission Control of CH_4, $NO_x$and NMVOC in Asia

*Hajime Akimoto[1], Tatsuya NNagashima[1], Hiroshi Tanimoto[1], Zig Klimont[2], Markus Amann[2] (1.National Institute for Environmental Studies, 2.International Institute for Applied Systems Analysis)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[AAS04-17] **Determination of atmospheric NO_2 column densities using a Pandora instrument measuring direct-sun spectra at Yokosuka, Japan: Improved validation of TROPOMI satellite observations**

*Yugo Kanaya[1], Hisahiro Takashima[2,1], Masato I. Nodzu[3], Takashi Sekiya[7], Kazuyuki Miyazaki[1], Henk Eskes[4], Gaia Pinardi[5], Daniel Santana Diaz[6], Moritz Müller[6], Alexander Cede[6] (1.Research and Development Center for Global Change, Japan Agency for Marine-Earth Science and Technology (JAMSTEC), 2.Fukuoka University, 3.Tokyo Metropolitan University, 4.KNMI, 5.BIRA-IASB, 6.LuftBlick, 7.Japan Agency for Marine-Earth Science and Technology (JAMSTEC))

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[AAS04-18] A high-resolution global data assimilation for air pollution analysis on megacity scale using multi-sensor satellite measurements including TROPOMI NO_2 data

*Takashi Sekiya[1], Kazuyuki Miyazaki[2,1], Henk Eskes[3], Folkert Boersma[3], Koji Ogochi[1], Kengo Sudo[4,1], Masayuki Takigawa[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Jet Propulsion Laboratory/California Institute for Technology, 3.Royal Netherlands Meteorological Institute (KNMI), 4.Graduate School of Environmental Studies, Nagoya University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[AAS04-19] Recent trends of NO_2, VOC, and tropospheric ozone concentrations observed around Chiba, Japan in 2013-2018

*Daichi Yonekawa[1], Hitoshi Irie[2] (1.Chiba university Graduate school, 2.Chiba university)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[AAS04-20] Long-term seasonal changes in tropospheric ozone over Japan

*Natsumi Kawano[1], Tatsuya Nagashima[1], Seiji Sugata[1] (1.National Institute for Environmental Studies)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[AAS04-21] **Characteristics of Atmospheric Photochemical Pollution at a Comprehensive Site in Guangzhou, China**

*Yu Zou[1] (1.Institute of Tropical and Marine Meteorology, CMA,Guangzhou,China)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 102 1F

[A-AS04] Atmospheric Chemistry

convener:Tomoki Nakayama(Graduate School of Fisheries and Environmental Sciences, Nagasaki University), Yoko Iwamoto(Graduate School of Biosphere Science, Hiroshima University), Sakae Toyoda(Department of Chemical Science and Engineering, Tokyo Institute of Technology), Nawo Eguchi(Kyushu University), Chairperson:Fumikazu Taketani(海洋研究開発機構), Michihiro Mochida(名古屋大学)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[AAS04-22] LC/MS analysis of molecular markers present in biogenic secondary organic aerosols collected during year-round observations at a cool-temperature forest

*Kei Sato[1], Sathiyamurthi Ramasamy[1], Satoshi Inomata[1], Yuzo Miyazaki[2] (1.National Institute for Environmental Studies, 2.Hokkaido University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[AAS04-23] Surfactant Effects on Acid-Catalyzed Reactions at Aqueous Aerosol Surfaces

*Shinnosuke Ishizuka[1], Tetsuya Hama[2], Shinichi Enami[1] (1.National Institute for Environmental Studies, 2.Institute for Low Temperature Science, Hokkaido University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[AAS04-24] Roles of heterogeneous reactions in the tropospheric chemistry: a global modeling study

*Phuc Thi Minh Ha[1], Fumikazu Taketani[2], Yugo Kanaya[2], Kengo Sudo[1,2] (1.Graduate School of Environmental Studies, Nagoya University, 2.Research and Development Center for Global Change, JAMSTEC)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[AAS04-25] Sensitivity of regional deposition of inhaled atmospheric aerosols in human respiratory tract to their size distribution and hygroscopicity: A case study

*Minrui Wang[1], Toshiyuki Mihara[2,4], Mizuo Kajino[5], Kaori Kawana[2,6], Michihiro Mochida[1,2,3] (1.Institute for Space Earth Environmental Research, 2.Graduate School of Environmental Studies, Nagoya University, 3.Institute for Advanced Research, Nagoya University, 4.Now at Gifu Prefectural Industrial Research Institute, 5.Meteorological Research Institute, Japan Meteorological Agency, 6.Now at Research and Development Center for Global Change, JAMASTEC)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[AAS04-26] Biogeochemical cycle between atmosphere and ocean via particulate matters
-Award lecture for JpSAC Young Scientist Award-

★Invited Papers

*Yoko Iwamoto[1] (1.Graduate School of Biosphere Science, Hiroshima University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[AAS04-27] Kinetic Studies for Quantitative Elucidation of Heterogeneous Halogen Chemistry in the Troposphere
-JpSAC Early Career Scientist Award Lecure-

★Invited Papers

*Yosuke Sakamoto[1,2] (1.Graduate School of Global Environmental Studies, Kyoto University , 2.Graduate School of Human and Environmental Studies, Kyoto University)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 103 1F

[A-AS04] Atmospheric Chemistry

convener:Tomoki Nakayama(Graduate School of Fisheries and Environmental Sciences, Nagasaki University), Yoko Iwamoto(Graduate School of Biosphere Science, Hiroshima University), Sakae Toyoda(Department of Chemical Science and Engineering, Tokyo Institute of Technology), Nawo Eguchi(Kyushu University), Chairperson:Hideaki Nakajima(国立環境研究所)

3:30 PM - 4:00 PM JST | 6:30 AM - 7:00 AM UTC

[AAS04-28] Planetary atmosphere - Mars and Venus -

★Invited Papers

*Hiroyuki Maezawa[1] (1.Department of Physical Science Osaka Prefecture University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[AAS04-29] Validation of methane profile observed with FTIR at Tsukuba

Yuki Dai[2], *Isao Murata[1], Hideaki Nakajima[3], Isamu Morino[3] (1.Graduate School of Environmental Studies, Tohoku University, 2.Graduate School of Science, Tohoku University, 3.National Institute for Environmental Studies)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[AAS04-30] **Retrieval of HFC-23 from FTIR observations at Syowa Station, Rikubetsu and Tsukuba**

*Masanori Takeda[1,2], Hideaki Nakajima[2,1], Isao Murata[1], Tomoo Nagahama[3], Isamu Morino[2] (1.Graduate School of Environmental Studies, Tohoku University, 2.Center for Global Environmental Research, National Institute for Environmental Studies, 3.Institute for Space-Earth Environmental Research, Nagoya University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[AAS04-31] Roles of cloud distribution in global atmospheric photochemistry

*Ryoki Matsuda[1], Kengo Sudo[1,2] (1.Graduate School of Environmental Studies, Nagoya University , 2.Japan Marine-Earth Science and Technology)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[AAS04-32] Evaluating global distribution and interannual variation of stratosphere-troposphere exchange of ozone: impacts of climate variabilities

*Kengo Sudo[1,2], Xin Li[1] (1.Graduate School of Environmental Studies, Nagoya University, 2.Research and Development Center for Global Change, JAMSTEC)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 106 1F

[A-CG36] Earth & Environmental Sciences and Artificial Intelligence

convener:Tomohiko Tomita(Faculty of Advanced Science and Technology, Kumamoto University), Ken-ichi Fukui(Osaka University), Daisuke Matsuoka(Japan Agency for Marine-Earth Science and Technology), Satoshi Ono(Kagoshima University), Chairperson:Tomohiko Tomita(Kumamoto University, Faculty of Advanced Science and Technology)

10:50 AM - 11:20 AM JST | 1:50 AM - 2:20 AM UTC

[ACG36-01] Recent Progress in Deep Neural Network Architectures and their Applications

★Invited Papers

*Shinichi Shirakawa[1] (1.Yokohama National University)

11:20 AM - 11:35 AM JST | 2:20 AM - 2:35 AM UTC

[ACG36-02] Improving performance of oxidant prediction using machine learning by optimizing input data based on atmospheric science knowledge

*Tomohiro Sato[1], Peijiang Zhao[1], Koji Zettsu[1] (1.National Institute of Information and Communications Technology)

11:35 AM - 11:50 AM JST | 2:35 AM - 2:50 AM UTC

[ACG36-03] Spatiotemporal Climate Forecasting with ConvLSTM

*Ekasit Phermphoonphiphat[1], Tomohiko Tomita[3], Masayuki Numao[2], Ken-ichi Fukui[2] (1.Graduate School of Information Science and Technology, Osaka University, 2.The Institute of Scientific and Industrial Research, Osaka University, 3.Faculty of Advanced Science and Technology, Kumamoto University)

11:50 AM - 12:05 PM JST | 2:50 AM - 3:05 AM UTC

[ACG36-04] Deep-Learning Based Short-Term Prediction Method for Sea Ice Concentration Using Explanatory Variables

*Issei Kawashima[1], Toru Kouyama[1], Ryu Sugimoto[1], Ryosuke Nakamura[1] (1.National Institute of Advanced Industrial Science and Technology)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 104 1F

[A-CG36] Earth & Environmental Sciences and Artificial Intelligence

convener:Tomohiko Tomita(Faculty of Advanced Science and Technology, Kumamoto University), Ken-ichi Fukui(Osaka University), Daisuke Matsuoka(Japan Agency for Marine-Earth Science and Technology), Satoshi Ono(Kagoshima University), Chairperson:Tomohiko Tomita(Kumamoto University, Faculty of Advanced Science and Technology)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[ACG36-05] **Remote sensing of cloud using the deep learning based on three-dimensional radiative transfer**

*Hironobu Iwabuchi[1], Ryosuke Masuda[1], K. Sebastian Schmidt[2,3], Alessandro Damiani[4], Rei Kudo[5] (1.Graduate School of Science, Tohoku University, 2.Department of Atmospheric and Oceanic Sciences, University of Colorado, 3.Laboratory for Atmospheric and Space Physics, University of Colorado, 4.Center for Environmental Remote Sensing, Chiba University, 5.Meteorological Research Institute, Japan Meteorological Agency)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[ACG36-06] Time series of cloud cover during the night derived from an omnidirectional camera

*Karin miyabe[1], Kazunori Ogohara[1] (1.University of Shiga Prefecture)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[ACG36-07] Time series prediction of cloud cover using whole-sky images and meteorological elements

*Kazunori Ogohara[1], Teppei Sonoda[2] (1.School of Engineering, University of Shiga Prefecture, 2.Graduate School of Engineering, University of Shiga Prefecture)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[ACG36-08] Fundamental investigation about the inductive prediction of precipitation based on the time series data

*Naoki Matsumoto[1], Tomohiko Tomita[1], Kenichi Fukui[2] (1.Kumamoto Univ., 2.Osaka Univ.)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[ACG36-09] Identification of ships image on SAR data using machine learning

*Takashi Sonoke[1], Hirohide Demura[1] (1.University of Aizu)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 303 3F

[A-CG37] Science in the Arctic Region

convener:NAOYA KANNA(Arctic Research Center, Hokkaido University), Masashi Niwano(Meteorological Research Institute), Tetsu Nakamura(Faculty of Environmental Earth Science, Hokkaido University), Shunsuke Tei(Arctic Research Center, Hokkaido University), Chairperson:Tetsu Nakamura(Faculty of Earth Environmental Science, Hokkaido University), Shunsuke Tei(Arctic Research Center, Hokkaido University)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[ACG37-01] **Arctic midlatitude linkage modulated by the QBO**

*Jinro Ukita[1], Kazuhiro Hoshi[1], Meiji Honda[1], Tetsu Nakamura[2], Koji Yamazaki[2] (1.Niigata University, 2.Hokkaido University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[ACG37-02] **Interhemispheric synchronization between the AO and the AAO**

*Yoshihiro Tachibana[1], Yusuke Inoue[1], Kensuke K komatsu[1], Tetsu Nakamura[2], Meiji Honda[3], Koto Ogata[1,4], Koji Yamazaki[2] (1.Mie University, 2.Hokkaido University, 3.Niigata University, 4.Japan Meteorological Agency)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[ACG37-03] Marginal ice zone sea ice observations in the refreezing Chukchi Sea

*Takehiko Nose[1], Tsubasa Kodaira[1], Takuji Waseda[1], Jun Inoue[2] (1.The university of Tokyo, 2.National Institute of Polar Research)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[ACG37-04] **Prediction of wildfire and air pollution with machine learning over the five domains of Eastern Eurasia**

*Teppei J Yasunari[1,2], Ichigaku Takigawa[3], Kyu-Myong Kim[4], Arlindo M da Silva[4] (1.Faculty of Engineering, Hokkaido University, 2.Arctic Research Center, Hokkaido University, 3.Graduate School of Information Science and Technology, Hokkaido University, 4.NASA Goddard Space Flight Center)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[ACG37-05] Hydrological Changes in the Four Largest Siberian Arctic River Basins

*Kazuyoshi Suzuki[1], Tetsuya Hiyama[2], Kazuhito Ichii[3], Yoshihiro Iijima[4], Koji Matsuo[5], Dai Yamazaki[6,1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Institute for Space-Earth Environmental Research, Nagoya University, 3.Chiba University, 4.Graduate School of Bioresources, Mie University, 5.Geospatial Information Authority of Japan, 6.Institute of Industrial Sciences, The University of Tokyo)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[ACG37-06] Mapping thermokarst subsidence in Central Yakutia using L-band SAR interferometry

*Takahiro Abe[1], Go Iwahana[2,3], Takeo Tadono[1] (1.Earth Observation Research Center, Japan Aerospace Exploration Agency, 2.International Arctic Research Center, University of Alaska, Fairbanks, 3.Arctic Research Center, Hokkaido University)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 303 3F

[A-CG37] Science in the Arctic Region

convener:NAOYA KANNA(Arctic Research Center, Hokkaido University), Masashi Niwano(Meteorological Research Institute), Tetsu Nakamura(Faculty of Environmental Earth Science, Hokkaido University), Shunsuke Tei(Arctic Research Center, Hokkaido University), Chairperson:Shunsuke Tei(Arctic Research Center, Hokkaido University), Masashi Niwano(Meteorological Research Institute)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[ACG37-07] Spatiotemporal variation of thaw subsidence and frost heave of permafrost caused by wildfire around Batagay, East Siberia

*Kazuki Yanagiya[1], Masato Furuya[2] (1.Graduate School of Science, Hokkiado University, 2.Faculty of Science, Hokkaido University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[ACG37-08] Influence of recent climate change on permafrost coast dynamics in the Kara Sea, Russian Arctic Ocean

*A. Kioka[1,2], V. S. Isaev[2], A. V. Koshurnikov[2], A. Pogorelov[2], R. M. Amangurov[2], O. Podchasov[2], D. O. Sergeev[3], S. N. Buldovich[2], D. M. Aleksyutina[4], E. A. Grishakina[5] (1.Institut für Geologie, Leopold-Franzens-Universität Innsbruck, Austria, 2.Department of Geocryology, Lomonosov Moscow State University, Russia, 3.Sergeev Institute of Environmental Geoscience, Russian Academy of Science, Russia, 4.Research Laboratory of Geoecology of the Northern Territories, Lomonosov Moscow State University, Russia, 5.Vernadsky Institute of Geochemistry and Analytical Chemistry, Russian Academy of Science, Russia)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[ACG37-09] Ice front variations of Heilprin Glacier in northwestern Greenland controlled by the ocean and glacier bed geometries

*Izumi Asaji[1,2], Daiki Sakakibara[3], Takuto Ando[3], Shin Sugiyama[1] (1.Institute of Low Temperature Science, Hokkaido University, 2.Graduate School of Environmental Science, Hokkaido University, 3.Arctic Research Center, Hokkaido University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[ACG37-10] Meltwater discharge and flooding of the outlet stream of Qaanaaq Glacier, northwestern Greenland

*Ken Kondo[1,2], Daiki Sakakibara[3,2], Shungo Fukumoto[1,2], Shin Sugiyama[2] (1.Graduate School of Environmental Science, Hokkaido University, 2.Institute of Low Temperature Science, Hokkaido University, 3.Arctic Research Center, Hokkaido University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[ACG37-11] Occurrence frequency of lee-side downslope winds near Siorapaluk in northwest Greenland

*Akihiro Hashimoto[1], Tetsuhide Yamasaki[2], Teruo Aoki[3,1], Masashi Niwano[1], Satoru Yamaguchi[4] (1.Meteorological Research Institute, 2.Avangnaq, 3.The Graduate School of Natural Science and Technology, Okayama University, 4.Snow and Ice Research Center, National Research Institute for Earth Science and Disaster Resilience)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[ACG37-12] **Impacts of clouds on the Greenland ice sheet surface melt and mass balance**

*Masashi Niwano[1], Akihiro Hashimoto[1], Teruo Aoki[2] (1.Meteorological Research Institute, 2.Graduate School of Natural Science and Technology, Okayama University)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 303 3F

[A-CG37] Science in the Arctic Region

convener:NAOYA KANNA(Arctic Research Center, Hokkaido University), Masashi Niwano(Meteorological Research Institute), Tetsu Nakamura(Faculty of Environmental Earth Science, Hokkaido University), Shunsuke Tei(Arctic Research Center, Hokkaido University), Chairperson:Naoya Kanna(Arctic Research Center, Hokkaido University)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[ACG37-13] Introduction of the IASC project "T-MOSAiC"

Masaki Uchida[1], *Tetsuo Sueyoshi[1] (1.National Institute of Polar Research)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[ACG37-14] Estimation of ice thickness and volume in the Sea of Okhotsk using ICESat and CryoSat-2 data

*Sohey Nihashi[1], Nathan T. Kurtz[2], Takenobu Toyota[3] (1.National Institute of Technology, Tomakomai College, 2.NASA GSFC, 3.Institute of Low Temperature Science, Hokkaido University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[ACG37-15] Arctic Sea Ice Changes in the DAMIP experiments using the MRI Earth System Model

*Takuro Aizawa[1], Masayoshi Ishii[2], Naga Oshima[2], Seiji Yukimoto[2], Hiroyasu Hasumi[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Meteorological Reseaerch Institute)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[ACG37-16] **Oceanographic Observation in the Refreezing Warm Chukchi Sea during 2018 Mirai Cruise**

*Tsubasa Kodaira[1], Takehiko Nose[1], Takuji Waseda[1], Jun Inoue[2] (1.The University of Tokyo, 2.National Institute of Polar Research)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[ACG37-17] **Observed Waves in the refreezing eastern Chukchi Sea during 2018 Mirai Cruise**

*Takuji Waseda[1], Takehiko Nose[1], Tsubasa Kodaira[1], Alison Kohout[2], Johannes Gemmrich[3], Hui Shen[4], Jun Inoue[5] (1.The University of Tokyo, 2.National Institute of Water and Atmospheric Research, 3.University of Victoria, 4.Bedford Institute of Oceanography, 5.National Institute for Polar Research)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[ACG37-18] Mooring measurement near a marine-terminating glacier in Bowdoin Fjord in northwestern Greenland

*Yoshiki Fujishi[1,2], Yasushi Fukamachi[1,3], NAOYA KANNA[3], Shin Sugiyama[1,3] (1.Institute of Low Temperature Science, Hokkaido University, 2.Graduate School of Environmental Science, Hokkaido University , 3.Arctic Research Center, Hokkaido University)

[J] Oral | H (Human Geosciences)：H-DS Disaster geosciences

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 106 1F

[H-DS15] Human environment and disaster risk

convener:Tatsuto Aoki(School of Regional Development Studies, Kanazawa University), Hisao Kondo(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Chairperson:Tatsuto Aoki(金沢大学地域創造学類)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[HDS15-01] Influence of inhomogeneous structure in surficial reclaimed body traced by aerial photos and delineated by near surface geophysical survey at Makuhari-Kaihin Park liquefied by the 2011 off the Pacific coast of Tohoku earthquake.

*Tomio INAZAKI[1], Takanori Ogahara[1] (1.Public Works Research Institute, Tsukuba Central Institute)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[HDS15-02] Distribution morphology of deformed reclaimed valley associated with the 2018 Hokkaido Eastern Iburi Earthquake

*Takayuki Nakano[1], Satoshi Fujiwara[1], Hiroshi Une[1] (1.GSI of Japan)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[HDS15-03] Liquefaction risk evaluation using relative height data of natural levee

*Mamoru Koarai[1], Kouta Uchiyama[1], Takayuki Nakano[2] (1.Earth Science course, College of Science, Ibaraki University, 2.Geospatial Information Authority of Japan)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[HDS15-04] **Spatial Analysis of Social Vulnerability to large-scale flood: a case study on the Katsushika Ward, Tokyo**

*LIAN XIAO[1] (1.University of Tsukuba)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[HDS15-05] Importance and method of visualization of future occurrence possibilities of giant earthquakes along the Nankai trough

*Yo Fukushima[1] (1.International Research Institute of Disaster Science, Tohoku University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[HDS15-06] Investigation of efficient tsunami evacuation using real-time disaster information

*Yusuke Oishi[1,2,3], Takashi Furumura[2], Fumihiko Imamura[3], Yoshiteru Mihara[4], Fumiyasu Makinoshima[3], Yamashita Kei[3], Takao Higashiyama[5], Tomonori Goto[5], Makoto Oomura[4], Mitsuyuki Nagayama[4] (1.Fujitsu Laboratories Ltd., 2.Earthquake Research Institute, the University of Tokyo, 3.IRIDeS, Tohoku University, 4.Kawasaki City, 5.Fujitsu Ltd.)

[J] Oral | H (Human Geosciences)：H-TT Technology & Techniques

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 301B 3F

[H-TT23] Geographic Information System and Cartography

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Kazunari Tanka(Department of Civil Engineering and Urban Design, Faculty of Engineering, Osaka Institute of Technology), Kazuhiko Nakamura(The University of Tokyo), Chairperson:Mamoru KOARAI(Ibaraki University), Kazunari Tanaka(大阪工業大学)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[HTT23-01] **An analysis of the year-round distribution of $PM_{2.5}$ and Oxidant by (Web)GIS and R**

★Invited Papers

*Junji Yamakawa[1] (1.Graduate School of Natural Science and Technology, Okayama University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[HTT23-02] Development Process and Spatial Structure of Urban Villages in Shenzhen City China

*YARONG LUAN

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[HTT23-03] An analysis on the location characteristic of alley spaces in Tokyo

*Ryo Taniguchi[1], Go Ishikawa[1], Mayumi Oka[2] (1.Tokyo Map Research Inc., 2.Research Organization of Information and Systems The Institute of Statistical Mathematics)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[HTT23-04] Image analysis of night scape using lyrics

*Hiroki Komai[1], Kazunari Tanaka[1] (1.Osaka Institute of Technology)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[HTT23-05] On the Method to Evaluate Signboards based on the Relationship with the Surrounding Space

*Akihiro Kishikawa[1], Kazunari Tanaka[1] (1.Osaka Institute of Technology)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[HTT23-06] ON THE LANDSCAPES ELEMENTS FROM A BIRD'S-EYE VIEW SCAPE

*Nobuaki Tanaka[1], kazunari Tanaka[1] (1.Osaka Institute of Technology)

[J] Oral | H (Human Geosciences)：H-CG Complex & General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 101 1F

[H-CG31] Nuclear Energy and Geoscience

convener:Eiji Sasao(Tono Geoscience Center, Japan Atomic Energy Agency), Ryuta Hataya(Central Research Institute of Electric Power Industry), Shinji Takeuchi(Department of Earth and Environmental Sciences, College of Humanities & Sciences, Nihon University), Chairperson:Tadafumi Niizato

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[HCG31-01] **Uplift estimation in coastal sea area by extrapolation of the land area model and its uncertainty**

*Ryuta Hataya[1], Takaomi Hamada[1], Yohei Shimizu[1] (1.Central Research Institute of Electric Power Industry)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[HCG31-02] Deep groundwater mobility at costal area estimated by groundwater dating

*Takuma HASEGAWA[1], Kotaro NAKATA[1], Yuichi Tomioka[1], Tomoko Ota[1], Atsunao Marui[2], Isao Machida[2], Reo Ikawa[2], Masahiko Ono[2], Shinji Matsumoto[2] (1.Central Research Institute of Electric Power Industry, 2.The National Institute of Advanced Industrial Science and Technology)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[HCG31-03] Attempt to Estimate permeability of rock mass based on elasticity and resistivity measurement in underground tunnel

*Sota Kawaguchi[1], Tada-nori Goto[1], Koki Kashiwaya[1] (1.Graduate School of Engineering, Kyoto University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[HCG31-04] Study on relationship between pathway of groundwater and mass transport, and cooling process of granitic rock

*Eiji Sasao[1], Takashi Yuguchi[2], Masayuki Ishibashi[1] (1.Tono Geoscience Center, Japan Atomic Energy Agency, 2.Faculty of Science, Yamagata University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[HCG31-05] Fracture characterization in the accretionary complex from the view point of mass transfer

*Shinji Takeuchi[1], Chikara Kurata[1], Masakazu Niwa[2], Tadamasa Ueki[2] (1.Department of Earth and Environmental Sciences, College of Humanities & Sciences, Nihon University, 2.Japan Atomic Energy Agency)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[HCG31-06] Retardation of Cs and Sr leachings by geopolymer matrices with zeolte and titanate adsorbent

*Kazuma Kuroda[1], Soonthornwiphat Natatsawas[1], Chaerun Raudhatul Islam[1], Hnin Wint Wint Two[1], Kanako Toda[1], Yutaro Kobayashi[1], Tsutomu Sato[2], Tsubasa Otake[2] (1.Graduate school of Engineering, Hokkaido University, 2.Faculty of Engineering, Hokkaido University)

[J] Oral | H (Human Geosciences)：H-CG Complex & General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 101 1F

[H-CG31] Nuclear Energy and Geoscience

convener:Eiji Sasao(Tono Geoscience Center, Japan Atomic Energy Agency), Ryuta Hataya(Central Research Institute of Electric Power Industry), Shinji Takeuchi(Department of Earth and Environmental Sciences, College of Humanities & Sciences, Nihon University), Chairperson:Shinji Takeuchi

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[HCG31-07] Focus points of post-closure monitoring in geological disposal

*Hiroaki Murakami[1], Yusuke Watanabe[1], Kenji Fukuda[1], Teruki Iwatsuki[1] (1.Japan Atomic Energy Agency)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[HCG31-08] 5 years monitoring results for the environmental dynamics of radiocesium in mountainous forest of the Abukuma Mountains, Fukushima

*Tadafumi Niizato[1], Takayoshi Watanabe[1], Yoshito Sasaki[1], Katsuaki Mitachi[2], Satomi Ito[1], Hironobu Abe[1] (1.Japan Atomic Energy Agency, 2.ATOM TRANSPORT SERVICE CO., LTD)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[HCG31-09] Problems of geological disposal based on the contaminated water issues at Fukushima Daiichi NPS

*Naoaki Shibasaki[1] (1.Fukushima University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[HCG31-10] Examination of "Nationalwide Map of Scientific Features" for HLRW geological disposal in case of Niigata Prefecture and fundamental problems in the fair discussion on this task

*Junji Akai[1], Ryuichiro Ohno (1.Emeritus Professor of Niigata University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[HCG31-11] Problems of the "Nationwide Map of Scientific Features for Geological Disposal" in Saitama prefecture and storage method of High-level Radioactive Waste (HLW)

*Kazuaki SEKINE[1], Kazuyuki SUENAGA[2], Tadao KOBAYASHI (1.Saitama Prefectural Chichibu High School, 2.SUENAGA Environmental Geology)

[J] Oral | H (Human Geosciences)：H-CG Complex & General

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 202 2F

[H-CG34] Education and research for rehabilitation of agriculture against harmful rumors in nuclear disaster areas

convener:Masaru Mizoguchi(Graduate school of Agricultural and Life Sciences, The University of Tokyo), Chairperson:Masaru Mizoguchi(The University of Tokyo), Kousuke Noborio(School of Agricultural Science, Meiji University)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[HCG34-01] Education and research for rehabilitation of agriculture against harmful rumors in nuclear disaster areas

*Masaru Mizoguchi[1] (1.Graduate school of Agricultural and Life Sciences, The University of Tokyo)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[HCG34-02] Towards the reborn of Iitate village 'Agriculture'

★Invited Papers

Makoto Sugisoka[2], *Masaru Mizoguchi[1] (1.Graduate school of Agricultural and Life Sciences, The University of Tokyo, 2.Division of Reconstruction Measures, Iitate Village)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[HCG34-03] Difference among crop species by radiocesium absorption from different soil fractions

*Nihei Naoto[1], Yoshimi Ohmae[1], Makoto Furukawa[1], Syuichiro Yoshida[1] (1.The University of Tokyo, Graduate School of Agricultural and Life Sciences)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[HCG34-04] Wild vegetables and mushrooms retrieving agriculter in Iitate Village, Fukushima Prefecture

*Kosuke Noborio[1], Yudai Fukuyama[2], Satoko Fujita[1], Hiroaki Sugino[2], Masaru Mizoguchi[2] (1.Meiji University, 2.the Univewrsity of Tokyo)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[HCG34-05] Effect of Study Tour toward Participants' Attachment on the Study Site - Case Study of University Student Tour to
Iitate Village, Fukushiima Prefecture -

*Natsumi Ebitani[1], Masaru Mizoguchi[1], Hiroaki Sugino[1] (1.Graduate school of Agricultural and Life Sciences, The University of Tokyo)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-SS12] Crustal Structure

convener:Kazuo Nakahigashi(Tokyo University of Marine Science and Technology), Chairperson:Yoshio Murai(Hokkaido University), Genti Toyokuni(東北大学)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SSS12-01] Shrinking and draining continental lower crust: its binary effects of stress and fluid on crustal activities

*Takehito Koyama[1] (1.Institute of Industrial Science, the University of Tokyo)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SSS12-02] Seismic velocity structure in southern Hokkaido deduced from ocean-bottom seismographic and land observations

*Yoshio Murai[1], Kei Katsumata[1], Tetsuo Takanami[2], Tomoki Watanabe[3], Tadashi Yamashina[4], Ikuo Cho[5], Masayuki Tanaka[6], Ryosuke Azuma[7] (1.Institute of Seismology and Volcanology, Faculty of Science, Hokkaido University, 2.Department of Terrestrial Magnetism, Carnegie Institution of Washington, 3.Marine Works Japan LTD, 4.Kochi University, 5.National Institute of Advanced Industrial Science and Technology, 6.Meteorological Research Institute, 7.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SSS12-03] Structural Complexity Associated with Arc-Arc Collision in Hokkaido Island, Japan - Review on Controlled-Source Seismic Researches in Western and Central Hokkaido -

★Invited Papers

*Takaya Iwasaki[1], Noriko Tsumura[2], Tanio Ito[3], Kazunori Arita[4], Hiroshi Sato[1] (1.Eathquake Research Institute, the University of Tokyo, 2.Graduate School of Science, Chiba University, 3.Association for the Development of Earthquake Prediction, 4.Hokkaido Research Center of Geology)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SSS12-04] **Seismic imaging of the eastern Japan forearc region using S-net data**

*Genti Toyokuni[1], Dapeng Zhao[1], Naoki Uchida[1], Takashi NAKAYAMA[1] (1.RCPEVE, Tohoku Univ.)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SSS12-05] The relationship between the location of the mid crustal reflector and seismicity in Iwaki area, northeastern Japan

*Takashi Iidaka[1], Shin'ichi Sakai[1], Toshihiro Igarashi[1], Kazushige Obara[1], Aitaro Kato[1], Tetsuya Takeda[2], Shigeki Nakagawa[1] (1.Earthquake Research Institute, University of Tokyo, 2.National Research Institute for Earth Science and Disaster Resilience)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SSS12-06] Abnormal Seismic Anisotropy beneath the Tokyo Metropolitan Area (1) Mantle of the Philippine Sea Slab

*Motoko Ishise[1], Shin'ichi Sakai[1], Aitaro Kato[1], Shin Aoi[2], Makoto MATSUBARA[2] (1.Earthquake Reseach Institute, University of Tokyo, 2.National Research Institute for EarthScience and Disaster Resillience)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-SS12] Crustal Structure

convener:Kazuo Nakahigashi(Tokyo University of Marine Science and Technology), Chairperson:Tsuruga Kayoko(Tokyo University of Marine Science and Technology), Yojiro Yamamoto(Japan Agency for Marine-Earth Science and Technology)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SSS12-07] Deep seismic reflection profiling across the Suruga trough, Shizuoka, Japan

*Hiroshi Sato[1], Kayoko Tsuruga[2], Hisatoshi Baba[3], Tatsuya Ishiyama[1], Shinji Kawasaki[4], Yasuhisa Tanaka[4], Toshifumi Hayashi[2], Yoshihiro Sekino[2], Masanao Shinohara[1], Takaya Iwasaki[1], Makoto MATSUBARA[5], Naoshi Hirata[1,5] (1.Earthquake Research Institute, The University of Tokyo, 2.Tokyo University of Marine Science and Technology, 3.Tokai Univerisity, 4.JGI Inc., 5.National Research Institute for Earth Science and Disaster Resilience)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SSS12-08] Multi-channel seismic profiling in the northern part of Suruga bay using the Shiyomaru-vessel of Tokyo University of Marine Science and Technology (Preliminary report)

*Kayoko Tsuruga[1], Hiroshi Sato[2], Hisatoshi Baba[3], Yoshihiro Sekino[1], Toshifumi Hayashi[1], Hayato Kondotec[1], Chiharu Aoyama[1], Tetsutaro Aikawa[1], Tatsuya Ishiyama[2], Masanao Shinohara[2], Shinji Kawasaki[4], Yasuhisa Tanaka[4] (1.Tokyo University of Marine Science and Technology, 2.University of Tokyo, 3.Tokai University, 4.JGI, Inc.)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SSS12-09] Crustal structure refraction survey using Airgun-OBS in the northern part of Suruga Bay -Fujikawa fault zone- (Preliminary Report)

*Hisatoshi Baba[1], Kayoko Tsuruga[2], Hiroshi Sato[3], Tatsuya Ishiyama[3], Masanao Shinohara[3], Takahito Nishimiya[4], Shintaro Abe[5] (1.Department of Marine and Earth Science, Tokai University, 2.Tokyo University of Marine Science and Technology, 3.Earthquake Research Institute, University of Tokyo, 4.Meteorological Research Institute, Japan Meteorological Agency, 5.Association for the Development of Earthquake Prediction)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SSS12-10] 3D seismic attenuation profiling for imaging an active fault in Uchiura wan

*Tetsuro Tsuru[1], Shio Shimizu[1], Mayu Ogawa[1], Jin-Oh Park[2], Seishiro Furuyama[1], Kosaku Arai[3], Takahiko Inoue[3], Chen Guo[2] (1.Tokyo University of Marine Science and Technology, 2.Atmosphere and Ocean Research Institute, The University of Tokyo, 3.National Institute of Advanced Industrial Science and Technology)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SSS12-11] Gravity survey at the extension of the Takahama fault and the Yokosuka fault in Nishio City, Aichi Prefecture

*Tokunosuke Tatsuzawa[1,2], Tatsuya Sumita[2], Shinobu Ito[2], Tomoya Abe[2] (1.Department of Earth Sciences, Resources and Environmental Engineering, Creative Science and Engineering, Faculty of Science and Engineering, Waseda University, 2.National Institute of Advanced Industrial Science and Technology)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SSS12-12] Subduction geometry and seismicity around northern Ryukyu subduction zone

*Yojiro Yamamoto[1], Tsutomu Takahashi[1], Yasushi Ishihara[1], Koichiro Obana[1], Seiichi Miura[1], Shuichi Kodaira[1], Yoshiyuki Kaneda[2] (1.Japan Agency for Marine-Earth Science and Technology (JAMSTEC), 2.Kagawa University)

[J] Oral | S (Solid Earth Sciences)：S-GL Geology

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A10 TOKYO BAY MAKUHARI HALL

[S-GL27] Geochronology and Isotope Geology

convener:Takahiro Tagami(Graduate School of Science, Kyoto University), Yuji Sano(Division of Ocean and Earth Systems, Atmosphere and Ocean Research Institute, University of Tokyo), Chairperson:Takahiro Tagami, Yuji Sano

9:00 AM - 9:30 AM JST | 12:00 AM - 12:30 AM UTC

[SGL27-01] Terrestrial cosmogenic nuclides as a dating tool of landforms and near-surface materials: applicability and limitations

★Invited Papers

*Yuki Matsushi[1] (1.Disaster Prevention Research Institute, Kyoto University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SGL27-02] Dating of marine erosional terraces using cosmogenic nuclides: A case study of the Hyuga City, Miyazaki Prefecture, southwest Japan (preliminary results)

*Shigeru Sueoka[1], Tetsuya Komatsu[1], Yuki Matsushi[2], Yusuke Yonaga[1], Naomi Sano[1], Noriaki Hirao[1], Tadamasa Ueki[1], Natsuko Fujita[1], Yoko Kokubu[1], Masakazu Niwa[1] (1.Japan Atomic Energy Agency, 2.Disaster Prevention Research Institute, Kyoto University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SGL27-03] Estimation of thermal history of Toki granite over 0.1Myr timescale by Multi-OSL-thermochronometry

*Manabu Ogata[1], Georgina E King[2], Frédéric Herman[2], Shigeru Sueoka[1] (1.Tono Geoscience Center, Japan Atomic Energy Agency, 2.University of Lausanne)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SGL27-04] Depth condition under which OSL signal of quartz gouge experiences coseismic zeroing

*Yuki Minomo[1], Kiyokazu Oohashi[1], Noriko Hasebe[2], Kazumasa Miura[3] (1.Graduate School of science and Technology for Innovation, Yamaguchi University , 2.Institute of Nature and Environmental Technology, Kanazawa University, 3.Kanazawa University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SGL27-05] Result of age determination of samples from Hokuriku Group

*Noriko Hasebe[1], Ryo Kamiguchi[2] (1.Institute of Nature and Environmental Technology, Kanazawa University, 2.Department of Earth Sciences, Kanazawa University)

[J] Oral | S (Solid Earth Sciences)：S-GL Geology

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A10 TOKYO BAY MAKUHARI HALL

[S-GL27] Geochronology and Isotope Geology

convener:Takahiro Tagami(Graduate School of Science, Kyoto University), Yuji Sano(Division of Ocean and Earth Systems, Atmosphere and Ocean Research Institute, University of Tokyo), Chairperson:Yuji Sano, Takahiro Tagami

10:45 AM - 11:15 AM JST | 1:45 AM - 2:15 AM UTC

[SGL27-06] **Geochemical origin/cycle analysis with isotopologues and isotopomers**

★Invited Papers

*Naohiro Yoshida[1] (1.Department of Chemical Science and Engineering, Earth-Life Science Institute, Tokyo Institute of Technology)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SGL27-07] Estimation of Paleoenvironment by sedimentary rocks in Labrador, Cacada

*katsutaka sudo[1], Yuji Sano[1], Tsuyoshi Komiya[1], Bakert David[2], Michael Broadley[2], Bernard Marty[2] (1.University of Tokyo, 2.CRPG-CNRS, Université de Lorraine)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SGL27-08] Hf-W dating of zircons from mesosiderites with high-pressure sintered sample

*Yuta Koyama[1], Naoto Takahata[1], Yuji Sano[1], Naoji Sugiura[1], Mizuho Koike[2], Makiko K. Haba[3], Sakata Shuhei[4], Hideharu Kuwahara[5], Tetsuo Irifune[5] (1.the University of Tokyo, 2.Japan Aerospace Exploration Agency, 3.Tokyo Institute of Technology, 4.Gakushuin University, 5.Geodynamics Research Center, Ehime University)

11:45 AM - 12:15 PM JST | 2:45 AM - 3:15 AM UTC

[SGL27-09] Radiometric ages *vs.* astrophysical ages -with regard to the numerical age in the International Stratigraphic Chart

★Invited Papers

*Ichiro Kaneoka[1] (1.Earthquake Research Institute, University of Tokyo)

[J] Oral | S (Solid Earth Sciences)：S-MP Mineralogy & Petrology

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 301B 3F

[S-MP32] Deformed rocks, Metamorphic rocks and Tectonics

convener:Yumiko Harigane(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Yoshihiro Nakamura(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Chairperson:Yoshihiro Nakamura(産総研), Yumiko Harigane(産総研)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SMP32-19] Thermal interaction of the lithosphere and asthenosphere revealed from internal variations of pressure-temperature history in orogenic peridotite complexes

*Kazuhito Ozawa[1], Carlos J. Garrido[2], Karoly Hidas[2], Jean-Louis Bodinier[3] (1.Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo, 2.Instituto Andaluz de Ciencias de la Tierra (IACT), CSIC – UGR, Armilla, Granada, Spain, 3.Geosciences Montpellier, Montpellier, France)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SMP32-20] **Hydration and Ca-metasomatism in Mantle Wedge: An evidence from the Alag Khadny Accretionary Wedge, Western Mongolia**

*OTGONBAYAR DANDAR[1], Atsushi Okamoto[1], Masaoki Uno[1], Noriyoshi Tsuchiya[1] (1.Graduate School of Environmental Studies, Tohoku University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SMP32-21] **Attenuated Total Reflection Infrared (ATR-IR) Spectroscopy of Antigorite, Chrysotile and Lizardite**

*Ilona Talvikki Sakaguchi[1] (1.Nagoya University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SMP32-22] Fabric and petrological characteristics of sheared peridotites in Marion transform fault, Southwest Indian Ridge

*Kakihata Yuki[1], Katsuyoshi Michibayashi[2], Henry Dick[3] (1.Shizuoka University Graduate School of Science, 2.Nagoya University Graduate School of Environmental Studies, 3.Woods Hole Oceanographic Institution)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SMP32-23] Structure and formation mechanism of lithosphere-asthenosphere boundary decoded from Ichinomegata peridotite xenoliths

*Yuto Sato[1], Kazuhito Ozawa[1] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SMP32-24] Metasomatic banding and deformation instability in the metamorphic rocks

*mitsuhiro toriumi[1] (1.Japan agency of marine science and technology)

[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-VC37] Dynamics of volcanic eruptions and their physical and chemical processes

convener:Yujiro Suzuki(Earthquake Research Institute, The University of Tokyo), Chairperson:Yujiro Suzuki(Earthquake Research Institute, The University of Tokyo), Hiroyuki Shimizu(Earthquake Research Institute, The University of Tokyo)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SVC37-01] Volcanic activities triggered or inhibited by resonance of volcanic edifices to large earthquakes

*Atsuko Namiki[1], Eleonora Rivalta[2], Heiko Woith[2], Timothy Willey[2], Stefano Parolai[3], Thomas R Walter[2] (1.Graduate School of Integrated Arts and Sciences, Hiroshima University, 2.GFZ, 3.OGS)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SVC37-02] **Groundmass crystallization experiments of an andesitic pumice under low vapor pressure.**

*Yasukawa Hiroki[1], Mayumi Mujin[1], Michihiko Nakamura[1], Shizuka Otsuki[2] (1.Division of Earth and Planetary Materials Science, Department of Earth Science, Graduate School of Science, Tohoku University., 2.National Institute of Advanced Industrial Science and Technology)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SVC37-03] Decoding pre-eruptive magma evolution and water behavior from plagioclase phenocrysts: Application to the Hoei eruption of Mt. Fuji

*Tsuyoshi Iizuka[1], Chiyo Harada[1], Kenji Shimizu[2], Takayuki Ushikubo[2], Morihisa Hamada[2], Mitsuhiro Yoshimoto[3] (1.University of Tokyo, 2.JAMSTEC, 3.Mount Fuji Research Institute)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SVC37-04] Probing magmatic processes just prior to historic eruptions at Sakurajima volcano: Toward understanding “magma pre-charge”

*Naoki Araya[1], Michihiko Nakamura[1], Satoshi Okumura[1] (1.Division of Earth and Planetary Materials Science, Department of Earth Science, Graduate School of Science, Tohoku UniversityUniversity)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SVC37-05] Magmatic processes prior to the Vulcanian eruptions of Sakurajima volcano: A combined petrologic and geophysical approach

*Sakauchi Nono[2], Michihiko Nakamura[2], ATSUSHI YASUDA[1], Satoshi Okumura[2], Naoki Araya[2], Masato Iguchi[3], Daisuke Miki[3], Nobuo Geshi[4] (1.Earthquake Research Institute, University of Tokyo, 2.Division of Earth and Planetary Materials Science, Department of Earth Science, Graduate School of Science, Tohoku University, 3.Sakurajima Volcano Research Center, Disaster Prevention Research Institute, Kyoto University, 4.Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SVC37-06] Cyclic degassing behavior accompanying dome-forming lava effusion at Shinmoedake volcano in the 2018 eruption

★Invited Papers

*Taishi Yamada[1], Hideki Ueda[1], Toshiya Mori[2], Toshikazu Tanada[1] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Geochemical Research Center, Graduate School of Science, The University of Tokyo)

[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-VC37] Dynamics of volcanic eruptions and their physical and chemical processes

convener:Yujiro Suzuki(Earthquake Research Institute, The University of Tokyo), Chairperson:Yujiro Suzuki(Earthquake Research Institute, The University of Tokyo), Taishi Yamada

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SVC37-07] Estimation of the amplitude of infrasoundsignal based on sound diffraction

*Kyoka Ishii[1], Akihiko Yokoo[1] (1.Graduate School of Science, Kyoto University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SVC37-08] Mechanism and frequency change of pressure oscillation in the laboratory geyser system

*Noriko Teshima[1], Atsushi Toramaru[2] (1.Department of Earth and Planetary Sciences, Graduate School of Sciences, Kyushu University, 2.Department of Earth and Planetary Sciences, Faculty of Sciences, Kyushu University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SVC37-09] Effects of temperature on the run-out distance of large-scale pyroclastic density currents: Numerical simulation of a two-layer depth-averaged model

*Hiroyuki A. Shimizu[1], Takehiro Koyaguchi[1], Yujiro J. Suzuki[1] (1.Earthquake Research Institute, The University of Tokyo)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SVC37-10] **Total grain-size distribution of pumice fallout deposits (Kj-P1) from 54 ka plinian eruption at Kuju Volcano**

*Tomohiro Tsuji[1], Kishimoto Hiroshi[2], Fujita Kouji[2], Chisato Nakamura[3], Nagata Tomohiro[3], Kimura Kazunari[3], Michiharu Ikeda[1], Naoki Nishizaka[4], Kozo Onishi[4] (1.Shikoku Research Institute Inc., 2.Asia Air Survey Co. Ltd., 3.Naiba, 4.Shikoku Electric Power Co. Inc.)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SVC37-11] Estimating ashfall volumes for the 2018 Shinmoedake eruptions using the Ellipse Approximated Isopach (EAI) method - How to quantify ashfall volumes from limited ashfall observation locations

*Yasuhisa Tajima[1], Setsuya Nakada[2], Masashi NAGAI[2], Fukashi Maeno[3], Jun Oikawa[3], Teruki Oikawa[4], Yasuo Miyabuchi[5], Toshiaki Hasenaka[5], Masataka Kawaguchi[5] (1.NIPPON KOEI CO.,LTD., 2.NIED, 3.ERI, the Univ. Tokyo, 4.Geological Survey of Japan, AIST, 5.Kumamoto Univ.)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SVC37-12] Optical disdrometer measurement of tephra fall: Constraints on radar parameters for eruption cloud observations

★Invited Papers

*Tomofumi Kozono[1], Masato Iguchi[2], Takahiro Miwa[3], Masayuki Maki[4], Takeshi Maesaka[3], Daisuke Miki[2], Takeshi Nishimura[1] (1.Department of Geophysics, Graduate School of Science, Tohoku University, 2.Sakurajima Volcano Research Center, Disaster Prevention Research Institute, Kyoto University, 3.National Research Institute for Earth Science and Disaster Resilience, 4.Research and Education Center for Natural Hazards, Kagoshima University)

[J] Oral | S (Solid Earth Sciences)：S-TT Technology & Techniques

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A11 TOKYO BAY MAKUHARI HALL

[S-TT43] seismic monitoring and processing system

convener:Takahiro Maeda(National Research Institute for Earth Science and Disaster Resilience),
Chairperson:Masanao Shinohara(Earthquake Research Institute, The University of Tokyo)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[STT43-01] Summary and Considerations about Characteristics of Borehole Stress Meter for Continuous Observation

*Hiroshi Ishii[1], Yasuhiro Asai[1] (1.Tono Research Institute of Earthquake Science, Association for the Development of Earthquake Prediction)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[STT43-02] Seismic monitoring by an autonomous robotic float equipped with a hydrophone: MERMAID

*Masayuki Obayashi[1], Hiroko Sugioka[2] (1.Japan Agency for Marine-Earth Science and Technology, 2.Department of Planetology, Kobe University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[STT43-03] Earthquake observation in a borehole over 250 °C using high temperature optical fiber and DAS technology

*Tsunehisa KIMURA[1] (1.Schlumberger)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[STT43-04] Distributed Acoustic Sensing measurement by using seafloor optical fiber cable system off Sanriku for dense seismic observation

*Masanao Shinohara[1], Tomoaki Yamada[1], Takeshi Akuhara[1], Kimihiro Mochizuki[1], Takeo Kasajima[2], Takahiro Arioka[2], Masayuki Hamakawa[3], Shunsuke Kubota[4] (1.Earthquake Research Institute, University of Tokyo, 2.Fujitsu Laboratories Ltd., 3.Fujitsu Limited, 4.YK Giken Co., Ltd.)

[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[S-CG52] Petrology, Mineralogy & Resource Geology

convener:Tatsuo Nozaki(Research and Development Center for Submarine Resources, Japan Agency for Marine-Earth Science and Technology), Satoshi SAITO(Graduate School of Science and Engineering, Ehime University), Koichi Momma(National Museum of Nature and Science), Nobutaka Tsuchiya(Department of Geology, Faculty of Education, Iwate University), Chairperson:Tatsuo Nozaki(JAMSTEC), Satoshi Saito

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SCG52-01] Coordinated sample preparation with cryo-FIB-SEM and X-ray CT: Applications to chemical analysis for fluid inclusions in minerals

*Yu Kodama[1], Naotaka Tomioka[2], Tatsuhiko Kawamoto[3], Junichiro Kuroda[4], Masafumi MURAYAMA[5], Motoo Ito[2] (1.Marine Works Japan Ltd., 2.Kochi Institute for Core Sample Research, JAMSTEC, 3.Department of Geoscience, Faculty of Science, Shizuoka University, 4.Atmosphere and Ocean Research Institute, the University of Tokyo, 5.Faculty of Agriculture and Marine Science, Kochi University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SCG52-02] Feasibility Study for Precise Particle Characterization of Fine Clay Particle Using An Automated Particle Image Analysis and Nanotrakcking Analysis.

*Daisuke Sasakura[1], Aiko Hayauchi[1], Sho Kimura[2] (1.MalvernPanalytical Japan ,Div of Spectris Co.Ltd,., 2.Faculty of Agriculture, University of the Ryukyu)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SCG52-03] Crystal structure and local structures of natural perovskite-type (Na,REE,Ca)(Ti, Nb)O_3 loparite by single crystal diffraction and XAFS analyses

*Ginga Kitahara[1], Akira Yoshiasa[1], Makoto Tokuda[1], Kazumasa Sugiyama[2] (1.Kumamoto University, 2.Tohoku University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SCG52-04] Crystal Size Distributions based on crystal habit of groundmass pyroxene crystals in the ejecta of the Shinmoedake 2011 eruption

*Shota Okumura[1], Mayumi Mujin[2], Akira Tsuchiyama[1], Norimasa Shimobayashi[1], Akira Miyake[1] (1.Department of Geology and Mineralogy, Graduate School of Science, Kyoto University, 2.Division of Earth and Planetary Materials Science, Department of Earth Science, Tohoku University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SCG52-05] Petrochemistry and zircon U-Pb age of ``lateritic'' metamorphic rocks from the Kitakami Mountains

*Nobutaka Tsuchiya[1], Yamato Kumagai[1], Tatsuro Adachi[2], Nobuhiko Nakano[2], Yasuhito Osanai[2] (1.Department of Geology, Faculty of Education, Iwate University, 2.Department of Earth Sciences, Faculty of Social and Cultural Studies, Kyushu University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SCG52-06] How to make 'syn-plutonic dike' - - - Another story from the Ryoke granitic province, Southwest Japan

*Takashi Nakajima[1], Hiroyuki Kamiyama[2], Ian S. Williams[3] (1.Geological Survey of Japan, 2.Ueyama-Shisui, Co. Ltd., 3.Australian National University)

[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-CG53] Environment formed and maintained by active faults

convener:Naoji Koizumi(School of Environmental Science,the University of Shiga Prefecture), Makoto Yamano(Earthquake Research Institute, the University of Tokyo), Takafumi Kasaya(Japan Agency for Marine-Earth Science and Technology), Hideki Hamamoto(Center for Environmental Science in Saitama), Chairperson:NAOJI KOIZUMI, TADANORI GOTO(Graduate School of Engineering, Kyoto University)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SCG53-01] **Effect of the Hanaore fault and Biwako-seigan fault on the water quality of the Ado river in Shiga Prefecture**

*Naoji Koizumi[1], Masahiro Ueda[1], Shinsuke Minote[1], Tatsuya Tanaka[1], Masahiro Maruo[1], Kanto Mitani[2] (1.School of Environmental Science,the University of Shiga Prefecture, 2.Daikokuten Bussan Co., Ltd.)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SCG53-02] **Hydrothermal vents in the deep basin of Lake Biwa**

★Invited Papers

*Michio Kumagai[1] (1.Ritsumeikan University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SCG53-03] Heat flow anomalies observed on the seafloor in the vicinity of faults: indication of fluid flow

*Makoto Yamano[1], Shusaku Goto[2], Yoshifumi Kawada[3], Hideki Hamamoto[4] (1.Earthq. Res. Inst., Univ. Tokyo, 2.Geol. Surv. Japan, AIST, 3.IRIDeS, Tohoku Univ., 4.Center Environ. Sci. Saitama)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SCG53-04] How can we quantify the hydraulic permeability of fault based on geophysical survey?

*Tada-nori Goto[1], Sota Kawaguchi[1] (1.Graduate School of Engineering, Kyoto University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SCG53-05] Healing process of the Nojima Fault zone after 1995 Hyogo-ken Nanbu earthquake

*Hideki Murakami[1], Naoto Oshiman[2], Ryokei Yoshimura[2], Tsutomu Miura[2], Masato Kamo[2] (1.Research and Education Faculty,Kochi University, 2.Disaster Prevention Research Institute,Kyoto University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SCG53-06] Discussion on the environment formed and maintained by active faults

*Naoji Koizumi[1] (1.School of Environmental Science,the University of Shiga Prefecture)

[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A11 TOKYO BAY MAKUHARI HALL

[S-CG55] Crustal fluids and deformation

convener:Yuichi Kitagawa(Tectono-Hydrology Research Group, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Naoji Koizumi(School of Environmental Science,the University of Shiga Prefecture), Koji Umeda(Hirosaki University), Fumiaki Tsunomori(Geochemical Research Center, Graduate School of Science, University of Tokyo), Chairperson:Yuichi Kitagawa(産業技術総合研究所地質調査総合センター地震地下水研究グループ), Fumiaki Tsunomori(東京大学大学院理学系研究科地殻化学実験施設)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SCG55-01] Estimation of fault models of the short-term SSE using groundwater pressures at the Hokusei observation site

*Yuichi Kitagawa[1], Norio Matsumoto[1] (1.Tectono-Hydrology Research Group, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology)

9:15 AM - 9:35 AM JST | 12:15 AM - 12:35 AM UTC

[SCG55-02] Groundwater level changes during the 2018 Hokkaido Eastern Iburi earthquake

★Invited Papers

*Tomo Shibata[1], Ryo Takahashi[2], Hiroaki Takahashi[3], Takanori Kagoshima[4], Yuji Sano[4], Daniele Pinti[5] (1.Graduate School of Science, Kyoto University, 2.Geological Survey of Hokkaido, Hokkaido Research Organization, 3.Graduate School of Science, Hokkaido University, 4.Atmosphere and Ocean Research Institute, The University of Tokyo, 5.GEOTOP, Université du Québec)

9:35 AM - 9:50 AM JST | 12:35 AM - 12:50 AM UTC

[SCG55-03] Postseismic streamflow changes after the 2016 Kumamoto earthquake

*Naoji Koizumi[1], Shinsuke Minote[1], Tatusya Tanaka[1] (1.School of Environmental Science,the University of Shiga Prefecture)

9:50 AM - 10:05 AM JST | 12:50 AM - 1:05 AM UTC

[SCG55-04] Development of Radium Concentration Monitoring System based on Gamma-Ray Spectroscopy

*Fumiaki Tsunomori[1], Shigekazu Nagai[2], Junji Yoshii[3], Yoshihide Kimura[4], Yoriyuki Kamakura[5], Yuki Inoue[5], Norihito Sato[6], Shiro Sakuragi[7], Ryuichi Shimizu[8], V N Gluchschenko[9] (1.Geochemical Research Center, Graduate School of Science, University of Tokyo, 2.Graduate School of Engineering, Mie University, 3.Advanced Clinical Research Center, Fukushima Medical University, 4.Graduate School of Engineering, Osaka University, 5.Faculty of Information Science and Technology, Osaka Institute of Technology, 6.Chiyoda Technol corp., 7.Union Material Inc., 8.Office for University-Industry Collaboration, Osaka University, 9.Institute of Nuclear Physics, Almaty, Republic of Kazakhstan)

10:05 AM - 10:25 AM JST | 1:05 AM - 1:25 AM UTC

[SCG55-05] ^{222}Rn concentration distribution in Yatsushiro Sea

★Invited Papers

*Kuniyo Kawabata[1], Fumiaki Tsunomori[2], Yujin Kitamura[1], Hakuho-Maru K18-3 scientists (1.Graduate School of Science and Engineering, KAGOSHIMA UNIVERSITY, 2.Geochemical Research Center, Graduate School of Science, University of Tokyo)

[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-CG58] Brittle-Ductile Transition and Supercritical Geofluids for Crustal Energy in Island Arc

convener:Noriyoshi Tsuchiya(Graduate School of Environmental Studies, Tohoku University), Hiroshi Asanuma(AIST), Yasuo Ogawa(Volcanic Fluid Research Center, School of Science, Tokyo Institute of Technology), Shigemi Naganawa(Akita University), Chairperson:Noriyoshi Tsuchiya, Atsushi Okamoto

1:45 PM - 1:55 PM JST | 4:45 AM - 4:55 AM UTC

[SCG58-01] Supercritical Geothermal Resources as a Function of Mass and Energy Transport in Subduction Zone

*Noriyoshi Tsuchiya[1] (1.Graduate School of Environmental Studies, Tohoku University)

1:55 PM - 2:05 PM JST | 4:55 AM - 5:05 AM UTC

[SCG58-02] Outline of NEDO Supercritical Geothermal Project

*Hiroshi Asanuma[1] (1.AIST)

2:05 PM - 2:30 PM JST | 5:05 AM - 5:30 AM UTC

[SCG58-03] Mineral precipitation/dissolution from water and brine with decreasing temperatures along hydrostatic pressures

★Invited Papers

*Kenichi Hoshino[1] (1.Department of Earth and Planetary Systems Science, Hiroshima University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SCG58-04] Thermodynamic data of aqueous species for supercritical water–rock interaction: dissolution experiments and density-based extrapolation

*Atsushi Okamoto[1], Hajime Ishii[1], Ryosuke Oyanagi[2], Noriyoshi Tsuchiya[1] (1.Graduate School of Environmental Studies, 2.JAMSTEC)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SCG58-05] Nitrogen isotope ratios of ammonium in hypersaline hot spring waters distributed along Arima-Takatsuki fault zone.

*Kazuhiro Amita[1], Takashi Nakamura[2], Shinji Ohsawa[3] (1.Faculty of Engineering Science, Akita University, 2.International Research Center for River Basin Environment, University of YAMANASHI, 3.Institute for Geothermal Sciences, Graduate School of Science, Kyoto University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SCG58-06] **Crustal fluid pressure gradients and permeability estimated from fluid-rock reaction zones**

*Masaoki Uno[1], Diana Mindaleva[1], Noriyoshi Tsuchiya[1] (1.Graduate School of Environmental Studies, Tohoku University)

[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-CG58] Brittle-Ductile Transition and Supercritical Geofluids for Crustal Energy in Island Arc

convener:Noriyoshi Tsuchiya(Graduate School of Environmental Studies, Tohoku University), Hiroshi Asanuma(AIST), Yasuo Ogawa(Volcanic Fluid Research Center, School of Science, Tokyo Institute of Technology), Shigemi Naganawa(Akita University), Chairperson:Noriyoshi Tsuchiya

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SCG58-07] 3D S-wave velocity structure in volcanic region using surface-wave tomography

*Hiro Nimiya[1], Tatsunori Ikeda[1], Takeshi Tsuji[1] (1.Kyushu University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SCG58-08] Resistivity-Based Temperature and Permeability Estimation of the Kakkonda Geothermal Field, Japan, Using a Neural Network

*Ugou Tsubasa[1], Kazuya Ishitsuka[2], Toru Mogi[3] (1.Department of Socio-Environmental Engineering Scool of Engineering Hokkaido University, 2.Division of Urban Management, Grduate School of Engineering, Kyoto University, 3.Division of Sustinable Resources Enginieering, Faculty of Engineering, Hokkaido University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SCG58-09] Preliminary report on geothermal structure revealed by geological and MT surveys around Akayumatasawa river in Sanzugawa caldera, NE Japan

*Keishi Nunohara[1], Kuo Hsuan Tseng[2], Hiroki Okano[1], Yasuo Ogawa[2], Noriyoshi Tsuchiya[1] (1.Graduate school of Environmental Studies Tohoku University , 2.Graduate school of Science , Tokyo Institute of Technology)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SCG58-10] Characterization of hydraulic fracturing phenomena in supercritical geothermal environments revealed by elastic wave measurements

*Miura Takahiro[1], Noriaki Watanabe[1], Kiyotoshi Sakaguchi[1], Ryota Goto, Kota Yamane, Takeshi Komai[1], Youqing CHEN[2], Takuya ISHIBASHI[3], Noriyoshi Tsuchiya[1] (1. Graduate School of Environmental Studies, Tohoku University, 2.Graduate School of Energy Science, Kyoto University, 3.AIST, FREA)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SCG58-11] Experimental measurements of transport pore radius of thermally cracked granite and the relationship of pore structure to permeability

*Sueyoshi Kazumasa[1], Tadashi Yokoyama[2], Ikuo Katayama[1] (1.Department of Earth and Planetary Systems Science, Hiroshima University, 2.Graduate School of Integrated Arts and Sciences, Hiroshima University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SCG58-12] Geothermal reservoir evaluation by using TL of Quartz and Fluid Flow Simulation Model of the Kakkonda system in Japan

*Alvaro Josue Amaya[1], Nobuo Hirano[1], Noriyoshi Tsuchiya[1] (1.Tohoku University. Graduate School of Environmental Studies)

[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[S-CG59] Reducing risks from earthquakes, tsunamis & volcanoes: new applications of realtime geophysical data

convener:Masashi Ogiso(Meteorological Research Institute, Japan Meteorological Agency), Naotaka YAMAMOTO CHIKASADA(National Research Institute for Earth Science and Disaster Resilience), Satoshi Kawamoto(Geospatial Information Authority of Japan), Mitsuyuki Hoshiba(Meteorological Research Institute), Chairperson:Mitsuyuki Hoshiba(Meteorological Res. Inst., JMA, Japan), Satoshi Kawamoto(Geospatial Information Authority of Japan)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SCG59-01] Earthquake early warning in the United States and beyond

★Invited Papers

*Richard M Allen[1] (1.University of California Berkeley)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SCG59-02] Study on the relationship between seismometer site environment and earthquake early warning seismic parameter estimation accuracy

*Katsutomo Niwa[1], Naoyasu Iwata[1], Shunroku Yamamoto[1] (1.Railway Technical Research Institute)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SCG59-03] **Prediction of surface ground motion using underground seismic records based on data assimilation (2)**

*Masaya Ishihara[1], Hisashi Nakahara[1] (1.Solid Earth Physics Laboratory, Department of Geophysics, Graduate School of Science, Tohoku University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SCG59-04] Development of Realtlime Long-Period Ground-Motion Prediction System and Demonstration Experiment

★Invited Papers

*Shin Aoi[1], Takeshi Kimura[1], Takashi Kunugi[1], Wataru Suzuki[1], Yadab Prasad Dhakal[1], Naoto Kojya[2] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Japan Meteorological Agency)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SCG59-05] Real-time forecasting of long-period ground motions for the Nankai Trough earthquake: The effectivity of the Green function-based data assimilation method

*Atsuki Oba[1], Takashi Furumura[1], Takuto Maeda[2] (1.Earthquake Research Institute, University of Tokyo, 2.Graduate School of Science and Technology, Hirosaki University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SCG59-06] Development of EEW system exchanging real-time seismic intensity and seismic waveform

*Shigeki Horiuchi[1], Yuko Sato[1], Taku Urabe[2], Yamaimaiti Nizhamudong[3], Kazuo Sasaki[3] (1.Home Seismometer Corporation, 2.telemetra , 3.Challenge)

[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[S-CG59] Reducing risks from earthquakes, tsunamis & volcanoes: new applications of realtime geophysical data

convener:Masashi Ogiso(Meteorological Research Institute, Japan Meteorological Agency), Naotaka YAMAMOTO CHIKASADA(National Research Institute for Earth Science and Disaster Resilience), Satoshi Kawamoto(Geospatial Information Authority of Japan), Mitsuyuki Hoshiba(Meteorological Research Institute), Chairperson:Naotaka Chikasada(National Res. Inst. for Earth Science and Disaster Resilience), Masashi Ogiso(Meteorological Research Institute, JMA)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SCG59-07] Enhancements of real time seismic intensity estimation using seismic intensity meters maintained by a local government – Case study on Tottori prefecture -

*Takao Kagawa[1] (1.Tottori University Graduate School of Engineering)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SCG59-08] **Drawig of the realtime seismic intesity on live screen and maximum distribution map for the Earthquak disaster prevension.**
-Planar indication of seismic intensity using surface ground amplification factor-

*Kenji Kanjo[1], Isao Takahashi[1], Yoshinori Shinohara[1], Rami Ibrahim[2] (1.Takamisawa cybernetics Co. Ltd, 2.Earthquake Research Institute, University of Tokyo)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SCG59-09] Improvements of the GEONET real-time analysis system (REGARD) for more reliable operation

*Kazuyuki Ohashi[1], Satoshi Abe[1], Yasuaki Kakiage[1], Satoshi Kawamoto[1], Hiroshi Munekane[1] (1.GSI of Japan)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SCG59-10] Development of “real-time” uncertainty evaluation algorithm for the estimated coseismic fault model using MCMC approach

*Keitaro Ohno[1], Yusaku Ohta[1] (1.Recerch Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SCG59-11] Drifting float measurement of pressure change by tsunami

*Masayuki Obayashi[1], Shingo Watada[2], Hiroko Sugioka[3] (1.Japan Agency for Marine-Earth Science and Technology, 2.Earthquake Research Institute, University of Tokyo, 3.Department of Planetology, Kobe University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SCG59-12] Development of the Real-time Forecasting for Meteorite Impact Tsunami

*Naotaka YAMAMOTO CHIKASADA[1], Toshitaka Baba[2], Tetsuharu Fuse[3] (1.NIED, 2.Tokushima University, 3.NICT)

[J] Oral | B (Biogeosciences) : B-PT Paleontology

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 201A 2F

[B-PT05] Biotic History

convener:Isao Motoyama(Department of Earth and Environmental Sciences, Yamagata University), Takao Ubukata(Division of Geology & Mineralogy, Department of Earth & Planetary Sciences, Kyoto University), Kazuyoshi Moriya(Department of Earth Sciences, Faculty of Education and Integrated Arts and Sciences, Waseda University), Chairperson:Isao Motoyama, Takao Ubukata, Kazuyoshi Moriya

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[BPT05-01] Cause of accelerated evolution of Earth's life; four-layered underground robust bio-communities played a critical role for the accelerated genome evolution as a response of mass extinction

*Shigenori Maruyama[1], Akio Kanai[2], Issay Narumi[3] (1.Earth-Life Science Institute, Tokyo Institute of Technology, 2.keio University, 3.Toyo University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[BPT05-02] Amino acid composition in molluscan shells and its relation to taxa and shell microstructure ~ Toward reconstruction of ancient trophic level using compound specific isotope analysis of amino acids ~

*Naoki Yugami[1], Akiko Goto[2], Robert Jenkins[2] (1.Graduate School of Natural Science & Technology. Kanazawa Univercity, 2.Institute of Science & Engineering . Kanazawa Univercity)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[BPT05-03] Relation of shell form to rocking motion in planispiral cephalopods

*Takao Ubukata[1] (1.Division of Geology & Mineralogy, Department of Earth & Planetary Sciences, Kyoto University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[BPT05-04] Paleoenvironment aross the Meddle Eocene Climatic Optimum

Hiroki Masui[1], *Kazuyoshi Moriya[1] (1.Department of Earth Sciences, Faculty of Education and Integrated Arts and Sciences, Waseda University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[BPT05-05] Reconstruction of the North Pacific subtropical gyre from the Middle to Late Miocene as inferred from radiolarian assemblages

*Shin-ichi Kamikuri[1], Isao Motoyama[2], Taiki Sawada[3] (1.Faculty of Education, Ibaraki University, 2.Faculty of Science, Yamagata University, 3.Japan Petroleum Exploration Co.,Ltd.)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[BPT05-06] Fossilization processes of Pliocene tree fossils from the Yasu River, Shiga Prefecture, Japan: Organic geochemical approach

*Jinya Nakamura[1], Ken Sawada[2], Masashi A Ikeda[1], Hideto Nakamura[3], Minoru Tsukagoshi[4] (1.Graduate School of Science, Hokkaido University, 2.Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University, 3.Faculty of Science, Osaka City Univerisity, 4.Osaka Museum of Natural History)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 102 1F

[M-IS09] dust

convener:Ishizuka Masahide(Kagawa University), Yasunori Kurosaki(Arid Land Research Center, Tottori University), Thomas Sekiyama(Meteorological Research Institute), Kana Nagashima(Japan Agency for Marine-Earth Science and Technology, Research and Development Center for Global Change), Chairperson:Tsuyoshi Sekiyama

1:55 PM - 2:15 PM JST | 4:55 AM - 5:15 AM UTC

[MIS09-01] Global modeling study of atmospheric supply of lithogenic and pyrogenic Fe-containing aerosols to the ocean

★Invited Papers

*Akinori Ito[1], Akitomo Yamamoto[1], Michio Watanabe[1], Maki Noguchi Aita[1], Ying Ye[2] (1.Japan Agency for Marine-Earth Science and Technology, 2.Alfred Wegener Institute for Polar and Marine Research)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MIS09-02] Regional variations in the elemental and mineral compositions of solid particles in rainwater in Iran

*Yoriko Yokoo[1], Chihiro Sakamoto[1], Atsushi Kitamura[1], Ryo Anma[2], Shiva Mehrabani[3] (1.Faculty of Science and Engineering, Doshisha University, 2.Tokushima University, 3.Kurdistan University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MIS09-03] Comparison of airborne microbial variations in air samples from Asian-dust source and arrival regions

*Teruya Maki[1], Tatsuyuki Fujita[1], Yuuma Mastuba[1], Yasunori Kurosaki[2], Masahide Ishizuka[3], Kei Kawai[4], Yasunobu Iwasaka[5] (1.College of Science and Engineering, Kanazawa University, 2.Arid Land Research Center, Tottori University, Tottori University, 3.Faculty of Engineering, Kagawa University, 4.Graduate School of Environmental Studies, Nagoya Universit, 5.Center for Environmental Creative Studies)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MIS09-04] Prediction of health effects of cross-border atmospheric pollutants using the Model of Aerosol Species in the Global Atmosphere (MASINGAR)

*Kazunari Onishi[1], Thomas Sekiyama[2], Yasunori Kurosaki[3], Masato Shinoda[4] (1.Graduate School of Public Health, Support Unit for Conducting Clinically Essential Studies, St.Luke's International University, 2.Meteorological Research Institute, 3.Arid Land Research Center, Tottori University, 4.Graduate School of Environmental Studies Nagoya University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MIS09-05] Dust layer captured by an inversion layer over the Gobi Desert on 29–30 April 2015

*Kei Kawai[1], Yuta Nishio[2], Kenji Kai[1,3], Jun Noda[4], Erdenebadrakh Munkhjargal[1,5], Masato Shinoda[1], Nobuo Sugimoto[6], Atsushi Shimizu[6], Enkhbaatar Davaanyam[5,7], Dashdondog Batdorj[8] (1.Nagoya University, 2.Japan Meteorological Agency, 3.Ibaraki University, 4.Rakuno Gakuen University, 5.Information and Research Institute of Meteorology, Hydrology and Environment, Mongolia, 6.National Institute for Environmental Studies, 7.University of Tsukuba, 8.National Agency for Meteorology and Environmental Monitoring, Mongolia)

[J] Oral | M (Multidisciplinary and Interdisciplinary) : M-IS Intersection

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 102 1F

[M-IS09] dust

convener:Ishizuka Masahide(Kagawa University), Yasunori Kurosaki(Arid Land Research Center, Tottori University), Thomas Sekiyama(Meteorological Research Institute), Kana Nagashima(Japan Agency for Marine-Earth Science and Technology, Research and Development Center for Global Change), Chairperson:Kana Nagashima

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MIS09-06] Favorable regions for dust haze transport revealed by ensemble simulations

*Kazunori Ogohara[1], Shogo Isoda[1] (1.School of Engineering, University of Shiga Prefecture)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MIS09-07] Measurement of adhesion force of individual aerosol particles by atomic force microscopy

*Kohei Ono[1], Yuki Mizushima[4], Ayumi Iwata[3], Furuya Masaki[1], Nozomu Tsuchiya[1], Atsushi Matsuki[2] (1.Graduate School of Natural Science and Technology, Kanazawa University, 2.Institute of Nature and Environmental Technology, Kanazawa University, 3.Faculty of Science and Technology, Keio University, 4.College of Science and Technology, Kanazawa University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MIS09-08] Occurrence of micro-meso scale dust storms and its relationship to the vegetation and topography in Mongolian grassland and Gobi Desert

*Kenji Kai[1], Kei Kawai[2], Teruya Maki[3], Jun Noda[4] (1.College of Education, Ibaraki University , 2.Nagoya University, 3.Kanazawa University, 4.Rakuno-Gakuen University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MIS09-09] A trial of elucidation for dust emission conditions in East Asia by synoptic data analyses and a field observation

*Yasunori Kurosaki[1], Jing Wu[1], Batjargal Buyantogtokh[1], Ishizuka Masahide[2], Batdelger Gantsetseg[3] (1.Tottori University, 2.Kagawa University, 3.IRIMHE, Mongolia)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MIS09-10] Monitoring and assessing aeolian desertification processes based on a dust erodibility index – A case study in the Xilingol grassland, China

*Jing Wu[1], Yasunori Kurosaki[1], Chunling Du[2], Tao Wang[3] (1. Arid Land Research Center, Tottori University, 2.School of Economics and Management, Inner Mongolia Agricultural University, 3.Northwest Institute of Eco-Environment and Resources, Chinese Academy of Sciences)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MIS09-11] Influences of land surface conditions and human activities on dust events in Inner Mongolian grasslands, China

*Mei Yong[1], Masato Shinoda[2], Nandintsetseg Banzragch[2] (1.Inner Mongolia normal university, 2.Nagoya university)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Convention Hall B 2F

[M-IS12] tsunami deposit

convener:Takashi Chiba(Faculty of Bioresource Sciences, Akita Prefectural University), Tetsuya Shinozaki(Center for Research in Isotopes and Environmental Dynamics (CRiED), University of Tsukuba), Daisuke Ishimura(Department of Geography, Tokyo Metropolitan University), Chairperson:Daisuke Ishimura(Department of Geography, Tokyo Metropolitan University)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[MIS12-01] Geological Record of Tsunamis and Storms Influenced by Relative Sea-Level Change, Southern Hidaka Coast, Hokkaido, Japan.

*RYO NAKANISHI[1], Satoshi Okamura[1,2], Tsumoru Sagayama[3], Yusuke Yokoyama[4], Yosuke Miyairi[4] (1.Hokkaido Edu. Univ., 2.Hokkaido Soil Res. Co-op., 3.HRCG, 4.Univ. Tokyo)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[MIS12-02] Before and after relationship between the seismic uplift and the large tsunami due to the seventeenth-century giant earthquake observed in the seismic barrier systems around the Kuril subduction zone

*Futoshi Nanayama[1,5], Kazuaki Watanabe[1], Keita Fukatsu[2], Takeshi Hasegawa[4], Kiyoyuki Shigeno[3], Masayuki Ishii[6], Kazuhito Ishiwata[7], Shigeto Inokuma[8] (1.Geological Survey of Japan, AIST, 2.Notsuke Peninsula Nature Center, 3.Meiji consultant Co., Ltd., 4.Ibaraki University, 5.CWMD, Kumamoto Univ., 6.Ishii Professional Engineer Office, 7.Betsukai municipal museum, 8.Nemuro City museum history and nature)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[MIS12-03] Coastal landform changes and Washover deposits due to high waves generated by anatmospheric low-pressure system in June 2016 at Horokayanto, Hokkaido, Japan

*Takashi Chiba[1], Yuichi Nishimura[2] (1.Faculty of Bioresource Sciences, Akita Prefectural University, 2.Graduate School of Science, Hokkaido University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[MIS12-04] Survey of tsunami deposits in Kunashiri Island: Results obtained in the 2015-2018 projects

*Yuichi Nishimura[1], Yasuhiro Takashimizu[2], Daisuke Sugawara[3], Takafumi Enya[4], Takashi Chiba[5], Ryo Nakanishi[6], Alexander Shishkin[7], Alexey Gorbunov[8], Victor Kaistrenko[8], Asuka Takahashi[9], Hiroki Muramatsu[10], Yasuyuki Kawazoe[11], Naofumi Takamatsu[11] (1.Graduate School of Science, Hokkaido University, 2.Institute of Humanities, Social Sciences and Education, Niigata University, 3.Museum of Natural and Environmental History, Shizuoka, 4.Hokkaido Museum, 5.Faculty of Bioresource Sciences, Akita Prefectural University, 6.Hokkaido Education University, 7.Shikotan Geophysical Observatory, 8.Institute of Marine Geology and Geophysics, Russian Academy of Sciences, 9.Japan Meteorological Agency, 10.Geospatial Information Authority of Japan, 11.Ministry of Education, Culture, Sports, Science and Technology)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[MIS12-05] Deposit-based assessment of tsunami size: example from Nankai-Trough earthquakes

*Daisuke Sugawara[1], Kentaro Imai[2], Shinsuke Okada[3], Takuto Maeda[4] (1.Museum of Natural and Environmental History, Shizuoka, 2.JAMSTEC, 3.Tohoku University, 4.Hirosaki University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[MIS12-06] Flume experiments for understanding variety of tsunami deposit

★Invited Papers

*Naofumi Yamaguchi[1] (1.Center for Water Environment Studies, Ibaraki University)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Convention Hall B 2F

[M-IS12] tsunami deposit

convener:Takashi Chiba(Faculty of Bioresource Sciences, Akita Prefectural University), Tetsuya Shinozaki(Center for Research in Isotopes and Environmental Dynamics (CRiED), University of Tsukuba), Daisuke Ishimura(Department of Geography, Tokyo Metropolitan University), Chairperson:Tetsuya Shinozaki(Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MIS12-07] **Inverse modeling of Tsunami deposit using Deep Learning Neural Network**

*Rimali Mitra[1], Hajime Naruse[1] (1.Kyoto University, Graduate School of Science)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MIS12-08] Numerical estimation of tsunami size using boulders deposited by the 2011 Tohoku-oki tsunami at Settai, Miyako city, Japan

*Tatsuya Takei[1,4], Kazuhisa Goto[2], Masaki Yamada[3] (1.Department of Earth Sciences, Graduate School of Science, Tohoku University, 2.International Research Institute of Disaster Science (IRIDeS), Tohoku University, 3.Earthquake Research Institute, University of Tokyo, 4.Department of Complexity Science and Engineering, Graduate School of Frontier Sciences, Tokyo University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MIS12-09] Constraint of the ages of historical tsunami deposits on the Ishinomaki Plain

*Hiroshi Tetsuka[1], Kazuhisa Goto[2], Takashi Ishizawa[1], Daisuke Sugawara[3], Yusuke Yokoyama[4], Yosuke Miyairi[4] (1.Department of Earth Science, Tohoku University, 2.International Research Institute of Disaster Science, Tohoku University, 3.Museum of Natural and Environmental History, Shizuoka, 4.Atmosphere and Ocean Research Institute, University of Tokyo)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MIS12-10] Non-destructive analyzes of sediments to discern tsunami-related mud cap and overlying muds to improve age determination of tsunami deposits

*Takashi Ishizawa[1], Kazuhisa Goto[2], Yusuke Yokoyama[3], Yosuke Miyairi[3] (1.Department of Earth Science, Tohoku University, 2.International Research Institute of Disaster Science, Tohoku University, 3.Atmosphere and Ocean Research Institute, The University of Tokyo)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MIS12-11] Sedimentological and paleontological studies of storm surge deposits in intertidal mud floor -case study of Ena Bay on Miura Peninsula, Central Japan.

*Akihisa Kitamura[1], yamamoto yuka[1], Takashi Toyofuku[2] (1.Institute of Geosciences, Faculty of Science, Shizuoka University, 2.Japan Agency for Marine-Earth Science and Technology (JAMSTEC))

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[MIS12-12] Shallow marine tsunami deposits and bioturbation

★Invited Papers

*Koji Seike[1] (1.Geological Survey of Japan, AIST)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[M-IS16] Dynamics of eruption cloud and cumulonimbus; modelling and observation

convener:Eiichi Sato(Meteorological Research Institute), Fukashi Maeno(Earthquake Research Institute, University of Tokyo), Takeshi Maesaka(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Eiichi Sato(Meteorological Research Institute)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[MIS16-01] **Observations of Volcanic Eruption Columns with Different Types of Weather Radars**

★Invited Papers

*Masayuki Maki[1], Takehiko KOBORI[1], Yura Kim[1], Yasushi Fujiyoshi[2], Eiichi Sato[3], Hidehiko Tokushima[4], Masato Iguchi[5] (1.Kagoshima University, 2.Hokkaido University, 3.Meteorological Research Institute, 4.Field Researchers Corporation, 5.Kyoto University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[MIS16-02] Observation of Eruption Plumes by X-Band MP radar and Lidar at Sakurajima and Kuchinoerabujima

*Haruhisa Nakamichi[1], Atsushi Shimizu[2], Makoto Shimomura[1], Magfira Syarifuddin[1], Masato Iguchi[1] (1.Sakurajima Volcano Research Center, Disaster Prevention Research Institute, Kyoto University, 2.National Institute for Environmental Studies)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[MIS16-03] 2018-2019 Kuchinoerabu-jima eruption plume/cloud echoes observed by JMA weather radar network

*Eiichi Sato[1], Keiichi Fukui[2], Toshiki Shimbori[1] (1.Meteorological Research Institute, 2.Japan Meteorological Agency)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[MIS16-04] Numerical Study on the Ejection Conditions of Ash Clouds during Recent Eruptions of Kuchinoerabujima Volcano

*Yasuhiro Ishimine[1], Teruki Oikawa[2], Nobuo Geshi[2] (1.Research and Education Center for Natural Hazards, Kagoshima University, 2.Geological Survey of Japan, AIST)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[MIS16-05] Image analysis of volcanic clouds during the 2011 Kirishima Shinmoedake eruption

*Takehiko KOBORI[1], Kisei KINOSHITA[1], Naoko IINO[2], Masayuki MAKI[1], Seiji FUKUSHIMA[1] (1.Kagoshima University, 2.Kumamoto University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[MIS16-06] Cloud Radar Network for Early Detection of Cumulonimbus Generation

*Takeshi Maesaka[1], Tadayasu Ohigashi[1], Koyuru Iwanami[1], Shin-Ichi Suzuki[1], Yukari Shusse[1], Namiko Sakurai[1] (1.National Research Institute for Earth Science and Disaster Resilience)

[J] Oral | M (Multidisciplinary and Interdisciplinary) : M-IS Intersection

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 304 3F

[M-IS19] Paleoclimatology and paleoceanography

convener:Yusuke Okazaki(Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University), Akira Oka(Atmosphere and Ocean Research Institute, The University of Tokyo), Michinobu Kuwae(Center for Marine Environmental Studies), Hitoshi Hasegawa(Faculty of Science and Technology, Kochi University), Chairperson:Hitoshi Hasegawa

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[MIS19-17] Paleotemperature and precipitation history (18.1–4.5 ka) in stalagmite bulk and clumped isotopes from Hiroshima, Japan

*Hirokazu Kato[1], Shota Amekawa[1], Akihiro Kano[1] (1.Department of Earth and Planetary Science, The University of Tokyo)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[MIS19-18] Terrestrial paleoclimate since 80 ka recorded in stable and clumped isotopes of two stalagmites obtained from the Pacific side of the Japanese islands

*Shota Amekawa[1], Hirokazu Kato[1], Akihiro Kano[1], Kenji Kashiwagi[2], Taiki Mori[3], Ryoko Senda[3], Chuan–Chou Shen[4] (1.Graduate School of Science, The University of Tokyo, 2.Graduate School of Science and Engineering for Research, University of Toyama, 3.Graduate School of Integrated Sciences for Global Society, Kyushu University, 4.Department of Geosciences, National Taiwan University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[MIS19-19] Seasonal changes in Li/Ca ratio and inferred phytoplankton abundance as analyzed by daily growth increments of *Pecten albicans* (Bivalvia)

*Kondo Yasuo[1], Hondo Shutaro, Hasegawa Hitoshi[1], Nshio Yoshiro[1], Hirota Takayoshi (1.National University Corporation Kochi University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[MIS19-20] Geological reconstruction of Antarctic Ice Sheet deglaciation on Soya Coast, East Antarctica since the Last Glacial Maximum

*Moto Kawamata[1], Yusuke Suganuma[2,1], Koichiro Doi[2,1], Takanobu Sawagaki[3], Akihisa Hattori[1] (1.Department of Polar Science, School of Multidisciplinary Science, SOKENDAI (The Graduate Unversity for Advanced Studies), 2.National Institute of Polar Research, 3.Hosei University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[MIS19-21] Os isotope record of the Quaternary seawater derived from pelagic sediment in the Lau Basin, western South Pacific Ocean, and its implications for global climate changes

*Yusuke Kuwahara[1], Kazutaka Yasukawa[1,2], Koichiro Fujinaga[2,3], Tatsuo Nozaki[4,3,5,2], Junichiro Ohta[2,6,3], Honami Sato[2,4], Jun-Ichi Kimura[6], Kentaro Nakamura[1], Yasuhiro Kato[3,1,2] (1.Department of Systems Innovation, School of Engineering, The University of Tokyo, 2.Ocean Resources Research Center for Next Generation, Chiba Institute of Technology, 3.Frontier Research Center for Energy and Resources, School of Engineering, The University of Tokyo, 4.Research and Development Center for Submarine Resources, Japan Agency for Marine-Earth Science and Technology , 5.Department of Planetology, Graduate School of Science, Kobe University, 6.Department of Solid Earth Geochemistry, Japan Agency for Marine-Earth Science and Technology)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[MIS19-22] Rapid glaciation and sea level changes during the Last Glacial Maximum and the deglaciation

*Yusuke Yokoyama[1], Tezer M Esat[9], William G Thompson[10], Alexandar L Thomas[11], Jody W Webster[2], Yosuke Miyairi[1], Chikako Sawada[1], Takahiro AZE[1], Hiroyuki Matsuzaki[1], Jun'ichi Okuno[3], Stewart Fallon[9], Juan-Carlos Braga[12], Marc Humblet[4], Yasufumi Iryu[5], Donald C Potts[13], Kazuhiko Fujita[6], Atsushi Suzuki[7], Hironobu Kan[8] (1.Atmosphere and Ocean Research Institute, University of Tokyo, 2.University of Sydney, Australia, 3.National Institute of Polar Research, 4.Nagoya University, 5.Tohoku University, 6.University of the Ryukyus, 7.The Geological Survey of Japan, AIST, 8.Kyushu University, 9.Research School of Earth Sciences, The Australian National University, Australia, 10.Woods Hole Oceanographic Institute, USA, 11.University of Edinburgh, UK, 12.Universidad de Granada, Spain, 13.University of California Santa Cruise, USA)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 304 3F

[M-IS19] Paleoclimatology and paleoceanography

convener:Yusuke Okazaki(Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University), Akira Oka(Atmosphere and Ocean Research Institute, The University of Tokyo), Michinobu Kuwae(Center for Marine Environmental Studies), Hitoshi Hasegawa(Faculty of Science and Technology, Kochi University), Chairperson:Yusuke Okazaki

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MIS19-23] Long-chain alkenediones found from marine sediments and their unsaturation ratios: key compounds to study the evolution of alkenone biosynthetic pathway?

*Satoshi Furota[1], Hideto Nakamura[2], Ken Sawada[3] (1.Department of Biogeochemistry, Japan Agency for Marine-Earth Science and Technology (JAMSTEC), 2.Faculty of Science, Osaka City University, 3.Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MIS19-24] **Geomorphic and pedogenic forcing on the distribution of organic matter from vegetation to soil- a concern for paleoenvironment studies**

*Biswajit Roy[1], Kanva Goyal[1], Prasanta Sanyal[1] (1.Indian Institute of Science Education Research Kolkata)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MIS19-25] Sea surface salinity of the Kuroshio Current along the Nansei Islands in the mid-Holocene inferred from fossil corals

*Kohki Sowa[1], Chuki Hongo[2], Kentaro Tanaka[3], Takuma Fujii[4], Saburo Sakai[1], Kosei E. Yamaguchi[6,5] (1.Japan Agency for Marine-Earth Science and Technology, 2.Ryukyu University, 3.The University of Tokyo , 4.Kagoshima University, 5.Toho University, 6.NASA Astrobiology Institute)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MIS19-26] An ocean-dynamic model for the periodic inflow of Tsushima Current in the early Holocene

*Atsuhiko Isobe[1] (1.Research Institute for Applied Mechanics, Kyushu University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MIS19-27] Centennial to millennial scale variability of the Aleutian Low and Westerly Jet during the Holocene

*Kana Nagashima[1], Naomi Harada[1] (1.Japan Agency for Marine-Earth Science and Technology, Research and Development Center for Global Change)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[MIS19-28] **Monsoon-related errors in paleotemperature estimation based on leaf margin analysis in central Japan**

*Yuqing Wang[1], Arata Momohara[1], Yongjiang Huang[2] (1.Graduate School of Horticulture, Chiba University, 2.Key Laboratory for Plant Diversity and Biogeography of East Asia, Kunming Institute of Botany, CAS)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 303 3F

[M-IS26] Arctic and Antarctic Science and Future Plan

convener:Yoshifumi Nogi(National Institute of Polar Research), Takuji Nakamura(National Institute of Polar Research), Atsuko Sugimoto(Arctic Research Center, Hokkaido University), Shin Sugiyama(Institute of Low Temperature Science, Hokkaido University), Chairperson:Tetsuo Sueyoshi(National Institute of Polar Research), Yoshifumi Nogi(National Institute of Polar Research)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MIS26-01] Antarctic Circumpolar Interdisciplinary Survey - ACIS

★Invited Papers

*Robin Elizabeth Bell[1], Kirsteen Tinto[1], Xiaojun Yuan[1] (1.Lamont Doherty Earth Observatory of Columbia University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MIS26-02] Proposal of Polar Science to Master Plan 2020

*Takuji Nakamura[1], Atsuko Sugimoto[2], Shin Sugiyama[2], Yoshifumi Nogi[1], Tetsuo Sueyoshi[1] (1.National Institute of Polar Research, 2.Hokkaido University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MIS26-03] Towards the understanding of mass balance variation of Arctic and Antarctic ice sheets

Teruo Aoki[1,2,4], Masashi Niwano[4], *Tetsuo Sueyoshi[2,3] (1.Okayama Univ., 2.National Institute of Polar Research, 3.Japan Agency for Marine-Earth Science and Technology, 4.Meteorological Research Institute)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MIS26-04] **Modelling Perspective for the Past and Future tipping points of ice-sheets and climate**

*Ayako Abe-Ouchi[1,2,3], Fuyuki SAITO[2], Takashi Obase[1], Ralf Greve[4], Sam Sherriff-Tadano[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.JAMSTEC, 3.NIPR, 4.Hokkaido University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MIS26-05] Prediction of sea level rise caused by ice sheet melt

*Takeshi Tamura[1], Junichi Okuno[1], Yusuke Suganuma[1], Tetsuo Sueyoshi[1], Yoshifumi Nogi[1], Takuji Nakamura[1] (1.NIPR National Institute of Polar Research)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MIS26-06] Future Research Plan in the Polar region

*Yoshifumi Nogi[1], Tetsuo Sueyoshi[1], Takuji Nakamura[1] (1.National Institute of Polar Research)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-AG Applied Geosciences

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A10 TOKYO BAY MAKUHARI HALL

[M-AG39] Marine-Earth Informatics

convener:Seiji Tsuboi(JAMSTEC, Center for Earth Information Science and Technology), Keiko Takahashi(Japan Agency for Marine and Earth Science and Technology), Masaki Kanao(National Institute of Polar Research), Daisuke Matsuoka(Japan Agency for Marine-Earth Science and Technology), Chairperson:Daisuke Matsuoka, Seiji Tsuboi

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MAG39-01] Future direction of Marine Earth Informatics

*Keiko Takahashi[1] (1.Japan Agency for Marine and Earth Science and Technology)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MAG39-02] Extraction method of weather informations from camera image using Deep Neural Network

*DAISUKE SUGIYAMA[1], RYO ONISHI[1], HIDENORI FUDEYASU[2] (1.Japan Agency for Marine-Earth Science and Technology, 2.Yokohama National University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MAG39-03] Automatic detection of weather front around Japan using deep convolutional neural network

*Daisuke Matsuoka[1,2], Shiori Sugimoto[1], Yujin Nakagawa[1], Fumiaki Araki[1], Shintaro Kawahara[1], Yosuke Onoue[4], Masaaki Iiyama[3], Koji Koyamada[3] (1.Japan Agency for Marine-Earth Science and Technology, 2.Japan Science and Technology Agency, 3.Nihon University, 4.Kyoto University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MAG39-04] Detection of multiple earthquakes by using theoretical seismograms as training dataset of machine learning

*Seiji Tsuboi[1], DAISUKE SUGIYAMA[1] (1.JAMSTEC, Center for Earth Information Science and Technology)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MAG39-05] Classification with imbalanced cloud data using deep convolutional neural network

*Daisuke Matsuoka[1,2], Masuo Nakano[1], Daisuke Sugiyama[1], Seiichi Uchida[3] (1.Japan Agency for Marine-Earth Science and Technology, 2.Japan Science and Technology Agency, 3.Kyushu University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MAG39-06] discussion

*Seiji Tsuboi[1] (1.JAMSTEC, Center for Earth Information Science and Technology)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-AG Applied Geosciences

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A10 TOKYO BAY MAKUHARI HALL

[M-AG39] Marine-Earth Informatics

convener:Seiji Tsuboi(JAMSTEC, Center for Earth Information Science and Technology), Keiko Takahashi(Japan Agency for Marine and Earth Science and Technology), Masaki Kanao(National Institute of Polar Research), Daisuke Matsuoka(Japan Agency for Marine-Earth Science and Technology), Chairperson:Seiji Tsuboi, Daisuke Matsuoka

3:30 PM - 3:50 PM JST | 6:30 AM - 6:50 AM UTC

[MAG39-07] Farmed fish management: integration of observation and simulation

★Invited Papers

*Haruka Nishikawa[1] (1.Japan Agency for Marine-Earth Science and Technology)

3:50 PM - 4:05 PM JST | 6:50 AM - 7:05 AM UTC

[MAG39-08] **Q-factor estimation for Greenland ice sheet using 3-D seismic waveform modeling**

*Genti Toyokuni[1], Hiroshi Takenaka[2], Masanao Komatsu[2], Ryota Takagi[1], Masaki Kanao[3], Seiji Tsuboi[4] (1.RCPEVE, Tohoku Univ., 2.Okayama Univ., 3.NIPR, 4.JAMSTEC)

4:05 PM - 4:20 PM JST | 7:05 AM - 7:20 AM UTC

[MAG39-09] CLCL: CAVELib Compatible Library for Head-mounted Displays

*Shintaro Kawahara[1] (1.Japan Agency for Marine-Earth Science and Technology)

4:20 PM - 4:35 PM JST | 7:20 AM - 7:35 AM UTC

[MAG39-10] Super-Resolution Simulation for Real-Time Prediction of Urban Micrometeorology

*Ryo Onishi[1], DAISUKE SUGIYAMA[1], Keigo Matsuda[1] (1.Japan Agency for Marine-Earth Science and Technology)

4:35 PM - 4:50 PM JST | 7:35 AM - 7:50 AM UTC

[MAG39-11] Proposal of adaptation measures for the anthropogenic heat release to improve the summer heat environment in a district

*Toru Sugiyama[1], Xiaoran Tong[2], Satoshi Yoshida[2], Satoru Sadohara[2] (1.Japan Agency for Marine-Earth Science and Technology Center for Earth Information Science and Technology, 2.Yokohama National Univercity Institute of Urban Innovation)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-TT Technology & Techniques

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 202 2F

[M-TT49] Brand-new scope of coupling geophysics being established by infrasound and associated waves

convener:Masa-yuki Yamamoto(Department of systems engineering, Kochi University of Technology), Mie Ichihara(Earthquake Research Institute, University of Tokyo), Nobuo Arai(Disaster Mitigation Research Center, Nagoya University), Chairperson:Masa-yuki Yamamoto(Kochi University of Technology), Hiroaki Saito(Kochi University of Technology)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MTT49-01] A two-step amplification mechanism of infrasound waves in the ocean-atmosphere system

★Invited Papers

*Hiroyuki Shinagawa[1] (1.National Institute of Information and Communications Technology)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MTT49-02] Propagation of infrasound generated by an explosive eruption of Mt. Shinmoedake on 10 March 2018

*Hiroaki Saito[1], Tetsuo Yamamoto[2], Masa-yuki Yamamoto[1] (1.School of Systems Engineering, Kochi University of Technology, 2.Hokkaido University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MTT49-03] Infrasound observations of atmospheric disturbances due to a sequence of 2018 explosive volcano eruptions in Japan.

*Mario Batubara[1], Masa-yuki Yamamoto[1], Saito Hiroaki[1] (1.Kochi University of Technology)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MTT49-04] Comparison of seismic waveforms observed by co-located seismometer and barometer installed indoors 2nd report

*Makiko Iwakuni[1], Nobuo Arai[2], Takayuki Otsu[1], Masashi Motohashi[1], Toyomi Sakamoto[1], Takanari Fujii[1], Ryohei Emura[1], Mami Nogami[1], Takahiko Murayama[1], Takuma Oi[3] (1.Japan Weather Association, 2.Disaster Mitigation Research Center, Nagoya University, 3.Toho Mercantile co., Ltd.)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MTT49-05] Ionospheric disturbances associated with typhoons and a tornado observed by HF doppler sounding

★Invited Papers

*Hiroyuki Nakata[1], Ryuichi Mashiko[1], Hiroyo Ohya[1], Toshiaki Takano[1], Keisuke Hosokawa[2], Ichiro Tomizawa[3], Hiromichi Nagao[4] (1.Graduate School of Science and Engineering, Chiba University, 2.Graduate School of Communication Engineering and Informatics, the University of Electro-Communications, 3.Center for Space Science and Radio Engineering, the University of Electro-Communications, 4.Earthquake Research Institute, the University of Tokyo.)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[MTT49-06] Two-year infrasound monitoring by using a prefectural-level sensor network in Kochi

*Masa-yuki Yamamoto[1] (1.Department of systems engineering, Kochi University of Technology)

[J] Oral | O (Public)：Public

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | IC 2F

[O-01] Exploring Buratamori - How to make science accessible

convener:Kazutaka Mannen(Hot Springs Research Institute of Kanagawa Prefecture), Takayuki Ogata(Disaster Prevention Research Center for Island Regions, University of the Ryukyus), Chairperson:Takayuki Ogata

Buratamori is a Saturday prime-time TV show of NHK (Japanese public broadcasting). Each episode features geoscience of a region including geography, geology, history and ecology, and local experts host a comedian named Tamori, who has a wide knowledge and a female announcer, who represents ordinary citizen. Such a style of the show has been popular among people in this decade and geoscience experts also highly regard the show. In this session, directors and previous hosts of the show describe its making process from each point of the view. Since the show needs to reach widely, bold simplification of complex scientific context is sometimes unavoidable, and this makes tension between the producers and experts. Through the session, we would like to discuss how the experts can make a simple but adequate explanation for geoscience issues to wide audience.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[O01-01] Lessons from Buratamori – An introduction to the session

★Invited Papers

*Kazutaka Mannen[1] (1.Hot Springs Research Institute of Kanagawa Prefecture)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[O01-02] **The history of Buratamori**

★Invited Papers

*Mikio Hayashi[1] (1.Japan Broadcasting Corporation)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[O01-03] My experience as a geoscientific guide for the NHK-TV program Buratamori

★Invited Papers

*Masato Koyama[1] (1.Shizuoka Univ.)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[O01-04] A Visualized History by Buratamori

★Invited Papers

*Noriko Matsuda[1] (1.Kyoto Prefectural University)

2:45 PM - 3:15 PM JST | 5:45 AM - 6:15 AM UTC

[O01-05] General discussion 1

*Takayuki Ogata[1] (1.Disaster Prevention Research Center for Island Regions, University of the Ryukyus)

Lessons from Buratamori –An introduction to the session

*Kazutaka Mannen[1]

1. Hot Springs Research Institute of Kanagawa Prefecture

Buratamori, airing from 7:30 pm on every Saturday, is a TV program broadcasted by NHK (Japanese public broadcast). In the program, local experts on geology, geography and history host a well-known TV talent Tamori and a female announcer and stroll a location to reveal its history and development with them. This program originally started in 2008 as a late-night program featuring areas in Tokyo and its surrounding and won the Geographical Society of Japan Award in 2011. Since 2015, the TV program has been aired in the prime time as the present and began to feature locations all over Japan. After this time, the TV program has won awards from National Geographical Information Authority of Japan, Geological Society of Japan and Japanese Geotechnical Society. As implied from presenters of the awards, the Buratamori is highly recognized by earth scientists in Japan. In this session, we would like to reveal how the program, which satisfies even professional earth scientists, was made from diversified stand points including the TV producer, experts who host the show and the audience. The followings are my schedule and personal impression when I hosted the show.

I have hosted three episodes entitled “Hakone” (aired on April 22, 2017), “Hakone Sekisho (checkpoint)” (May 13, 2017), and “Hot springs in Hakone” (October 6, 2018), as a local geological expert. The preparation process for the episodes aired in 2017 began in the late December 2016 with a phone call from NHK to my office. The crew spent all January in 2017 to gather diverse information of the featuring area. The outlines of the episodes were fixed in the mid-February and I was requested to be the host by the directors. In the early March, the directors presented scripts for the episodes and a rehearsal without Tamori and the announcer was held. The shooting was held in the mid-March. After the filming, I was requested to review the the scripts of narration and animation movies that would be used in the episodes to help audience to understand until 2 weeks before the airing.

The preparation process of the program, which includes intensive information gathering by the crew members and detailed discussion with the experts, were interesting and very impressive for me. The effort made by crew to keep the cast members relax during filming was also impressive.

Recently, chances for scintist to explain his/her research to the taxpayers are increasing. Such a scientist can learn from the TV crews who have several specific capabilities including 1) extensive information gathering, 2) insight that extracts reality of the featuring area, 3) story making to convey the gathered information to the public and 4) efforts to keep the filming location relax and delightful.

On the other hand, the TV program simplifies scientific context boldly and this bothers experts in the show deeply. In my talk, my experience of such simplification will be also presented and discussed briefly.

Keywords: Buratamori, TV program, outreach

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The history of Buratamori

*Mikio Hayashi[1]

1. Japan Broadcasting Corporation

Development of the program

TV program “Buratamori” (City walking with Tamori’s view) started as a pilot late-night program in December 2008. At that time, NHK (Japan Broadcasting Corporation) had a unit named Program Development. Four members of the unit including the author created the program. The first episode of “Buratamori” was “Harajyuku and Omote-sando”. Even it was aired in the late night, the episode, which deeply read city sceneries looked by many people every day, received a lot of feedbacks from the audience.

Starting as a regular program

After the airing of the pilot version, the program started as a regular series including 15 episodes (October 2009 to Marth 2010) aired from 10:00 pm, each of which was 43 minutes long. Tamori hosted a regular program on NHK for the first time in the 20 years since he had hosted a show named “Watching”. After that, Buratamori had continued as a regular program of a season from October to March for 3 years. During this period, corners named “Delusion CG”, which created imaginal ancient view of a town using computer graphic, and “Buratamo photo studio”, which showed photos taken by Tamori, were popular. In the presentation, the author will show the materials used in the development of the program.

Making of the first Buratamori

The early program looks same as the present style from the audience’s view but there are differences. Most of the experts appeared in the program were researcher of civil engineering especially urban planning, development and renovation. The most significant difference of the making is the walking time by the directors. At that time, “riddle” given to Tamori in the present program does not exist. However, Tamori found “mysterious scenery” in the show and the background of the scenery was explained in the program. Since it was very difficult to find “mysterious scenery” and “topic” in the well-known Tokyo, the directors of the program walked a lot to search them until their shoes literary wearing out.

Present

The present regular broadcast from 19:30 pm every Saturday started from April 2015 has been watched by many people. Buratamori features joy of walking in the city; however, tend to focus on geology a lot recently. The present version continued 5 years. We would like to focus on not only geology but also history, geography, customs and culture depending on episodes to be an attractive TV program that

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unlock the secret of city and history of the location.

Keywords: TAMORI, Buratamori

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My experience as a geoscientific guide for the NHK-TV program Buratamori

*Masato Koyama[1]

1. Shizuoka Univ.

Buratamori is a popular NHK-TV program featuring a famous talent, Mr. Tamori, who visits various localities and tries to solve subjects about origins of local natural and social sceneries, products, and sightseeing resources. Many geoscientists, biologists, archeologists, historians, and other natural and social scientists appear as guides and lead Mr. Tamori to a final answer for each round of the program. The involving scientists do not only play touring guides but also make much efforts as advisors for selection of localities and contents. They also propose experiments showing natural processes and check scenarios, narration, and explanatory CG animations etc. The author reports experience as one of the geoscientific guides for the Buratamori and considers about how to explain complicated scientific knowledge simply, comprehensibly, and enjoyably.

Keywords: Buratamori, guide, geoscientist, TV program, outreach

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A Visualized History by Buratamori

*Noriko Matsuda[1]

1. Kyoto Prefectural University

A lecturer is an urban and architectural historian researching history of development and origin of cities from geological, architectural, social and cultural point of view. Backgrounds and circumstances which have had brought the current situation of lands, our dwelling spaces or any other spaces and places related to our life, have being explored through out the research. Essential relationship between lands and human and its fundamental meanings are considered from these studies.
Buratamori sets a question about a location near around the beginning of the show. The question seems to be an easy question to answer so that television viewers and actors can casually imagine a plot of the show whether if he/she is for or against the question.
However, giving an appropriate answer to this “easy” question is actually not an easy thing even for experts. This is not just because the question was created by a production team referenced various fields of academic studies, but also it was intended to allow anyone who have heard the question would associate the phrase with the location. That is to say, the question is well-balanced between academic complexity and popular understandability.
After giving the question, a route of city/land walk is defined by the question. Several experts will describe the place in turn and turn about during the walk. This relay-style description gives plurality or gives diversified observation. Finding an answer to the question in such way is similar to method of field survey. In a field survey, an object that are huge scale things such as cities, mountains or civil engineered structures or a vast scale of time are physically comprehended through our hands, feet or eyes that are literally small human scaled subject.
Therefore, the route or the plot of the show tends to be something that is visually understandable due to its media, a TV show. For example, historical documents, pictures and photos or remains at the site will fulfill a role. On the other hand, things that are not clear at a glance or articles that are historically important requiring complicated description are omitted. Such topics will be examined in the symposium.

Keywords: Buratamori, outreach, urban history, TV program, guide

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General discussion 1

*Takayuki Ogata[1]

1. Disaster Prevention Research Center for Island Regions, University of the Ryukyus

We will accept questions from the floor and have some discussions based on the questions.

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[J] Oral | O (Public)：Public

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | IC 2F

[O-01] Exploring Buratamori - How to make science accessible

convener:Kazutaka Mannen(Hot Springs Research Institute of Kanagawa Prefecture), Takayuki Ogata(Disaster Prevention Research Center for Island Regions, University of the Ryukyus), Chairperson:Kazutaka Mannen(Hot Springs Research Institute of Kanagawa Prefecture)

Buratamori is a Saturday prime-time TV show of NHK (Japanese public broadcasting). Each episode features geoscience of a region including geography, geology, history and ecology, and local experts host a comedian named Tamori, who has a wide knowledge and a female announcer, who represents ordinary citizen. Such a style of the show has been popular among people in this decade and geoscience experts also highly regard the show. In this session, directors and previous hosts of the show describe its making process from each point of the view. Since the show needs to reach widely, bold simplification of complex scientific context is sometimes unavoidable, and this makes tension between the producers and experts. Through the session, we would like to discuss how the experts can make a simple but adequate explanation for geoscience issues to wide audience.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[O01-06] The role of experiment in NHK's entertainment / educational program "Buratamori"

★Invited Papers

*Shintaro Hayashi[1] (1.Akita University Graduate School of Education)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[O01-07] An attempt of field work for middle and high school students to comprehend an “area” in an integrated manner

★Invited Papers

*Takeshi Uemura[1], Shigeyuki Yokoi[2] (1.Osaka Prefectural Otemae Senior High School part-time course, 2.Kaijo Junior and Senior High School)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[O01-08] Desirable way of outreach activities in the Museum,learn by participating in the making process of "Buratamori".

★Invited Papers

*Inoue Motoko[1] (1.Saitama Museum of Natural History)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[O01-09] Methodology of Geoscientific Outreach of “Buratamori”

★Invited Papers

*Takayuki Ogata[1] (1.Disaster Prevention Research Center for Island Regions, University of the Ryukyus)

4:30 PM - 5:00 PM JST | 7:30 AM - 8:00 AM UTC

[O01-10] General discussion 2

*Kazutaka Mannen[1] (1.Hot Springs Research Institute of Kanagawa Prefecture)

The role of experiment in NHK's entertainment / educational program "Buratamori"

*Shintaro Hayashi[1]

1. Akita University Graduate School of Education

What is "Buratamori"?

"Buratamori" is an entertainment / educational program that has been broadcast from NHK(Nippon Hoso Kyokai;Japan Broadcasting Corporation) TV since 2008, and its viewer rating sometimes exceeds 15%. In the program, both Tamori and NHK 's beautiful female announcer are thinking about various questions while walking around various places and discovering various things. Also, the program progresses according to the question of the guiding person. Something related to geology and geography often appears in the question, and it exerts a great effect on outreach of earth science. I appeared as the main guide person of "# 81 Towada Lake and Oirase: Why did Towada Lake become a mysterious lake?".

Guide person's responsibility

The Guide person of "Buratamori" is responsible for the scientific accuracy of the program.In order to guarantee the accuracy of the program, the guidance person takes a lot of time to investigate. In the case of a speaker, I referred to more than 100 books and papers related to Towada Lake and Oirase gorge. In addition to this, the guiding person also attends work of the location and rehearsals, to ensure the accuracy of the program.

Experiment in "Buratamori"

In the program of "Buratamori", experiments are often used as a means of explanation. In the program of "# 81 Towada Lake and Oirase: Why did Towada Lake become a mysterious lake?", I explained how to make Lake Caldera using cocoa and condensed milk.

Requirements for experiment to be adopted in "Buratamori"?

Actually, there are many experiments which were not adopted in the program. One example is "water cooled fractured lava experiment". I suggested it twice in other programs of "Buratamori", but both were rejected.Probably the reason for rejecting "water-cooled fractured lava experiment" is 1) it is not visual, 2) the materials such as glass and water are not very impressive.

"Buratamori" and outreach

Outreach activities in the field of earth science are important in three points: 1) acquisition of research funding; 2: training of successors; 3: recognition by the general public (Kamada, 2004). For that reason, it is necessary for scientists to transmit the results obtained by earth science in an easy-to-understand manner.

There are two outreaching effects of "Buratamori" . Firstly, "Buratamori" has a high viewer rating and outreach to many citizens is possible. Secondly, educational effect on scientists is great. Scientists learn how to make the program easier from the director.

Becoming a guide person of "Buratamori" is to use a lot of energy and time. However, as there is a large outreach effect, researchers should respond positively.

Keywords: "Buratamori", experiment, outreach

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An attempt of field work for middle and high school students to comprehend an “area” in an integrated manner

*Takeshi Uemura[1], Shigeyuki Yokoi[2]

1. Osaka Prefectural Otemae Senior High School part-time course, 2. Kaijo Junior and Senior High School

In the school education, things in our daily life and society are subdivided into subjects to study. Specialized teachers teach in the classes of middle and high schools and students tend to attend a class passively. However, the real things are mixture of contents dealt in various subjects. To solve emerging problems in our society, we need an ability to cooperate perseveringly with people having various background.

Based on this perspective, the authors launched a course named “General Field Exercise” for students between third-year of middle school and second year of high school. Approximately 15 students voluntarily attended the course, which lasted for two years. In this course, we focused on an “area” as the study target. Participants who have various background explore the “area” to comprehend the “area” in an integrated manner. Teachers of various subjects including earth science, Japanese history, Japanese language and etc. in charge of the course tried to study with the students from their point of view. Before going out to the “area”, teachers and students had a discussion in the classroom to share targets to solve in the “area”. Based on the proposals and preferences of the students, we set “area” and made contents of the course. The first “area” set in the course was Shinagawa, where is adjacent of the school and the Shinagawa’s religious connection led us city of Fuchu where we had three excursions. During the summer break, we went Osaka to have a field excursion of three days and two nights.

In Osaka, we walked around the Uemachi Hills to watch its morphology and historical heritages and visited Shitenoji temple, which have a history longer than 1400 years. On the approach to the temple, the earth-science teacher explained the relationship with fault activity that uplifted the Uemachi Hills and a slope seen in west of the approach. After that, the teacher of Japanese history led students to watch historical building and a monument of Ansei Tokai Earthquake and tsunami (1854) in the temple. The monument was built by townspeople of the area to commemorate victims of the earthquake and tsunami. The students started to read epigraph on the monument and discuss on the content with teachers. A discussion on tsunami caused by the Ansei Earthquake was led by teachers of Japanese history and earth-science. After the visit to Shitenoji temple, someone proposed to walk and see other temples on the way down from the temple.

As shown in above, we eliminated barrier between subjects and the students realized that the things they were facing were mixture of history and morphology. The teachers gave general direction of the excursion; however, the teachers exchanged their roles with the students. The teachers and students both learned deeply and independently.

Keywords: field work, school education, area

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Desirable way of outreach activities in the Museum,learn by participating in the making process of "Buratamori".

*Inoue Motoko[1]

1. Saitama Museum of Natural History

To promote earth science,it's important to make the general public to feel familiar with earth science and see the fun of it .Promoting popular interest is one of the missions of Natural History Museum,but it is too difficult to satisfy all museum users who have various levels of geoscientific literacy.The stuff of TV show,"Buratamori”,gave me a clue to settle such problems.I learn 5 important viewpoint of outreach activities by participating in the making process of "Buratamori”.

1) We should understand the thinking process of the general public,who are not much interested in earth science.
2) We should summarize relevant information of various field (earth science,history,culture) in each local area,and associate it with the life of the general public.
3) We should focus more on familiar stories in the local area than theory to promote interest of the general public.
4) Simple and easy-to-understand explanation is more important than showing the accuracy of the study results.
5) It is important for us to show people that we enjoy learning earth science rather than showing our knowledge.

Keywords: Geoscientific literacy, Region, Interpreter

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Methodology of Geoscientific Outreach of “Buratamori”

*Takayuki Ogata[1]

1. Disaster Prevention Research Center for Island Regions, University of the Ryukyus

Buratamori produced by NHK contributes especially to geoscientific outreach and lifelong education for leaning on various geographical and geological topics. Such geoscientific topics related seamlessly with other contents on history, biology, agricultural and engineering sciences. Seamless geoscientific stories (geostories) are also produced in geoparks as a method for geoconservation, geotourism and geoscience education. Geostories require well-selected and arranged contents targeting historical, vertical and/or horizontal phenomena based primarily on many geoscientific evidences. Much many Japanese geoscientists also watch Buratamori because various topics are interpreted by many specialists on geography and geology. Geoscientists interest scientific evidences and interpretations on each specialties, and multidisciplinary and interdisciplinary relationships to other disciplines. Comprehensive and seamless stories of Buratamori enhance educational effects as a methodology for outreach and science communications, which are supported by geoscientific knowledges of many scientists, directors, producers and Mr. Tamori.

Keywords: Buratamori, outreach, geostory, lifelong education, geoscience, science communication

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General discussion 2

*Kazutaka Mannen[1]

1. Hot Springs Research Institute of Kanagawa Prefecture

We will discuss the way of outreach in geoscience.

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[J] Oral | O (Public)：Public

Sun. May 26, 2019 10:15 AM - 11:25 AM JST | Sun. May 26, 2019 1:15 AM - 2:25 AM UTC | IC 2F

[O-02] Recent Advances in Earth and Planetary Science

convener:Tatsuhiko Hara(International Institute of Seismology and Earthquake Engineering, Building Research Institute), Katsuyoshi Michibayashi(Department of Earth and Planetary Sciences, Nagoya University), Hajime Naruse(Department of Geology and Mineralogy, Graduate School of Science, Kyoto University), Yasuhito Sekine(Earth-Life Science Insitute, Tokyo Institute of Technology), Chairperson:Kou Yamada

This is an outreach session, in which invited speakers present their recent findings and developments in fields of earth and planetary sciences. This session has been presented as a public session since 2005. The JpGU Publicity and Outreach Committee members are conveners of this session.

10:15 AM - 10:50 AM JST | 1:15 AM - 1:50 AM UTC

[O02-01] The challenges of Asteroid Exploration Mission Hayabusa2 and its results up to now

★Invited Papers

*Makoto Yoshikawa[1] (1.Japan Aerospace Exploration Agency)

10:50 AM - 11:25 AM JST | 1:50 AM - 2:25 AM UTC

[O02-02] Earth's core revealed by ultrahigh-pressure experiments

★Invited Papers

*Kei Hirose[1,2] (1.Earth-Life Science Institute, Tokyo Institute of Technology, 2.Department of Earth and Planetary Science, The University of Tokyo)

The challenges of Asteroid Exploration Mission Hayabusa2 and its results up to now

*Makoto Yoshikawa[1]

1. Japan Aerospace Exploration Agency

As the follow-on mission of Hayabusa, the first asteroid sample return mission in the world, Hayabusa2 was launched in December 2014. While the main purpose of Hayabusa was demonstration of technology, the main purpose of Hayabusa2 is to do scientific researches. Particularly the important subject is to study water and organic matters that existed when the solar system was born. In addition to this, it is also an important purpose to establish more reliable technology for planet exploration based on the experience of Hayabusa, which had a lot of technological troubles.

After about three and half year space journey, Hayabusa2 arrived at Asteroid Ryugu in June 2018. At first, we observed Ryugu in detail by using remote sensing instruments on board, then we were successful to land small rovers and a lander on the surface of Ryugu. However, we postponed the touchdown to get the surface materials of Ryugu to February 2019 from October 2018 of the original plan. After the touchdown, we will carry out an experiment to make a small crater of the surface of Ryugu. Hayabusa2 will leave Ryugu at the end of 2019, and will return to the earth at the end of 2020.

The asteroid Ryugu, which has a shape of a spinning top and which is covered by a lot of boulders, is very interesting from the point of science. It is rather different from what we assume before the arrival.

In this presentation, we will talk about the challenges of Hayabusa2 based on Hayabusa and the scientific results up to now.

Keywords: Asteroid, Exploration, Solar system

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Earth's core revealed by ultrahigh-pressure experiments

*Kei Hirose[1,2]

1. Earth-Life Science Institute, Tokyo Institute of Technology, 2. Department of Earth and Planetary Science, The University of Tokyo

The interior of the Earth is under high pressure and high temperature. The condition at the center of the Earth is 364 gigapascals and about 5000 kelvins. Such extreme condition can be generated in a laser-heated diamond-anvil cell (DAC). Any materials existing inside our planet can be synthesized using this technique.

I will discuss the formation and evolution of the Earth’ s core on the basis of recent DAC experimental results. Our recent work has shown that the core composition has changed to a large extent since its formation by exsolving oxide and silicates. Such core-derived oxide and silicates may have caused “anomalies” presently observed in the deep mantle and core.

I will introduce the latest works on core formation and evolution as well as ultrahigh-pressure experimental techniques using a DAC.

Keywords: core, high-pressure, deep Earth

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[J] Oral | O (Public)：Public

Sun. May 26, 2019 11:30 AM - 12:15 PM JST | Sun. May 26, 2019 2:30 AM - 3:15 AM UTC | IC 2F

[O-03] Poster presentations by senior high school students

convener:Tatsuhiko Hara(International Institute of Seismology and Earthquake Engineering, Building Research Institute), Katsuyoshi Michibayashi(Department of Earth and Planetary Sciences, Nagoya University), Miwa Kuri(International Research Institute of Disaster Science, Tohoku University), Kou Yamada(Waseda University), Chairperson:Kou Yamada, Katsuyoshi Michibayashi, Hajime Naruse(Kyoto University), Keiko Konya, Miwa Kuri(東北大学災害科学国際研究所)

Senior high school students provide poster presentations on subjects in fields of earth and planetary sciences. This session provides an opportunity for senior high school students to give their presentations in the JpGU meeting and to have discussions with researchers. This session has been conducted as a public outreach session since 2006.

11:30 AM - 12:15 PM JST | 2:30 AM - 3:15 AM UTC

[O03-01] Poster presentations by senior high school students

[J] Oral | O (Public) | Public

[O-03] Poster presentations by senior high school students

convener:Tatsuhiko Hara(International Institute of Seismology and Earthquake Engineering, Building Research Institute), Katsuyoshi Michibayashi(Department of Earth and Planetary Sciences, Nagoya University), Miwa Kuri(International Research Institute of Disaster Science, Tohoku University), Kou Yamada(Waseda University), Chairperson:Kou Yamada, Katsuyoshi Michibayashi, Hajime Naruse(Kyoto University), Keiko Konya, Miwa Kuri(東北大学災害科学国際研究所)

Sun. May 26, 2019 11:30 AM - 12:15 PM IC (2F)

Senior high school students provide poster presentations on subjects in fields of earth and planetary sciences. This session provides an opportunity for senior high school students to give their presentations in the JpGU meeting and to have discussions with researchers. This session has been conducted as a public outreach session since 2006.

11:30 AM - 12:15 PM

[O03-01]Poster presentations by senior high school students

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[J] Oral | O (Public)：Public

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | 106 1F

[O-04] New earth and planetary science education created by hybrid community between society and JpGU

convener:Yasushi Fujiwara(Evening Classes; Integrated Course, Kanagawa Prefectual Mukainooka Technical High School), Hiroaki Akimoto(Faculty of Economics,Dokkyo University),
Chairperson:Yasushi Fujiwara(Evening Classes; Integrated Course, Kanagawa Prefectual Mukainooka Technical High School), Hiroaki AKIMOTO(Dokkyo University)

In 2017, the curriculum guidelines for elementary and junior high school were announced by the Ministry of Education, Culture, Sports, Science and Technology. In addition high school curriculum guidelines were announced in 2018.
 These guidelines show "What we learn for (goals and contents of subjects and courses)" and "How to learn (improvement of learning course)" in order to foster student qualities and abilities.
 They also highlight how to develop a curriculum which is open to society and share the common understanding of "fostering of student qualities and abilities".
 Furthermore, High School/University Articulation Reforms will be regarded as important to considering the contents of university education and the admissions so that the results at elementary and secondary education are carried over to university education, and academic ability is reliably fostered.
 Earth and planetary science education also needs to clarify "what we learn for" and respond to what society demands, proposing inquiry activities through observation and experiments in the learning process.
 This session aims to deepen understanding about expectations for new earth and planetary science education and issues to be solved by participants from various viewpoints, including teachers, researchers, students, and citizens.

1:45 PM - 2:15 PM JST | 4:45 AM - 5:15 AM UTC

[O04-01] In the next Course of Study, let's send information on world standard "geography / geography" from Japan to the world

★Invited Papers

*YOJI TAKIKAWA[1] (1.NPO Association of Science Curriculum Initiative NPO Galileo Science Workshop)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[O04-02] What a mantle scientist hopes geoscience education

★Invited Papers

*Natsue Abe[1] (1.R&D Center for Ocean Drilling Science Japan Agency for Marine-Earth Science and Technology)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[O04-03] New high-school compulsory subject “General Geography” and related cooperation of geographers and earth scientists for human resource development

★Invited Papers

*Takashi Oguchi[1] (1.Center for Spatial Information Science, The University of Tokyo)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[O04-04] Visualization of terrain by Red Relief Image Map(RRIM) and geoscience education

★Invited Papers

*Tatsuro Chiba[1] (1.Asia Air Survey Co., Ltd.)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

Discussion

In the next Course of Study, let's send information on world standard "geography / geography" from Japan to the world

*YOJI TAKIKAWA[1]

1. NPO Association of Science Curriculum Initiative NPO Galileo Science Workshop

Previously, at the science education research meeting, a high school geology teacher introduced that "photographs before and after the earthquake" taken in his area, "predicting the dangerous place" is used for his lessons . I learned that we can predict where danger is.
Another geological teacher went to see the principal who invited me to come to my high school and said he refused "I do not want to work for a dangerous school in such a lowland". It might seem like a strange teacher at the present time, but I think that [the crisis management of Japan with many earthquakes] was quite different if these knowledge became common sense of citizens. It is also understood from this that learning of "Earth science education - natural geography, geology, mineralogy, geophysics, oceanography, meteorology etc" is indispensable for earthquake, disaster prevention, environmental understanding. However, teachers of earth science are currently endangered species in Japan. In this situation I hear that it may be forced to withdraw from the forefront of geoscience education.

On the other hand, the New Course of Study guarantees importance on "subjective, interactive and deep learning (active / learning)", not only knowledge but also "student’ s inquire” is claimed to be valued . This direction is also common to "PISA test of OECD, National curriculum of the UK, Standard NGSS of science education of the USA, etc." In short, it is considered important to acquire the "motivation, method, and the living knowledge on which it is based" necessary for the child to continue learning throughout his life. For this reason, the Ministry of Education, Culture, Sports, Science and Technology is also changing the way "college entrance examinations are implemented", especially for high schools and universities to change the direction of learning from "knowledge injection type education".

In the era when "birthrate aging and declining birthrate" and "IT" are rapidly changing the society, we are approaching a milestone that we have to reveal "content and method of education" to foster children appropriate for the next era in a fairly rapid manner. In "Geography / geography education", it is necessary to reconsider the significance of "what to teach" again. And it is time to re-send "geography / geography education" from Japan to the world. I hope everyone will work in a meaningful direction.

Keywords: New Course of Study, Active learning, Inquiry activities, Reform of entrance exam from high school to university, STEM education, The era of "low birthrate and aging" and "IT"

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What a mantle scientist hopes geoscience education

*Natsue Abe[1]

1. R&D Center for Ocean Drilling Science Japan Agency for Marine-Earth Science and Technology

When asking what kind of images you have about the Earth's mantle, most people answer "molten magma". People are probably influenced by movies broadcasting on TV, novels such as "Journey to the center of the earth by Jules Verne" and "Japan Sinks by Sakyo Komatsu", or many movies (such as Center of the earth) are strongly influenced. In general, people seem to think as follows. Because there is a hot substance deep under the ground, the "mantle" under the crust is a melted magma, and thinking that the liquid that reached the surface with some meter will erupt as lava It seems to be. I heard a conversation in the Kanto region and was shocked. Since the aftershock of the Great East Japan Earthquake on March 11, 2011, the aftershocks occurred quite a lot, "the Japanese archipelago became loose and decided to sink into the melted" mantle = (magma, but this is wrong!) " There was a person who was threatened by the fear of sinking into the lava. We geoscientists know the Japanese archipelago will never sink into the mantle in that short time-scale and never disappear our life time. Just having this basic knowledge, we are not trapped such fear, and probably know better how to deal with natural disasters such as earthquakes than general people. I think we earth scientists need to act and prepare for natural disasters as a norm for the general public. In this presentation, I would like to talk about some examples cited from my lecture and outreach experience.

As a mantle petrologist who study mantle peridotite, I strongly expect "geoscience classes" in junior high and high school that students learn basic knowledge to be able to properly fear natural disasters and prepare for it. Not only the students who are currently taking "Basic Earth Sciences", but also students entering the Department of Science other than those who wish to enter the Department of Earth Sciences at least as living in Japan, I hope that you will learn the knowledge of Geoscience literacy as a compulsory subject in high school. Contents that are covered within the scope of the current high school "basic earth science" is sufficient, broadly "scientific literacy" is needed for thinking deeply and act properly when something happens.

Keywords: geoscience education, mantle

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New high-school compulsory subject “General Geography” and related cooperation of geographers and earth scientists for human resource development

*Takashi Oguchi[1]

1. Center for Spatial Information Science, The University of Tokyo

In Japanese senior high schools, a new subject “General Geography” will be compulsory from the 2022 fiscal year. Although this subject belongs to a section of social sciences under the official education system, it puts emphasis on some physical sides of geosciences such as natural hazards, global environmental problems, and applications of digital data using GIS. Therefore, the new subject will contribute to education and human resource development in not only geography but also broader geosciences. To facilitate this, geographers and geoscientists belonging to the Japan Geoscience Union as well as some committees and subcommittees of Science Council of Japan should cooperate, as is the case with a recently established SCJ subcommittee for high-school education in geosciences and geography.

Keywords: General Geography, Geosciences, High-school education, Science Council of Japan

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Visualization of terrain by Red Relief Image Map(RRIM) and geoscience education

*Tatsuro Chiba[1]

1. Asia Air Survey Co., Ltd.

1.Introduction

Three-dimensional understanding of terrain in geoscience education is fundamental and important. For that, the reading of contour lines is a big problem. The contour line shows the planar position of the line of intersection between the topography and the plane as a representation method of the terrain. By altering the altitude at equal intervals, it is visualized as a striped pattern. In principle, horizontal and vertical planes can't be visualized. It is possible to objectively express the topography without individual skill. It is possible to transform mesh data, which is a wonderful invention. This skill is indispensable in order to read topography such as topography map of the GSI.

2. Numerical terrain data and terrain representation

Digitization of terrain had gradually become advanced since the 1980s. The national land numerical information started at 250 m, 50 m, 10 m, 5m. On the other hand, the technology for visualizing this method has remained around the time of low data density, there is no change, and the problem that detailed data can't be fully expressed can also be raised. It was difficult to read all the data in the shadow map, the gradient map, the advanced gradation diagram, and the like. Shaded figures had problems such as irregularities reversed depending on the light source direction, and there was a problem that it was impossible to distinguish between steps and grooves.

3. Principle and advancedness of RRIM

Chiba invented RRIM triggered by the topography survey of the Aokigahara ocean in Mt. Fuji in 2002. This was to visualize detailed data of a 1 m mesh by aerial laser measurement and complex topography of the lava surface where the irregularities are distributed complicatedly and to capture a large topography. The expression that it is redder as steep slope, brighter as a ridge and darker as a valley has the feature that it can be understood immediately even by ordinary people who do not receive special training and education. In addition, this figure could be overlapped with conventional contour diagrams, overlapped with advanced steps, and the understanding of the topography was greatly promoted. In many cases, it is used in media such as BURATAMORI, and recently it has become possible to select it as one of the backgrounds in geological map NAVI and GSI map.

4. JPGU and RRIM

In Asia Air Survey, as a place to transmit the goodness of the red 3D map, I regarded the exhibition of JPGU as a very good opportunity and have held a booth exhibition every year. For the first time here, some high school students also saw the red stereoscopic maps as an opportunity to be interested in topography and geology. It also leads to a series of work with JAMSTEC based on the idea that the exhibition here can be applied to the ocean bottom topography, and its submarine topographical map is bringing the further effect of geoscience education. Also, analog model experiments that flow shampoo lava on the topographical model of red 3D map repeated every year was very effective for understanding the hazard map. I would like to continue exploring what I can do for geoscience education through the activities of JPGU.

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Keywords: RRIM, hazardmap, education of earth science

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[J] Oral | O (Public)：Public

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | 106 1F

[O-04] New earth and planetary science education created by hybrid community between society and JpGU

convener:Yasushi Fujiwara(Evening Classes; Integrated Course, Kanagawa Prefectual Mukainooka Technical High School), Hiroaki Akimoto(Faculty of Economics,Dokkyo University), Chairperson:Yasushi Fujiwara(Evening Classes; Integrated Course, Kanagawa Prefectual Mukainooka Technical High School), Hiroaki AKIMOTO(Dokkyo University)

In 2017, the curriculum guidelines for elementary and junior high school were announced by the Ministry of Education, Culture, Sports, Science and Technology. In addition high school curriculum guidelines were announced in 2018.
 These guidelines show "What we learn for (goals and contents of subjects and courses)" and "How to learn (improvement of learning course)" in order to foster student qualities and abilities.
 They also highlight how to develop a curriculum which is open to society and share the common understanding of "fostering of student qualities and abilities".
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 This session aims to deepen understanding about expectations for new earth and planetary science education and issues to be solved by participants from various viewpoints, including teachers, researchers, students, and citizens.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[O04-05] A lesson plan using Tsunami to cultivate the ability to think critically about a subject based on the data given in New government curriculum guidelines for "Basic Earth Science"

★Invited Papers

*Kodama Hidefumi[1] (1.Chiba Prefectural Matudokokusai High School)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[O04-06] The planning of “Integrated Geography” and its aimed competency

★Invited Papers

*Yasutaka Kogawa[1] (1.Okayama Prefectural Tsuyama High School)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[O04-07] Earth and planetary science education considered by the current student

★Invited Papers

*Hideto Otsuka[1] (1.Geology Course, Department of Science, Faculty of Science, Shinshu University, National University Corporation)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[O04-08] Invitation to Geography —Relationship Between Geography and Intellectual Curiosity in Daily Life−

★Invited Papers

*Takuya Miyao[1] (1.Master Program in Education, University of Tsukuba)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[O04-09] Let's build a bridge between "Rika" and society with new geography and geology education in class

★Invited Papers

*Naoki Hosaka[1] (1.science writer)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

Discussion

A lesson plan using Tsunami to cultivate the ability to think critically about a subject based on the data given in New government curriculum guidelines for "Basic Earth Science"

*Kodama Hidefumi[1]

1. Chiba Prefectural Matudokokusai High School

New government curriculum guidelines for "Basic Earth Science" show cultivating the ability to think scientifically based on the data, in addition to observation, experiments.

I will compare New "Basic Earth Science" for current one and present a lesson plan using Tsunami for cultivating the ability to think scientifically.

Keywords: New government curriculum guidelines, Tsunami

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The planning of “Integrated Geography” and its aimed competency

*Yasutaka Kogawa[1]

1. Okayama Prefectural Tsuyama High School

The next curriculum guidelines were announced in March 2018, and “Integrated Geography” of required subject is provided as the new subject of geography for “sustainable society”. On International Charter on Geographic Education, five main concepts are “Location and Distribution”, “Place”, ”People-Environment Relationships”, ”Spatial Interaction”, ”Region”. These concepts are one of the guideline on constitution of geographical curriculum, and through International Geography Olympiad, International standard such as thought and skill which is cultivated in geographical education is indicated to high school students in all over the world.
To the implementation of “Integrated Geography”, what we are going to consider when we plan the class. As the point of view, based on the test of International Geography Olympiad and the present condition of the geographical perspective and thinking skill of student in Japan, this presentation introduce The planning of “Integrated Geography” and its aimed competency.

Keywords: integrated geography, Education for Sustainable Development, International Geography Olympiad

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Earth and planetary science education considered by the current student

*Hideto Otsuka[1]

1. Geology Course, Department of Science, Faculty of Science, Shinshu University, National University Corporation

It is necessary that Earth science and geography education for elementary and high school arranges the opportunity to touch the real things. In elementary school, there are many classes to touch the real things, but in high school, we don't have enough time to explain with them. I think that education with using the real thing, understanding of the learning purpose of the student, and knowledge of teacher to answer student's questions.
At first, the earth and planetary science needs to use the knowledge not only sciense but also various information. The students are good at considering and discussion with the real things, but it is difficult to understand conceptually field. So, we should present the real things to the students.
Secondly, it is necessary to understand a learning purpose so that a student is interested. The students like to study outdoor, and understand that studying the earth science contribute to thier lives, such as disaster prevention.
Thirdly, it is important to have the ability that teachers assist for the students to practice deep learning. It is necessary that teachers answer their questions, and lead them to understand.
From these, I think that we should teach earth and planet science practically and more clearly. It is improvement of the individual ability of the teacher to be important above all. Even if it is difficult to become the expert of all fields of earth science, the geography, it is important to deepen the knowledge. It is good for an opportunity attracting the interest of the student to teach the state-of-the-art study and common sense. I hope that practically and developmental earth and planetary science education become popular in the future.

Keywords: earth and planetary science education

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Invitation to Geography —Relationship Between Geography and Intellectual Curiosity in Daily Life–

*Takuya Miyao[1]

1. Master Program in Education, University of Tsukuba

I received geography education in school, learned geography at university, and now I’ m studying geography education in graduate school. In such a position, I’ d like to mention the abilities and various perspectives obtained from that looking back on myself that has been studying geography. Specific details are as follows.

Why Am I fascinated to Geography?

I’ ve been faced to the subject of geography, so what is the trigger that I was interested in geography? I’ d like to mention about the opportunity that I was involved in geography through reconsidering myself.

Relations Between Everyday Life and the Viewpoint That Can Get by Learning Geography, Application to Geography

Academic geography is close to our everyday life. It is because geography is a discipline that deal with an actual proof, and especially, the contents we learn from junior high school or high school have many things applying to information and experience we see in our daily life. So, what is the competency that acquired from learning geography? The typical one is “geographic viewpoint and way of thinking.” Then, if we acquire that competency, what are the benefits in daily life? I hope to mention based on my experience and the idea of graduate students who have been on the same situation.
On the other hand, the core point of view of the new geography course in Japanese high school, such as “GIS,” “international Understanding,” “disaster prevention,” there is no doubt that these contents are related to our living area when thinking on the micro scale. For students to learn geography actively, it may be necessary to incorporate contents that make use of students’ knowledge and experiences into the introduction of lessons. I suppose that this is the same in earth science.

About Learning Geography at University and Graduate School

In this part, I would like to mention about two things. One is about university education. It is often said that “geography is memorized subject,” but I strongly feel that was the lecture I took in a university. In teaching subjects, it is desirable to have opportunities for teachers and students to exchange opinions on the contents and methods of classes making full use of the characteristics of geography.
The other is about university and graduate school education. There are few opportunities for learning collaborated in geography, history and civics. It is necessary to exchange opinions among these subjects because these are not independent subjects, and there are many parts that work mutually.

Keywords: Geography Education , Geographic View and Way of Thinking, Intellectual Curiosity

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Let's build a bridge between "Rika" and society with new geography and geology education in class

*Naoki Hosaka[1]

1. science writer

Science does not seem to work well when it comes to the consensus formation of modern society, such as global warming. It can be due to the lack of reality of science, although it closely related to the social agenda. New geography and geology education should be a bridge between science and society.

Keywords: science, society, global

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[J] Oral | O (Public)：Public

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | 101 1F

[O-05] English improvement tips for Japanese scientists

convener:Chisato Yoshikawa(Japan Agency for Marine-Earth Science and Technology), Wonsuh Song(Waseda University), Rumi Ohgaito(Japan Agency for Marine-Earth Science and Technology), Chairperson:Chisato Yoshikawa(JAMSTEC), Wonsuh Song, RUMI OGAITO(JAMSTEC)

"Presentation in English" is inevitable skill not only for researchers but also for business people or students. In this session, we invite a native English-speaking researcher and a researcher of linguistic education. We learn misleading or unnatural expressions that Japanese tend to do in presentations in English. A mini-workshop is also planned in the session. In this workshop, the lecturers give advises for short presentations given by several Japanese. Why don't you join us to have practical learning to improve your presentation skill?

10:45 AM - 11:05 AM JST | 1:45 AM - 2:05 AM UTC

[O05-01] Giving a successful presentation in English: Mission Possible!

★Invited Papers

*Joel Laurier[1] (1.University of Tsukuba)

11:05 AM - 11:25 AM JST | 2:05 AM - 2:25 AM UTC

[O05-02] How to deliver good presentations in a foreign language

★Invited Papers

*S. Lan Smith[1] (1.Marine Ecosystem Dynamics Research Group, Research Centre for Global Change, Japan Agency for Marine-Earth Science and Technology)

11:25 AM - 12:15 PM JST | 2:25 AM - 3:15 AM UTC

Discussion

Giving a successful presentation in English: Mission Possible!

*Joel Laurier[1]

1. University of Tsukuba

As with all skills, delivering a successful presentation requires painstaking effort. For people presenting in their second (or third) language, the task is even more daunting because it requires detailed attention to each spoken word. This presentation aims to help presenters of all levels, from the beginner to the seasoned expert, deliver easy to understand and effective public speeches. We will first look at common mistakes made in delivering oral presentations, then look at proposed ways to prepare and deliver quality speeches. A special emphasis will be placed on effective techniques to use in English presentations given by non-native presenters. Attendees will learn how to use body language, effective visuals, and story telling to deliver quality presentations.

Keywords: presentation skills, English speech



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How to deliver good presentations in a foreign language

*S. Lan Smith[1]

1. Marine Ecosystem Dynamics Research Group, Research Centre for Global Change, Japan Agency for Marine-Earth Science and Technology

Presenting in a foreign language, for example at international scientific meetings such as JpGU, can be an intimidating challenge. This challenge includes not only communicating one’ s own ideas clearly, but also understanding and responding to critical questions, typically within only a few minutes. We researchers can all benefit from continually developing the skills to present in an engaging way that makes a good impression on the audience. To this end, I will share my thoughts based on my experiences as a native English speaker who has worked as a researcher in Japan for 20 years. I have presented results in Japanese at many seminars, conferences, hearings at funding agencies, and job interviews. Of course, no native Japanese would ever mistake me for a native speaker, as will be obvious to all attendees! But still, I have found ways to communicate effectively and have even become nearly as comfortable presenting in Japanese as in my native English. My techniques include: 1) use simple wording, clear statements, and slides that are not too complicated, 2) practice each presentation at least three times, cut out the unnecessary, and get comfortable with the flow, and 3) engage actively with questioners and ask them to clarify their questions if necessary. Accept the challenge, build up your presentation skills, and expand the possibilities for your own career!

Keywords: English, communication, career development, international, skills

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[J] Oral | O (Public)：Public

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | 103 1F

[O-06] How to cope with intensifyng storm and flood disasters

convener:Jun Matsumoto(Deaprtment of Geography, Tokyo Metropolitan University), Yukihiro Takahashi(Department of Cosmosciences, Graduate School of Science, Hokkaido University), Akira Wada(Tokyo Institute of Technology), Chairperson:Jun Matsumoto(Tokyo Metropolitan University)

In the year 2018, we experienced severe rainfalls in July and severe typhoons in September in West Japan, which impressed us that severe storm and flood disasters have been intensifying. Will such severe disasters intensify in future? We will discuss how to cope with intensifying storm and flood disasters. All the oral presentations are invited talks by the specialists in the Japan Geoscience Union (JpGU), and the Japan Academic Network for Disaster Reduction (JANET-DR) which was established in 2016. We will also exhibit poster presentations of various research activities in JpGU and JANET-DR.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[O06-01] Extreme rainfall and heat wave over Japan in 2018 summer: A series of extreme events and underlying global warming

★Invited Papers

*Hisashi Nakamura[1] (1.Research Center for Advanced Science and Technology, University of Tokyo)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[O06-02] **Influence of meteorological disasters on marine ecosystem**

★Invited Papers

*Yu Umezawa[1,2] (1.Tokyo University of Agriculture and Technology, 2.Study Group on Marine Environmental Problems, the Oceanographic Society of Japan)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[O06-03] Understanding of geomorphic condition indicating the flooding disaster and hazard mapping

★Invited Papers

*Yohta KUMAKI[1] (1.Senshu University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[O06-04] A role of free satellite remote sensing data as a case study of heavy rain disaster in July 2018

★Invited Papers

*Yuji Sakuno[1] (1.Graduate School of Engineering, Hiroshima University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[O06-05] State of the Crisis Mapping for heavy rain in west of Japan, 2018.

★Invited Papers

*Taichi Furuhashi[1] (1.Aoyama Gakuin University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[O06-06] A Study on Spatial and Temporal Resolution of Evacunation Infomation for Effective Evacuation Behavior

★Invited Papers

*Michinori Hatayama[1] (1.Disaster Prevention Research Institute, Kyoto University)

Extreme rainfall and heat wave over Japan in 2018 summer: A series of extreme events and underlying global warming

*Hisashi Nakamura[1]

1. Research Center for Advanced Science and Technology, University of Tokyo

In early July extreme rainfall occurred particularly over western Japan and the Tokai region, named “the Heavy Rain Event of July 2018”, which caused widespread havoc. It was followed by heat wave that persisted over most of Japan in setting the highest temperature on record in late July.
The rain event can be attributed to two extremely moist airflows from the Tropics confluent persistently into western Japan in addition to large-scale ascent along the stationary Baiu front. The heat wave is attributable to the enhanced surface North Pacific Subtropical High with a prominent barotropic anticyclonic anomaly just north of western Japan. The consecutive occurrence of these extreme events was related to persistent meandering of the upper-level subtropical jet, indicative of remote influence from the upstream. The heat wave can also be influenced by enhanced convective activity under the above-normal warmness over the tropical North Pacific. The global warming can influence not only the heat wave but also the rain event, as suggested from long-term increasing trends observed over Japan in intensity of extreme precipitation and water vapor amount. Another contribution was possible from anomalous warmth over the midlatitude Northern Hemisphere observed since March 2018.

Keywords: heavy rainfall event over western Japan in July 2018, heat wave over Japan, extreme climate events, jetstream meanders, global warming

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Influence of meteorological disasters on marine ecosystem

*Yu Umezawa[1,2]

1. Tokyo University of Agriculture and Technology, 2. Study Group on Marine Environmental Problems, the Oceanographic Society of Japan

Since the establishment in 1973, the Study Group on Marine Environmental Problems, the Oceanographic Society of Japan, has been organizing a night sessions and symposiums on marine environmental problems, and summarizing recommendations based on scientific knowledge.

In recent years, with the global warming, an increase in meteorological disasters such as typhoon, localized torrential rain and flood damages has been greatly affecting marine ecosystems, especially in coastal waters. However, our group has not done any efforts to consider weather disasters as one risk of marine environmental problems. In this presentation, I will report on previous studies on the effects of weather disasters on marine ecosystem and hope that this will be utilized in future collaborative research.

Keywords: coastal areas, marginal seas, climate change

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Understanding of geomorphic condition indicating the flooding disaster and hazard mapping

*Yohta KUMAKI[1]

1. Senshu University

It is important for the general public to know the place where the natural disaster risk is high. Some geomorphic features are strongly relating to flood or debris flow and useful for understanding the risk. For example, alluvial cone is a highly possible place of debris flow. Geomorphic features have been formed by repetitive phenomena that cause rapid landform changes, i.e. natural disasters. Therefore, it is useful for disaster estimation to know the geomorphic features. The geomorphic survey can be done everywhere at low cost using topographic maps, digital elevation models and air-photos.
The geomorphic condition has been basic information of hazard mapping. Hazard maps, however, show very much simplified information. It is desirable that people can judge the disaster risk by themselves. For it, some kinds of geomorphological maps are available in big plains in Japan.

Keywords: disaster risk, debris flow, landform change, geomorphological map

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A role of free satellite remote sensing data as a case study of heavy rain disaster in July 2018

*Yuji Sakuno[1]

1. Graduate School of Engineering, Hiroshima University

A heavy rain disaster occurred mainly in western Japan In July 2018. Immediately after the disaster, various types of aerial photographs and satellite remote sensing (RS) images were taken. In this presentation, I will introduce ground surface analysis using optical and synthetic aperture radar (SAR) in land and inland water around Hiroshima prefecture and their data roles which can be obtained free of charge, especially. It is useful to show the state of landslides and river sediment accumulation clearly by making difference image before and after the disaster using satellite optical sensors data such as LANDSAT-8 and Sentinel-2 with 10 to 30 m resolutions. However since such optical sensors are influenced by the cloud, it is not suitable for rapid damage estimation. Therefore, the difference image analysis similar to the optical sensor using SAR data such as Sentinel-1 was conducted. By this work, in particular, the flooded area was quickly extracted. In the future, we will make these tasks manual, and if any satellite data is downloaded, anyone will make software that can do the same analysis quickly. By regularly conducting data processing courses using such manual and software on local administrative agencies and consultants in construction, we would like to aim at early utilization of RS data in the event of frequent disasters.

Keywords: satellite, flood, SAR

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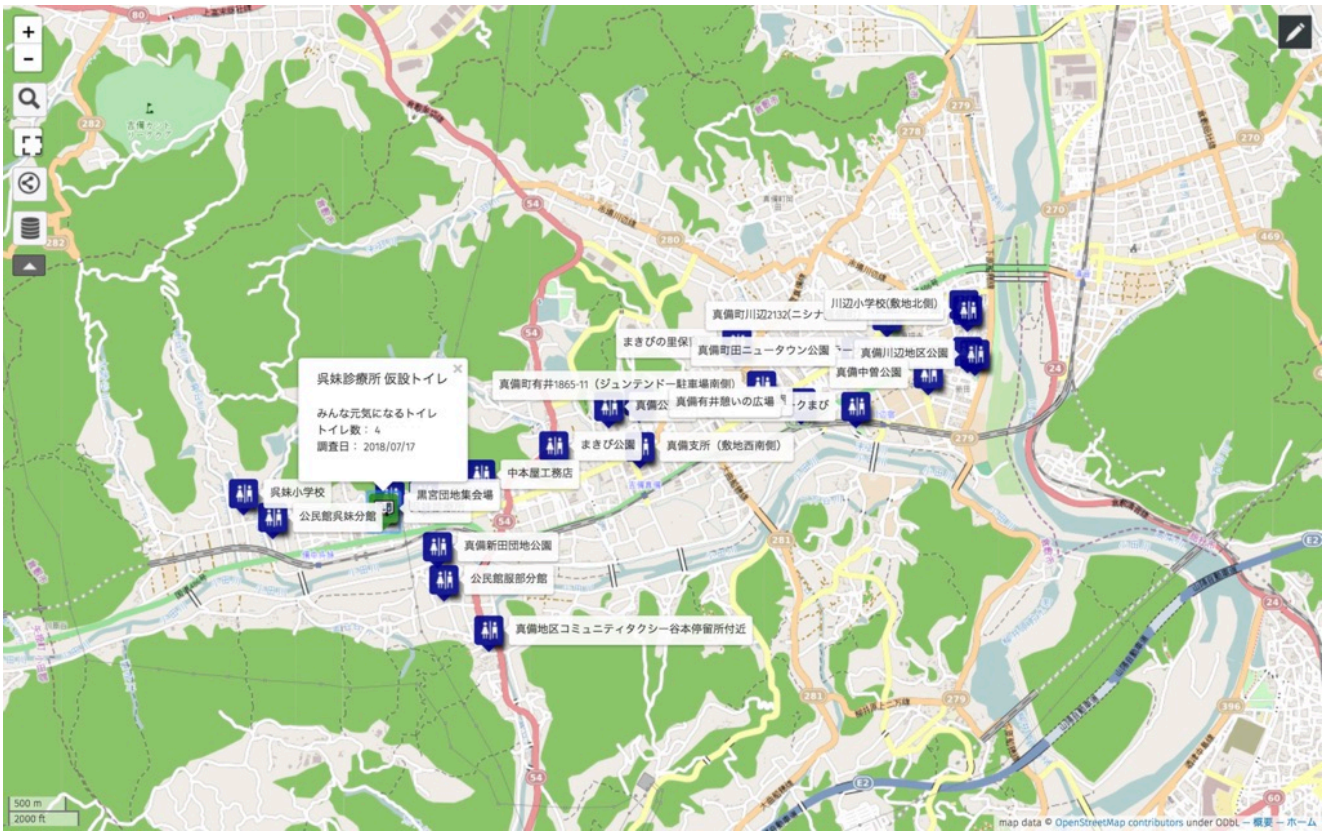
State of the Crisis Mapping for heavy rain in west of Japan, 2018.

*Taichi Furuhashi[1]

1. Aoyama Gakuin University

In early July 2018, heavy rain disasters happend in West part of Japan, floods and landslides occurred in many areas, including Mabi-cho in Kurashiki-shi, Okayama Prefecture. We worked with students on crisis mapping activities to implement maps of disaster affected areas as Volunteered Geographic Information (VGI). Specifically, navigation guide maps, evacuation centers / temporary toilets locations etc. were published on the map. In this session, we will report on current issues toward generalization of crisis mapping approach and future.

Keywords: GIS, VGI, map



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A Study on Spatial and Temporal Resolution of Evacunation Infomation for Effective Evacuation Behavior

*Michinori Hatayama[1]

1. Disaster Prevention Research Institute, Kyoto University

1. Introduction

In recent years, heavy rains and typhoons that have never been experienced in the past have attacked Japan, such as Northern Kyushu District Heavy Rain in 2017 and Heavy rain in July, 2018, due to the effects of climate change, leaving large damages in various places. In natural phenomena never experienced in the past, actions that protect lives, in other words, appropriate evacuation are required. Evacuation information that triggers evacuation is important, but in some cases, because it will create residents who don’ t take initiative for their evacuation, various discussions have been made on when and how to use and how to utilize evacuation information. In the case of the Izu Oshima Sediment disaster that occurred due to heavy rain accompanying Typhoon Wipha in 2013, the evacuation recommendation was not issued, and in Hiroshima landslide disaster caused by the Heavy Rain in August, 2014, the delay of the evacuation information was pointed out. Following these issues, the "Guidelines on evacuation advisory" was revised in the year of 2017. However, there remains room for discussion as to whether these information are linked to evacuation behaviors. In this paper, we discuss these issues.

2. Evacuation Information and Expected Behavior

In the "Guidelines on evacuation advisory", it is recommended to prepare criteria according to local circumstances about evacuation preparation, evacuation recommendation, and evacuation order from the view points of receivers. Evacuation actions were defined as follows;

(1) evacuation to the "urgent evacuation places" which are designated by administration,

(2) evacuation to the "safe place nearby", and

(3) movement to more secure room inside the building.

3. Temporal Resolution of Evacuation Information

In floods caused by heavy rain and sediment-related disasters, evacuation information will be announced in conjunction with time prediction of rainfall. In recent years, the occurrence of disasters is often expected to be late at night, but even if disaster information is announced at midnight, in many cases it cannot lead to evacuation behavior. Considering this, evacuation is proceeding from the time zone where evacuation behavior can be taken, but evacuation information in the absence of sense of crisis often leads to evacuation behavior.

4. Spatial Resolution of Evacuation Information

Evacuation information is generally presented to certain areas rather than to individual units. This spatial resolution does not have unified standards, but it varies from local governments. When the area is large,

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there are many places where high risk and low risk are mixed within the area, and many residents judge that it is not necessary to take evacuation action. However, it is difficult for the municipalities that do not allocate adequate personnel to respond to disasters, it is difficult to narrow down the areas further and it is difficult to judge whether evacuation should be made for each door.

5. Conclusion

Residents cannot be judged of evacuation behavior by evacuation information unless they know its time resolution and spatial resolution. In order to properly receive these information and to take appropriate action, it is necessary for residents to raise their awareness. In order to realize this, it is required not only to prepare administrative policies but also to arrange arrangements in the region and home.

Keywords: disaster information, evacuation behavior

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[J] Oral | O (Public)：Public

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | 103 1F

[O-06] How to cope with intensifyng storm and flood disasters

convener:Jun Matsumoto(Deaprtment of Geography, Tokyo Metropolitan University), Yukihiro Takahashi(Department of Cosmosciences, Graduate School of Science, Hokkaido University), Akira Wada(Tokyo Institute of Technology), Chairperson:Akira Wada(Tokyo Institute of Technology), Yukihiro Takahashi(Hokkaido University)

In the year 2018, we experienced severe rainfalls in July and severe typhoons in September in West Japan, which impressed us that severe storm and flood disasters have been intensifying. Will such severe disasters intensify in future? We will discuss how to cope with intensifying storm and flood disasters. All the oral presentations are invited talks by the specialists in the Japan Geoscience Union (JpGU), and the Japan Academic Network for Disaster Reduction (JANET-DR) which was established in 2016. We will also exhibit poster presentations of various research activities in JpGU and JANET-DR.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[O06-07] Multi-layered Countermeasures against Widespread Devastating Flood Disasters

★Invited Papers

*Koike Toshio[1] (1.International Centre for Water Hazard and Risk Management)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[O06-08] Technologies and wisdom in housings and buildings for protecting our lives from river floods

★Invited Papers

*Kazuo Tamura[1] (1.Seismic Design Laboratory)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[O06-09] State and Challenges of Disaster Waste Management - Lessons from Recent Disasters –

★Invited Papers

*Yuichi Moriguchi[1], Masahiro Osako[2] (1.Graduate School of Engineering, The University of Tokyo, 2.Center for Material Cycles and Wasre Management Research, National Institute for Environmental Studies)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[O06-10] Evacuation Planning for School Children and Community Residents

★Invited Papers

*Takeshi Sato[1], Yoshiaki Yazaki[2] (1.Tohoku University, 2.Institute of Safety Education for School Children)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[O06-11] Health Emergency and Nursing on Flood Disaster

★Invited Papers

*Sakiko Kanbara[1], Aiko Yamamoto[2] (1.University of Kochi, 2.Shitennoji University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[O06-12] General discussion

*Jun Matsumoto[1,2], Yukihiro Takahashi[3], Akira Wada[4] (1.Tokyo Metropolitan University, 2.JAMSTEC, 3.Hokkaido University, 4.Tokyo Institute of Technology)

Multi-layered Countermeasures against Widespread Devastating Flood Disasters

*Koike Toshio[1]

1. International Centre for Water Hazard and Risk Management

The largest water vapor convergence since 1958 was recorded across western Japan in early July 2018, breaking the records of 24-to-72-hour rainfall at many stations in the area and causing devastating disasters including floods due to bank breaches and overflows, debris flows, and urban inundations. We also witnessed new types of disasters induced by multiple causes including the backwater phenomenon at confluence zones and floods involving a huge scale of floodwater and sediment transport simultaneously. Furthermore, eight dams in western Japan exhausted their flood control capacities and had to start emergency water-discharge operations to avert reservoir overflows from the heavy rainfall. In addition, we later learned that dam discharge warnings were not used effectively to support residents in safe evacuation. As a consequence, 232 people either died or went missing, and prefectures in western Japan suffered significant economic damage. The number of more than 200 victims was the worst case since 1982. To prevent the recurrence of devastating disasters over a wide area, the Council for Social Infrastructure Development analyzed the characteristics and issues of the July 2018 disasters and submitted a report including the recommended countermeasures based on the key strategies to the Minister of Land, Infrastructure, Transport and Tourism on December 13, 2018. Towards building a community where everyone evacuates proactively, the report recommends that each community develop a cooperative framework to strengthen self-help and mutual support by enriching information of hazards, risks and evacuation and improving communication methods in cooperation with the mass media and the ICT private sector. The report also proposes more resilient infrastructure design, development and operation against complex disasters and hazards which exceed infrastructure capacities and suggests strategies for the implementation of quick disaster responses and recoveries and extra considerations of disaster risks in community development. We need to promote such multi-layered countermeasures as a package to cope with unprecedented disasters.

Keywords: flood, debris flows, backwater, emergency water-discharge operations to avert reservoir overflows

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Technologies and wisdom in housings and buildings for protecting our lives from river floods

*Kazuo Tamura[1]

1. Seismic Design Laboratory

There exist many areas which have high risk of flood damages in Japan. River dykes or dams have been constructed to suppress flood damages. However, these countermeasures are not enough, in the condition that severe meteorological phenomena with heavy rainfalls become more frequent. We should make use of technologies and wisdom or ideas in the field of buildings to protect our lives or to maintain our living environment. The river management of the whole river basin, with planning the houses or buildings of the area, is necessary against these severe conditions.

In this presentation, the author explains current situation and applicable technologies of building structures, focusing on maintaining safety of our lives against river floods.
For example, raising the ground level of the building is one selection for the countermeasure against floods. Another idea is to construct high strong foundation walls under the wooden housing to avoid flooding. The piloti structure whose first floor is supported by columns with no walls is effective to decrease flood water pressure to the building. The base isolated building on the piloti structure can decrease both flood load and earthquake load.

Keywords: flood, building structure, countermeasure, piloti, base isolation

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State and Challenges of Disaster Waste Management - Lessons from Recent Disasters –

*Yuichi Moriguchi[1], Masahiro Osako[2]

1. Graduate School of Engineering, The University of Tokyo, 2. Center for Material Cycles and Wasre Management Research, National Institute for Environmental Studies

Though legislative, institutional, technical and practical responses to disaster waste management have been strengthened since the Great East Japan Earthquake, recent disasters have been revealing further lessons to be learned. This presentation will show the current state and challenges of disaster waste management.

Keywords: Disaster waste, Tentative storage site, Separation and treatment, D.Waste-Net

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Evacuation Planning for School Children and Community Residents

*Takeshi Sato[1], Yoshiaki Yazaki[2]

1. Tohoku University, 2. Institute of Safety Education for School Children

The time line and the evacuation plan will help to reduce the number of effectively cut down human damage from floods or typhoons. On making the plan, It's difficult to consider the local characteristics of nature for school teachers and community residents because of a lack of special knowledge. Academic contribution is expected to support them. A few implementation cases by authors are introduced.

Keywords: Natural Disaster, Evacuation, Education

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Health Emergency and Nursing on Flood Disaster

*Sakiko Kanbara[1], Aiko Yamamoto[2]

1. University of Kochi, 2. Shitennoji University

It can be reduced in risk by comprehensive environmental improvement and holistic human care, and it is urgent to discuss as interdisciplinary and generalizable issues.

Keywords: Flood, Health Emergency, Nursing

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General discussion

*Jun Matsumoto[1,2], Yukihiro Takahashi[3], Akira Wada[4]

1. Tokyo Metropolitan University, 2. JAMSTEC, 3. Hokkaido University, 4. Tokyo Institute of Technology

In this session, general discussion will be conducted.

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[J] Oral | O (Public)：Public

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | Convention Hall B 2F

[O-07] Kitchen Earth Science: Let's stimulate your brain by hands-on experiments!

convener:Ichiro Kumagai(School of Science and Engineering, Meisei University), Miwa Kuri(International Research Institute of Disaster Science, Tohoku University), Kei Kurita, Mie Ichihara(Earthquake Research Institute, University of Tokyo), Chairperson:Ichiro Kumagai(Meisei University), Miwa Kuri(東北大学災害科学国際研究所), Mie Ichihara(Earthquake Research Institute, The University of Tokyo), Kei Kurita

"Kitchen Earth Science" aims at understanding a natural phenomenon in Earth and planetary sciences by analogue experiments using goods and tools in our daily life. Analogue experiments have a function to unveil the fundamental physics governing the phenomenon. At the same time, they essentially include uncertainties so that unexpected results are frequently obtained, which have a potential for surprising discoveries. These findings also provide a good opportunity for deeply thinking, and raise new questions to explore. Such experience is precious not only for young researchers in Earth and planetary sciences, but also non-expert people who need a scientific thinking to live wisely. In this session, we focus on "advantages of doing hands-on science experiments" and discuss the significance of analogue experiments with uncertainties, which cause unpredictable results: even if the experiment fails, we learn a lot of things from the failure which may lead to a great success. We are accepting a variety of experimental researches and case studies on scientific education such as introductory educational experiments for Earth and planetary sciences in elementally and junior/high schools, general science education and interdisciplinary researches in post-high schools, and new approaches to citizen science and outreach. We welcome all the participants who are interested in Kitchen Earth Science to stimulate your brain by hands-on science experiments.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[O07-01] Analogue experiments for understanding a crystal morphology variation of igneous rocks using a no-calorie sweetener

*Kuniyuki Furukawa[1], Ririka Watanabe[1], Risa Ito[1], Saori Kotani[1] (1.Faculty of Business Administration, Aichi University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[O07-02] Making volcanic edifice with edible lava

*Tatsuo Kanamaru[1], Akihiko Fujinawa[2] (1.Department of Earth and Environmental Sciences, College of Humanities & Sciences, Nihon University, 2.Department of Earth Sciences, Faculty of Science, Ibaraki University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[O07-03] Columnar joint: Geometric pattern analysis and analogue experiment using starch pastes

*Yuri Akiba[1], Aika Takashima[1], Hiroyuki Shima[2] (1.Graduate School of Life and Environmental Sciences, University of Yamanashi, 2.Department of Environmental Sciences, University of Yamanashi)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[O07-04] Viscoelastic characterization of a solid projectile impact onto a dense potato starch suspension

Kazuya Egawa[2], *Hiroaki Katsuragi[1] (1.Graduate School of Environmental Studies, Nagoya University, 2.Department of Earth and Planetary Sciences, Nagoya University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[O07-05] Pattern formation within a sandpile formed by a mixture of grains: The selection of stratification and segregation patterns

★Invited Papers

*Michiko Shimokawa[1], Hidestugu Sakaguchi[2] (1.Fukuoka Institute of Technology, 2.Kyushu University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[O07-06] Measuring radiation by DIY Geiger Counter Kit GC10

*George HASHIMOTO[1], Yusuke KOSHIO[1] (1.Department of Earth Sciences, Okayama University)

Analogue experiments for understanding a crystal morphology variation of igneous rocks using a no-calorie sweetener

*Kuniyuki Furukawa[1], Ririka Watanabe[1], Risa Ito[1], Saori Kotani[1]

1. Faculty of Business Administration, Aichi University

Crystallization of a magma is progressed during cooling. The number and morphology of crystals are chiefly controlled by degree of undercooling of a magma. Since igneous rocks are generally formed under various cooling profiles, crystal occurrences of natural igneous rocks are varied. As it is generally known, difference of crystal textures between plutonic and volcanic rocks are generated from difference of cooling rate. However, only that knowledge is not enough to understand results of field or microscopic observations. Therefore, students, who major in geology or petrology, should be understand general crystallization process. In this presentation, we propose the easy analog experiments to understand crystallization process of silicate melt.

Erythritol ($C_4H_{10}O_4$), which is no-calorie sweetener, is used for the experiments. The melting temperature is 121 ˚C, and erythritol can be easily melted using a hot plate. Since the melted erythritol is relatively low viscosity, crystallization is easily induced even if low degree of undercooling. This characteristic is different from a sugar.

We melted 25 g of erythritol in a petri dish with 90 mm in diameter. The petri dish including melted erythritol was cooled via various cooling rate. In the result, the crystal morphology was varied from euhedral to dendritic, and spherulitic with increasing degree of undercooling. The crystal size tends to be small with increasing degree of undercooling. The occurrences of crystal textures are consistent with those of natural igneous rocks.

The cooling rate can be easily quantified using an infrared thermometer. The boundary of cooling rate between euhedral and dendritic crystal formations was about 12 ˚C/min. The boundary of cooling rate between dendritic and spherulitic crystal formations was about 40 ˚C/min. Furthermore, latent heat could be also analyzed when crystallization progress. Latent heat is important, because it affect to rheology of advancing lavas or a magma chamber. The in-situ crystallization can be observed under a microscope. We consider that these experiments are strongly effective for geology and petrology education.

Keywords: Erythritol, Crystallization, Igneous rock

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Making volcanic edifice with edible lava

*Tatsuo Kanamaru[1], Akihiko Fujinawa[2]

1. Department of Earth and Environmental Sciences, College of Humanities & Sciences, Nihon University, 2. Department of Earth Sciences, Faculty of Science, Ibaraki University

Volcano is a window through which inside of the living earth can be seen, and also gives us a lot of grace and pleasure. On the other hand, volcanic disasters always hit human societies sitting on volcanic countries. In order to feel familiar with the volcano and get along well with the volcanoes, it is very important to know how the volcanoes have been formed. For this purpose, it is best to observe directly a volcanic eruption or perform a geological survey. However, it is difficult for non-experts to do the field survey. Therefore, efforts to make volcanoes understandable easily even by non-experts have to be made. In fact, the effort such as flow experiment of lava flow using miniature model, analog experiment of eruption using food, etc. have been conducted actively in recent years (e.g. Hayashi, 2006). In this presentation, we will introduce a lava flow experiment using pseudo-magma material prepared by mixing chocolate, gelatin, milk and heating it in a microwave oven. In addition, making pseudo-scoria formed by foaming of the same substance will be exhibited. In the lava flow experiment, it is possible to produce characteristic forms on the real lava flow surface, such as lava inflation, lava levee, ropy lava, etc. Pseudo-scoria produced by the experiment is optimum for observation of bubbling of lava.

Keywords: chocolate lava, gelatin, edible volcano

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Columnar joint: Geometric pattern analysis and analogue experiment using starch pastes

*Yuri Akiba[1], Aika Takashima[1], Hiroyuki Shima[2]

1. Graduate School of Life and Environmental Sciences, University of Yamanashi, 2. Department of Environmental Sciences, University of Yamanashi

Columnar joints are prismatic cracks that regularly penetrate the rock body. They are formed by contraction of cooled lava followed by sequential crack advances. Worldwide famous examples include: Giant's Causeway in Northern Ireland, Fingal Cave in the UK, and Devil's Tower in the United States.

Despite of much efforts reported thus far, a clear understanding for its formation mechanism has not yet been obtained, mainly because of the difficulty of experimental reproduction. In the last two decades, the situation changed drastically; it was discovered that regular crack structures, which look similar to columnar joints, can be realized very easily using starch paste. The way to make them is shown below. First, starch powder and distill water is mixed thoroughly to make paste. Next, this paste is poured into a container. Then, the surface of the paste is irradiated by an incandescent lamp, and it is left for a long time. As the moisture evaporates from the surface, the paste goes drying and causes cracking. As time elapses further, the cracks at the surface progress inward, and we finally obtain a prismatic structure which regularly penetrates the entire paste. After completely drying, a polygonal network pattern is generated on the surface of the paste.

Obviously, columnar joint and starch paste are different in the chemical composition, length scale, and crack initiation factors. But a similar prismatic crack is formed --- Why? This question motivated us to investigate the statistical properties of the polygonal pattern in both two systems.

Our drone aerial shooting of columnar joints was carried out at the following four domestic sites: (1) Tatami-ishi in Okinawa, (2) Tatami-ga-fuchi in Yamaguchi, (3) Tawara-iso in Shizuoka, and (4) Hi-no-misaki in Shimane. Importantly, the SiO_2content in constituent igneous rocks depends on the sites: the sites 1 and 3 are andesitic, the site 2 is basaltic, and the site 4 is rhyolitic. This difference would have influenced the statistical properties of the polygonal network pattern observed at present. Meanwhile, our starch-paste experiment was aimed at evaluation of the following two effects on the geometry of the polygonal crack pattern: (1) the fluctuation width in the size distribution of constituent starch particles, and (2) the degree of sphericity of the particles. To this end, we used two types of starch, corn starch and potato starch. We also examined the degree of correlation between the film thickness of the paste and the crack pattern obtained.

The first main finding was regarding the characteristic length scale of the polygonal network. For columnar joints, the length scale varies from sites to sites, probably because of the difference in the SiO_2 content. For the desiccated starch paste, the length scale increased with the film thickness only for the potato starch paste. The latter result can be explained from the water diffusion process in the paste and the spatial nonuniformity in the water concentration. Since both the water diffusion and concentration in the paste are directly affected by the size and shape of the constituent particles, our result indicates that the geometry of the dry crack pattern strongly depends on the particles' size and shape.

The second main finding was regarding the number of vertices in polygons. In columnar joint, pentagons

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and hexagons occurred in an almost equal frequency. On the other hand, in desiccated starch paste, only pentagons frequently occurred. This result can be interpreted by the difference in cooling/drying speed.

The third finding was regarding the probability distribution of polygon area. Both for the two systems, the distributions are well fitted on the curve of gamma distribution. This suggests the existence of a unified pattern formation mechanism which is common to both the cooling contraction of magma and the drying shrinkage of paste. Details of the results and its interpretation will be given in my talk of the session.

Keywords: igneous rock, rock fracture, drying paste, desiccation crack, polygonal pattern

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Viscoelastic characterization of a solid projectile impact onto a dense potato starch suspension

Kazuya Egawa[2], *Hiroaki Katsuragi[1]

1. Graduate School of Environmental Studies, Nagoya University, 2. Department of Earth and Planetary Sciences, Nagoya University

Dense suspension of non-Browning particles (e.g. mixture of water and potato starch) shows complex rheological properties such as discontinuous shear thickening (DST) [1]. Usually, DST is defined by the sudden jump of viscosity at a certain shear strain rate. The viscosity jump is observed in steady-state rheometry. However, in a very recent study, elasticity of DST fluid has also been measured by a steady penetration of a rod into a DST fluid [2]. In addition to the steady penetration, various impact experiments onto DST suspensions have also been performed to reveal the fundamental physical process of DST. The solid-like and/or peculiar behaviors have been found in the impacted DST fluid as well (e.g. dynamic jamming [3], dynamic fracturing [4], and negative pressure pulse [5]). Moreover, peculiar surface deformation and/or stable hole structure of the vibrated DST fluid has also been found under the influence of vibration [6]. Nevertheless, the origin of DST has not yet been understood well. Much more detail analyses of the transient rheological properties of DST fluid is necessary. The impact response is a useful way to approach the transient dynamics, Therefore, in this study, we perform a simple solid-projectile impact onto a DST fluid target (dense potato starch suspension), in order to observe the penetration and rebound dynamics. From the experimental results, the rebound timescale and restitution coefficient are measured. To characterize the transient viscoelasticity, we assume a simple linear viscoelastic model. Using the model, the effects of impact inertia, boundary conditions, and mechanical vibration on the rheological properties of the impacted DST fluid are systematically studied. Besides, to investigate the effect of vibration to the rheological properties of DST fluid, mechanical vibration is also used. Namely, the transient viscoelasticity of the vibrated DST fluid is experimentally measured. These results will be presented.

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Keywords: impact, discontinuous shear thickening

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Pattern formation within a sandpile formed by a mixture of grains: The selection of stratification and segregation patterns

*Michiko Shimokawa[1], Hidestugu Sakaguchi[2]

1. Fukuoka Institute of Technology, 2. Kyushu University

By pouring a mixture of two types of grains into a large vertical cell of narrow dimensions, an avalanche occurs toward the bottom of the sandpile, and the mixed grains separate into their respective grain types due to the Brazil nut effect, which is caused by the vibration of the avalanche. The effect causes spontaneous formations of stratification patterns or segregation patterns in a sandpile. The selection of the pattern in the sand pile is determined by a competition of angles of repose and the grain sizes of the two grain types. In the condition of a formation of a segregation pattern, a size of grain A is larger than that of grain B, and a repose angle of grain A is smaller than that of grain B. On the other hand, the grain size and repose angle of grain A are larger than those of grain B for the formation of the stratification pattern. We investigate pattern formation in a sandpile by pouring a ternary mixture of grains into a narrow vertical cell. Size segregation in avalanches causes the formation of patterns. Four kinds of patterns emerge: stratification, segregation, upper stratification–lower segregation, and upper segregation–lower stratification. A phase diagram is constructed in a parameter space of θ_{11}/θ_{33} and θ_{22}/θ_{33}, where θ_{11}, θ_{22}, and θ_{33} are the repose angles of small, intermediate, and large grains, respectively. To qualitatively understand pattern formation, a phenomenological model based on a roll-or-stay rule is proposed. A similar pattern formation is found in a numerical simulation of the phenomenological model. These results suggest that the ratios of the repose angles of the three grain types are important for pattern formation within a sandpile.

Keywords: pattern formation, sand pile, avalanche

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Measuring radiation by DIY Geiger Counter Kit GC10

*George HASHIMOTO[1], Yusuke KOSHIO[1]

1. Department of Earth Sciences, Okayama University

Radiation level is measured by DIY Geiger counger kit GC10.

Keywords: electronic kit, radiation level

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[J] Oral | O (Public)：Public

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | Convention Hall B 2F

[O-08] How to make the image of the earth's phenomenon to the general people in the Geopark

convener:Noritaka Matsubara(Graduate School of Regional Resource Management, University of Hyogo), Yayoi ICHIHASHI(Sado Island Geopark Promotion Office), Hokuto Obara(Mine-Akiyoshidai Karst Plateau Geopark Promotion Council), Marekazu OHNO(Unzen Volcanic Area Geopark Promotion Office), Chairperson:Yayoi Ichihashi, Hokuto Obara, Hiroko Imai, Suzuka Koriyama(San'in Kaigan Geopark Promotion Council), Noritaka Matsubara(兵庫県立大学大学院)

unesco global geoparks give international recognition for sites that promote the importance and significance of protecting the Earth's geodiversity through actively engaging with the local communities. in order for the general people to understand the earth's activity, it is necessary to imagine the phenomenon of the earth. in this session, we discuss about how to make the image of the earth's phenomenon to the general people in the Geopark.

10:45 AM - 11:15 AM JST | 1:45 AM - 2:15 AM UTC

[O08-01] Significance of the guide to introduce the landscape interestingly

★Invited Papers

*Daisuke Fukushima[1] (1.Sakurajima Museum)

11:15 AM - 11:45 AM JST | 2:15 AM - 2:45 AM UTC

[O08-02] Understanding of "geology" without difficult explanation. - Let's conduct experiment to tell about geology more easily. -

★Invited Papers

*Hikaru Yokoyama[1] (1.Hokusho University)

11:45 AM - 12:15 PM JST | 2:45 AM - 3:15 AM UTC

[O08-03] The appealing points and challenges of Japanese geoparks, as seen from a foreigner’s point of view.

★Invited Papers

*Jagoda Woloszyn[1] (1.Oki Islands UNESCO Global Geopark Promotion Committee)

Significance of the guide to introduce the landscape interestingly

*Daisuke Fukushima[1]

1. Sakurajima Museum

One of the objectives of the geopark is to convey the connection between the earth, people and nature. Many of those who have learned earth science can imagine the formation of the earth from the topography and geology, from which you can imagine the connection with people and nature. However, since many general people do not have knowledge of earth science, it is difficult to understand the story of the connection between the earth, people and nature from the landscape in front of the eyes.

On the other hand, there are many people who have deep knowledge about their hobbies and work, can imagine and enjoy various things. For example, if a person who likes history went to a famous battlefield, it would be possible to imagine and enjoy events of hundreds of years ago. However, it is familiar scenery for many general people. Whether you can enjoy the scenery is proportional to knowledge and imagination. If you have a lot of knowledge, the range you can imagine will expand and you will be able to enjoy various sceneries.

The role of the guides is to introduce the scenery interestingly even if the customer does not have knowledge. The guides provide the necessary knowledge to bring out imagination, take you to a place suitable for imagining, use imagery, photographs, illustrations etc so that guides and customers can imagine similar images. Then, the scenery in front of you seems to change, and you can know the story. It is the best way to tell the connection between earth and people and nature. Therefore, the role of the guide in geoparks is very important.

Keywords: geopark, guide, dissemination

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Understanding of "geology" without difficult explanation. - Let's conduct experiment to tell about geology more easily. -

*Hikaru Yokoyama[1]

1. Hokusho University

In the geopark, it is necessary to positively transmit the geoscientific appeal of the area. However, in Japan, many people are not sufficiently educated about geology. Therefore, it is very important task to communicate about the geological phenomena to the citizen easily.

Model experiments are one effective means to tell phenomena difficult to express in words easily. Several activities have been conducted to deepen understanding of geology through model experiments. "The kitchen volcano experiments" is an example of a typical model experiment. Experiments that can easily model geological phenomena and convey it are essential communication tools for the dissemination of geoparks and educational activities.

In this presentation, I will give some examples of experiments to model and convey complex geological phenomena. I will propose the effect of dissemination activities through experiments and how to utilize the experiment in geopark.

Keywords: Science communication, Outreach, Education

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The appealing points and challenges of Japanese geoparks, as seen from a foreigner’ s point of view.

*Jagoda Woloszyn[1]

1. Oki Islands UNESCO Global Geopark Promotion Committee

It has been almost three years since I started my work as a Coordinator of International Relations at the Oki Islands UNESCO Global Geopark Promotion Committee. Before coming here, I did not even know that organizations like geoparks existed. Therefore, at the beginning, Japanese geoparks became my model for geoparks. During my presentation I will talk about the appealing points of geoparks in Japan from an amateur’ s point of view.

Geopark Promotion Committees in Japan have the necessary resources to gather information about not only the local geology, but also the local nature, history and culture. Therefore, they can function as a hub for human resource development projects and high-quality tourism product creation.
I wish to look at the challenges that geopark promotion committees face in Japan, as well as talk about the differences between Japanese and European geoparks. Focusing on the differences resulting from the different starting points of the networks, differences in geopark office organization style and culture differences in working style, I will touch upon what I believe the networks can learn from each other.

Keywords: geopark, networks, differences in management style

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[J] Oral | O (Public)：Public

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | Convention Hall B 2F

[O-08] How to make the image of the earth's phenomenon to the general people in the Geopark

convener:Noritaka Matsubara(Graduate School of Regional Resource Management, University of Hyogo), Yayoi ICHIHASHI(Sado Island Geopark Promotion Office), Hokuto Obara(Mine-Akiyoshidai Karst Plateau Geopark Promotion Council), Marekazu OHNO(Unzen Volcanic Area Geopark Promotion Office), Chairperson:Yayoi Ichihashi, Hokuto Obara, Hiroko Imai, Noritaka Matsubara(兵庫県立大学大学院), Suzuka Koriyama(San'in Kaigan Geopark Promotion Council)

unesco global geoparks give international recognition for sites that promote the importance and significance of protecting the Earth's geodiversity through actively engaging with the local communities. in order for the general people to understand the earth's activity, it is necessary to imagine the phenomenon of the earth. in this session, we discuss about how to make the image of the earth's phenomenon to the general people in the Geopark.

1:45 PM - 2:15 PM JST | 4:45 AM - 5:15 AM UTC

[O08-04] What do we need to do fun geotours that interests the earth?

★Invited Papers

*kana nishitani[1] (1.Global nature club)

2:15 PM - 2:45 PM JST | 5:15 AM - 5:45 AM UTC

[O08-05] The Important Things in Communicating Earth's Activity to Local Residents: the Awareness during Four Years after Changing a Job from a Geoscience Postdoc to a Curator

★Invited Papers

*Kyoko Kanayama[1] (1.San'in Kaigan Geopark Museum of the Earth and Sea, Tottori Prefectural Government)

2:45 PM - 3:15 PM JST | 5:45 AM - 6:15 AM UTC

[O08-06] "Blatamori" How to communicate the earth activities valued by guide guides

★Invited Papers

*Makoto Hasuoka[1], Yusuke Suzuki[2], Hiroko Imai[3] (1.Bandai-san Geopark Council, 2.Izu Peninsula Geopark Promotion Council, 3.COM SUPPORT OFFICE)

What do we need to do fun geotours that interests the earth?

*kana nishitani[1]

1. Global nature club

I think that guides need to improve interpretation skills in order to make customers fun and make feel be on the earth.

I will apply my daily guide to the four elements "①Theme ②Organized ③Relative ④Enjoyable" which are said to be necessary for the interpretation, will organize it. And I will consider what is important for geo guide.

Keywords: Geopark, guide

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The Important Things in Communicating Earth's Activity to Local Residents: the Awareness during Four Years after Changing a Job from a Geoscience Postdoc to a Curator

*Kyoko Kanayama[1]

1. San'in Kaigan Geopark Museum of the Earth and Sea, Tottori Prefectural Government

Four years ago, I changed a job from a postdoctoral researcher at a university to a curator at the Tottori Prefectural Government. After my career change, a target for my communication changed from scientists and graduate students having a passion for earth sciences to local people and administrative staff who had never learned earth sciences deeply. How can I let them know the interest for earth sciences?
I believe the interest about earth sciences is to come to realize or imagine that "the earth is active". However, I feel many people are less interested in earth sciences because there is little opportunity to feel its interest. One of my missions as a curator is simply passing on "the earth is active" to as many people as possible.
What I gradually learned from my experience as a curator for four years is that telling memories of landscape and life which listeners had seen could link to their interest for earth sciences when I tell about earth activity. Including these stories, I would like to talk about some perceptions that I gained through the curatorial work in my presentation.

Keywords: Earth sciences, geopark, interpretation

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"Blatamori" How to communicate the earth activities valued by guide guides

*Makoto Hasuoka[1], Yusuke Suzuki[2], Hiroko Imai[3]

1. Bandai-san Geopark Council, 2. Izu Peninsula Geopark Promotion Council, 3. COM SUPPORT OFFICE

It is not easy for ordinary people and local residents who do not have expertise to image the earth's activities in the geopark - know the importance of geodiversity. In each geopark, local people such as experts and geo guides unravel the phenomena related to the activities of the earth and the relationship between people and the earth, communicate their enjoyment and importance to the general public through guided tours and activities There.
NHK Blatamori introduces to the tea room that it is close to activities that this geopark region is practicing.This program is a program of the concept that Mr. Tamori of the guru walking master approaches the history of the unknown city and the lives of people while walking around the glove.

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[J] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[P-PS07] Formation and evolution of planetary materials in the Solar System

convener:Yoko Kebukawa(Faculty of Engineering, Yokohama National University), Wataru Fujiya(Ibaraki University, College of Science), Shin Ozawa(Department of Earth Science, Graduate School of Science, Tohoku University), Megumi Matsumoto(Graduate School of Science, Tohoku University), Chairperson:Megumi Matsumoto, Wataru Fujiya

This session will focus on the evolution in the Solar System with interaction and co-evolution in minerals, water, organic matter, and noble gas in meteorites and interplanetary dust particles. New innovative analytical and theoretical techniques in various fields will be discussed. The developing methods are welcome to submit for the future mainstream of meteorite study. In order to explore the planetary materials and their evolution, both meteorite studies and experimental approaches are necessary. In this session, we will discuss these topics from extraterrestrial sample analyses and experimental works. Research works on undifferentiated and differentiated meteorites and parent body processes such as aqueous alteration, thermal metamorphism, shock metamorphism, volcanic activity, and core-mantle-crust differentiation are especially included in this session.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[PPS07-01] Investigation of sugars in meteorites

★Invited Papers

*Yoshihiro Furukawa[1], Yoshito Chikaraishi[2], Naohiko Ohkouchi[3], Nanako O. Ogawa[3], Tomoki Nakamura[1] (1.Graduate School of Science, Tohoku University, 2.Institute of Low Temperature Science, Hokkaido University, 3.JAMSTEC)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[PPS07-02] Establishment of ice sublimation method for detection of soluble organic matter contained in Antarctic micrometeorites in Antarctic glacier ice

*Yui Ishikawa[1], Yamamoto Kota[1], Hiroshi Naraoka[2], Toru Yada[3], Tatsuaki Okada[1,3] (1.Graduate School of Science, The University of Tokyo, 2.Graduate School of Science, Kyushu University, 3.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[PPS07-03] Magnesium-containing organic compounds in the Tagish Lake and Murchison meteorites.

*Minako Hashiguchi[1], Hiroshi Naraoka[2,1] (1.Research Center for Planetary Trace Organic Compounds, Kyushu University, 2.Department of Earth and Planetary Sciences, Kyushu University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[PPS07-04] Interactions between minerals and organic materials on thermal processes in meteorite parent bodies

*Naoki Hirakawa[1], Yoko Kebukawa[1], Kensei Kobayashi[1] (1.Yokohama National University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[PPS07-05] Organic matter in carbonaceous chondrite lithologies of Almahata Sitta meteorite, a polymict ureilite

*Yoko Kebukawa[1], Michael Zolensky[2], Cyrena Anne Goodrich[3], Motoo Ito[4], Nanako O. Ogawa[5], Yoshinori Takano[5], Naohiko Ohkouchi[5], Hiroki Suga[9], Matthew Marcus[6], David Kilcoyne[6], Takuji Ohigashi[7], Zia Rahman[2], Muawia H. Shaddad[8], Kensei Kobayashi[1] (1.Yokohama National University, 2.NASA Johnson Space Center, 3.Lunar and Planetary Institute, 4.Kochi Institute for Core Sample Research JAMSTEC, 5.Japan Agency for Marine-Earth Science and Technology, 6.Lawrence Berkeley National Laboratory, 7.Institute for Molecular Science, 8.University of Khartoum, 9.The University of Tokyo)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[PPS07-06] Thermal Evolution of Hydrous Minerals on Small Bodies: To Understand Thermal Histories of Ryugu and Bennu

*Kana Ishimaru[1], Shogo Tachibana[2] (1.University of Tokyo, 2.UTokyo Organization for Planetary and Space Science, University of Tokyo)

Investigation of sugars in meteorites

*Yoshihiro Furukawa[1], Yoshito Chikaraishi[2], Naohiko Ohkouchi[3], Nanako O. Ogawa[3], Tomoki Nakamura[1]

1. Graduate School of Science, Tohoku University, 2. Institute of Low Temperature Science, Hokkaido University, 3. JAMSTEC

Sugars are essential components of DNA and RNA and also are essential substrates of glycolysis. Ribose is especially an important sugar as the sole component in RNA that supports both genotype and phenotype of primordial life. Investigations of sugars in meteorites have been conducted since more than 50 years ago. However, no extraterrestrial sugar that composes life has been found from any astronomical samples including meteorites, although several sugar-related compounds have been detected from meteorites. This would be preliminary because of the low concentration, difficulty in extraction, and the absence of suitable derivatization for gas chromatographic separation. Therefore, we developed a protocol to extract and analyze sugars in meteorites. We have also investigated the compound-specific carbon isotope ratios (δ^{13}C values) of sugars. All meteorites have some possibilities of biological contamination, since they have been collected on the terrestrial environment filled with biota. Thus, the evaluation of the source of sugars in meteorites (i.e., biological or extraterrestrial) is significantly important. Biological sugars are all have negative δ^{13}C values (against VPDB). Conversely, soluble organic compounds in meteorites like amino acids, nucleobases, amines, and sugar-related compounds all have positive carbon δ^{13}C values. Thus, the isotope ratios are an essential indicator for the evaluation of the origin of sugars in meteorites. In this presentation, we show the results of identification and carbon isotope ratio analysis of sugars for two CR2 chondrites. We also report the mineral composition, and chemical state of C in insoluble organic matter in these meteorites.

Keywords: ribose, sugar, meteorites

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Establishment of ice sublimation method for detection of soluble organic matter contained in Antarctic micrometeorites in Antarctic glacier ice

*Yui Ishikawa[1], Yamamoto Kota[1], Hiroshi Naraoka[2], Toru Yada[3], Tatsuaki Okada[1,3]

1. Graduate School of Science, The University of Tokyo, 2. Graduate School of Science, Kyushu University, 3. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency

Earth is habitable even in the inner planetary region where volatiles are depleted, so that there should be sources and mechanism to supply them to earth. It has been revealed by the recent exploration of outer planets and comets that volatile components such as water and organics exist abundantly in the outer planetary region, where it is colder than in the inner planetary region. According to the researches, the existence of organic matter cannot be ignored for understanding the nature of small bodies in the outer planetary region (e.g., bodies in Edgeworth Kuiper Belt bodies or Oort Cloud). As means to get samples of that region not in the space but on the Earth, there are Antarctic MicroMeteorites (AMMs) [1]. There are interplanetary dust particles (IDPs) drifting in the interplanetary space, ejected from small solar system bodies such as asteroids and comets. Those dusts are called micrometeorites when they fall to the earth, and they are called AMMs especially when they fall to the Antarctic ice sheets. The size of MMs is defined as less than 2 mm. The accretion rate of MMs reaching the Earth’ s surface has been estimated tens of thousand tons in the previous study, which is about ten times as much as the annual influx of meteorites to the Earth [2]. Since soluble organic matter (SOM) and insoluble organic matter (IOM) are present in the MMs, it is considered that MMs rather than meteorites dominantly contributed to the supply of volatile components to the inner planetary region where they were deficient [3].

In order to understand chemical characteristics of organics in IDPs, we are aiming for the detection of SOM in AMMs. While it is difficult to determine the structure of IOM because they are Kerogen-like macromolecules, the structure of SOM can be determined. Therefore, it can be the key of elucidating the evolution of materials (chemical reaction) in the low temperature environment of the outer solar system specifically. In the previous study, samples were collected by filtering the melted water, so that no molecular species were evidently identified to have originated from primitive MMs [4, 5]. In this study, ice blocks that were collected from an ice sheet in Antarctica were sublimated as it was in order to prevent the leakage of SOM during sample collection. The apparatus for sublimation of ice blocks consists of a vacuum chamber with a sample holding jig and a dish for collecting sublimation residue set in the climate chamber. In order to prevent the ice blocks from melting before it is enough evacuated, the temperature in the climate chamber was set at -10.0 degrees Celsius. The whole apparatus was set and cooled in advance in the climate chamber. After ice blocks were set on the jig in the vacuum chamber, evacuation was started. In order to increase the efficiency of sublimation, the temperature in the climate chamber was set at 40.0 degrees Celsius after the pressure in the chamber reaching about 80 Pa.

About 330 g of Antarctica ice blocks were sublimated experimentally using the above apparatus. The residue was observed with a stereoscopic microscope. Most of the residue was occupied with white aggregated particles. According to the part of the observation by SEM-EDS, it was found that they are composed of Na, Cl, Ca, C, O and other elements. Their chemical compositions indicate that they should be marine or continental aerosols [6]. Particles composed of silicate minerals containing Mg and Fe were also found in the residue. The composition of them is consistent with that of AMMs [7]. However, it needs

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to be confirmed whether it is AMM by analytical methods such as μ-FTIR, μ-Raman, DESI-Orbitrap MAS and so on. We are planning to analyze samples in various ways, mainly on the degree of polymerization of insoluble organic matter and identification of soluble organic matter.

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Magnesium-containing organic compounds in the Tagish Lake and Murchison meteorites.

*Minako Hashiguchi[1], Hiroshi Naraoka[2,1]

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Introduction: Recent compound analyses using high-resolution mass spectrometry (HRMS) from the solvent extracts of the Murchison meteorite (CM2) reported various CHO, CHNO, CHOS and CHNOS compounds [Schmitt-Kopplin *et al.*, 2010] and ~600 alkylated homologues of CHN compounds [Naraoka *et al.*, 2017]. CHOMg compounds were also identified from methanol extracts of various meteorites by using HRMS [Ruf *et al.*, 2017]. To understand chemical evolution of the meteoritic organic matter, investigation of their relationship with surrounding minerals by *in-situ* analysis is necessary. Our previous studies revealed spatial distribution of alkylated homologues of CHN compounds in the Murray and Murchison meteorites using desorption electrospray ionization (DESI) with HRMS [Naraoka and Hashiguchi, 2018; Hashiguchi and Naraoka, 2019], but clear relationship with specific minerals was not found. In this study, we carried out DESI-HRMS imaging on the Tagish Lake meteorite to reveal the relationship between SOM and minerals.

Experimental: Fragments of the Tagish Lake (Ung-C2) meteorite and the Murchison meteorite with a flat surface of each meteorite were embedded in indium or alloy with low melting point (60 ºC). The DESI-HRMS imaging was performed using a 2D DESI ion source equipped with Orbitrap MS. A spray solvent was methanol 100% with the flow rate of 2–3 μL/min, and electrospray voltage was set at 3 kV. The positive ions (m/z 60–500) were collected with mass resolution of 140,000 ($m/\Delta m$ at m/z 200) on the surface of Tagish Lake (2.5×2.5 mm^2) and Murchison (4.5×4.5 mm^2). Antigorite grains was also analyzed to understand adsorption effects of organic compounds on clay minerals during storage in a clean room (Class 1000). After the imaging, FE-SEM-EDS analysis was carried out on the samples without coating and polishing.

Results and Discussion: Any CHN compounds were not detected from the Tagish Lake by DESI-HRMS imaging, whereas several alkylated homologues of CHN compounds were identified from Murchison similar to the previous study [Hashiguchi and Naraoka et al., 2019]. The distinctly different organic characteristics between the two meteorites was contrast to previous bulk analysis showing its quite low abundance of CHN compounds in Tagish Lake relative to Murchison [e.g. Pizzarello *et al.*, 2006]. Instead of the CHN compounds, abundant Mg-containing organic compounds were identified from Tagish Lake with mass precision of <1.5 ppm. Isotopomers of $^{24\text{-}26}$Mg for compounds were identified using the exact mass and Mg isotope simulation. Several families of $C_nH_mO_xMg^+$ (n=0-10) different from the compounds identified by Ruf *et al.* (2017), and $C_nH_mN_yO_xMg^+$ (n=1-7) were assigned using Kendrick mass defect plots. The Mg-organic compounds were also detected from Murchison, however, the abundance was more than an order of magnitude lower than that in Tagish Lake. By DESI-HRMS analysis on antigorite grains, some Mg-organic compounds (e.g. $C_nH_{2n+2}NO_2Mg^+$ families) showed high ion intensity after storage for 1 month, indicating their adsorption effects on the clay minerals. In contrast, other Mg-organic compounds were not found by the adsorption effect, suggesting that these compounds were indigenous in the meteorites.

The CHOMg and CHNOMg compounds showed a similar spatial distribution with various intensity among the different families in both meteorites. In the Tagish Lake meteorite, they were likely to be concentrated in the matrix with less framboidal magnetite and relatively saponite/serpentine-rich region. This indicates that the Mg-organic compounds might have been formed by ion exchange between organic species and

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the clay minerals during aqueous alteration. Moreover, the Mg-organic compounds and CHN compounds were also distributed in matrix of Murchison, however, their spatial distributions were different, suggesting different origins between these compounds.

Keywords: Primitive meteorites, Magnesium containing organic compounds, Molecular imaging

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Interactions between minerals and organic materials on thermal processes in meteorite parent bodies

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1. Yokohama National University

Introduction:
Carbonaceous chondrites and several other chondrites contain a few wt.% of organic matters. Pearson et al. (2002) reported co-existence of organic matters with phyllosilicates in the matrix or chondrule rim and discussed the roles of phyllosilicates on alteration of organic matters during aqueous processing in a meteorite parent body. However, interaction between minerals and organics has not been well-known compared to interactions between minerals and water or organics and water. In this study, molecular cloud organic material analogue (Kouchi et al, 2002; hereafter called MC) was heated with powdered minerals using an autoclave to understand, 1) the effect of minerals on thermal metamorphism of organic matter, 2) whether minerals were affected by organic matter or not.

Methods:
MC was prepared by mixing chemical compounds based on Kouchi et al. (2002). Samples used in this study were MC (5 g), MC (0.25 g) with olivine (0.25 g), and MC (0.25 g) + montmorillonite (0.25 g). Each sample was put in a pyrex glass tube without sealing and the tube was placed in the autoclave. The autoclave was purged with N2+H2 gas mixture (99 : 1, v/v). The samples were heated at 200 ˚C, 300 ˚C, and 400 ˚C in the autoclave for 5 hours under 1 atm. After cooling to room temperature, recovered samples were analyzed using FT-IR, GC/MS, XRD and SEM-EDS.

Results and Discussion:
MC heated products: Changes of the peak position and the intensity of carbonyl C=O in IR spectra with temperatures were consistent with the products at each temperature detected by GC/MS. The long-chain carboxylic acids in the initial MC were converted into long-chain ester compounds at 200 ˚C. Long-chain ester, amide and nitrile compounds were produced at 300 ˚C, and long-chain alkane and nitrile compounds were produced at 400 ˚C. Dehydration condensation of carboxylic acids with alcohols and amines in the initial MC formed esters and amides, respectively, at 200 ˚C and 300 ˚C. Alkanes and nitriles were formed at 400 ˚C through thermal cracking of long chain aliphatic compounds and dehydration of amides, respectively.

Monoaromatic hydrocarbons also increased at 400 ˚C. Monoaromatic hydrocarbons were probably formed through thermal cracking of bridged aromatic hydrocarbons (e.g.,
4,4’ -methylenebis-(2,6-dimethylphenol)) in the initial MC at 400 ˚C.

Effects of minerals: Changes in the peak position of carbonyl C=O was more significant with montmorillonite than with olivine. Carbonyl C=O significantly decreased at 300 ˚C and 400 ˚C with montmorillonite. This result could be explained by the differences of acidity and contact surface area of olivine and montmorillonite.

Alexander et al. (2007) reported that both O/C ratios and H/C ratios of insoluble organic matter (IOM) in heated CM chondrites and ordinary chondrites decreased by heating. However, O/C ratios of IOM in heated CM chondrites were much lower than these in ordinary chondrites when compared at the same

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H/C ranges. It may indicate that pyrolysis of IOM in heated CM chondrites was promoted by co-existed phyllosilicates even at lower degree of thermal processes compared to IOM in ordinary chondrites which contain large amount of olivine but less phyllosilicates.

Alteration of minerals: Possibility of partial hydrous alteration in olivine to serpentine was found in products at 200 ˚C and 300 ˚C by SEM observations, while the alteration was not detected at 400 ˚C. It could be due to the dehydration of MC that hydrates olivine at 200 ˚C and 300 ˚C. This result might indicate that hydrated minerals could have formed without water but with organics in some meteorite parent bodies accreted inside the snow line. Further analysis using TEM is now being conducted to confirm the formation of phyllosilicates on the surface of olivine particles reacted with MC.

Keywords: pyrolysis of organic matter, meteorite parent body, phyllosilicate

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Organic matter in carbonaceous chondrite lithologies of Almahata Sitta meteorite, a polymict ureilite

*Yoko Kebukawa[1], Michael Zolensky[2], Cyrena Anne Goodrich[3], Motoo Ito[4], Nanako O. Ogawa[5], Yoshinori Takano[5], Naohiko Ohkouchi[5], Hiroki Suga[9], Matthew Marcus[6], David Kilcoyne[6], Takuji Ohigashi[7], Zia Rahman[2], Muawia H. Shaddad[8], Kensei Kobayashi[1]

1. Yokohama National University, 2. NASA Johnson Space Center, 3. Lunar and Planetary Institute, 4. Kochi Institute for Core Sample Research JAMSTEC, 5. Japan Agency for Marine-Earth Science and Technology, 6. Lawrence Berkeley National Laboratory, 7. Institute for Molecular Science, 8. University of Khartoum, 9. The University of Tokyo

The Almahata Sitta (AhS) meteorite is a brecciated, polymict ureilite that has originated from the near-earth asteroid 2008 TC3 which is classified as an F-type asteroid (a group in C complex) in spectroscopic taxonomy [1]. Carbonaceous chondritic lithologies AhS 671 and 91/91A have been characterized and contain phyllosilicates, bruennerite, dolomite, magnetite, fayalite, ilmenite, phosphates, pyrrhotite, and pentlandite [2]. These lithologies are breccias and enclose fragments of ureilitic olivine and pyroxene [2]. We investigated organic matter (OM) in AhS 671 and 91A with various methods including C and N elemental and isotopic analysis and FTIR for bulk samples (~100 μg), and microscopic analysis of their FIB sections using STXM/C-XANES and NanoSIMS.

AhS 671

The IR absorption spectrum of AhS 671 show phyllosilicates and carbonates consistent with mineralogical observations [2], and similar to the IR spectra of CI chondrites [3]. AhS 671 contains 3.9 ±0.22 wt.% of C and 0.19 ±0.02 wt.% of N with δ^{13}C = -3.8 ±0.7 ‰and δ^{15}N = 50.5 ±2.6 ‰. Its δ^{15}N and N/C ratio (0.042 ±0.002, atomic) is close to the values of insoluble organic matter (IOM) in the Tagish Lake meteorite [4]. Note that the N/C ratio of OM in AhS 671 would be higher than the value of the bulk sample since the bulk value includes carbonates.

C-XANES spectra of the organic-rich regions in the AhS 671 FIB section show large peaks at 285 eV assigned to aromatic carbon with no other specific features. Although, organic matter in AS 671 is highly aromatic, there is no 1s-σ^* exciton peak at 291.7 eV of graphene structures that is characteristic of thermally-metamorphosed meteorites [5]. Such characteristics are similar to the C-rich aggregate in the Zag clast [6]. The difference of their organic matter is related to morphology; Zag organics form large (over 10 μm) aggregates while those in AhS 671 are smaller and mixed with the matrix at the submicron scale. δ^{13}C and δ^{15}N obtained with NanoSIMS in C-rich areas are homogeneous with averages of 3 ±3 ‰ and 234 ±32 ‰, respectively. The δ^{15}N is higher than the bulk value and is close to the value of IOM of CR chondrites [7]. The δD value in C-rich areas is 988 ±59 ‰. It is similar to the value of IOM of CI and CM chondrites [7], but less than the value of CRs [7]. The N isotopes of organic matter in AhS 671 shows an isotopically heavier than ureilitic fragments of AhS (-53 to -94 ‰[8]) and rather close to the values of primitive carbonaceous chondrites. However, OM is dominated in aromatic structure without any sign of graphitization.

AhS 91A

Not like AhS 671, the IR absorption spectrum of AhS 91A show no sighs if phyllosilicates and carbonates. The C and N contents vary up to 4.8 wt.% and 0.056 wt.%, respectively, with the average δ^{13}C of -17 ±8

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‰. It is consistent with the heterogeneous nature of AhS 91A. We could not obtain C-XANES due to low C contents in the FIB section of AhS 91A. We are going to analyze an additional FIB section since AhS 91A is highly heterogeneous.

Considering the molecular structure and the nitrogen isotope composition, the organic matter in AhS 671 is similar origin to the C-rich aggregate in the Zag clast [6], and thus perhaps related to D/P asteroids.

References: [1] Jenniskens P. et al. (2009) *Nature*, 458, 485-488. [2] Goodrich C. A. et al. (2018) *49th LPSC,* Abstract #1321. [3] Osawa T. et al. (2005) *Meteoritics & Planet. Sci.*, 40, 71-86. [4] Herd C. D. K. et al. (2011) *Science*, 332, 1304-1307. [5] Cody G. D. et al. (2008) *Meteoritics & Planet. Sci.,* 43, 353-365. [6] Kebukawa Y. et al. (2018) *Scientific Reports*, in press. [7] Alexander C. M. O' D. et al. (2007) *Geochim. Cosmochim. Acta*, 71, 4380-4403. [8] Downes et al. (2015) *Meteoritics & Planet. Sci.,* 50, 255-272.

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Thermal Evolution of Hydrous Minerals on Small Bodies: To Understand Thermal Histories of Ryugu and Bennu

*Kana Ishimaru[1], Shogo Tachibana[2]

1. University of Tokyo, 2. UTokyo Organization for Planetary and Space Science, University of Tokyo

Asteroid sample return missions JAXA's Hayabusa2 and NASA's OSIRIS-REx are currently exploring asteroids Ryugu and Bennu, respectively. Infrared spectroscopic observation done by the near-infrared spectrometer on board Hayabusa2 (NIRS3) suggests that Ryugu has a weak absorption feature of hydrous minerals, while the visible and infrared spectrometer on board OSIRIS-REx (OVIRS) have detected a clear absorption feature of hydrous minerals on the surface of Bennu. These findings indicate that two asteroids experienced different thermal histories, and dehydration of hydrous phases could have occurred more effectively on Ryugu. It is thus important to understand thermal transformation processes of hydrous minerals, but there has been limited kinetic data that can be extrapolated to the processes occurring in the geologic timescale. Therefore, with the aim of understanding thermal metamorphism on Ryugu/Bennu, we conducted heating experiments of serpentine in vacuum.

The starting material of serpentine was ground into powder using an agate mortar and pestle to a particle size of ~1 μm. Samples were heated at 500 - 800˚C, for durations of 2 –88 hours in vacuum (10^{-4} –10^{-5} Pa). The analyses were done with XRD (X-ray powder diffraction) at the University of Tokyo and FTIR (Fourier transform infrared spectroscopy) at Hokkaido University. The weight changes of the samples were obtained by weighing them before and after the experiments using an electric balance.

The serpentine samples heated at 500˚C were dehydrated with heating, but crystalline serpentine was still dominant in the run products. The samples heated at 600˚C decomposed to become amorphous. The XRD spectra of the samples heated at 650℃ show the presence of small and broad peaks of olivine that recrystallized from the amorphous and also a slight halo representing remaining amorphous. The samples heated at 700˚C also have small and broad XRD peaks of olivine without the halo feature of amorphous silicate. The XRD spectra of the samples heated at 800˚C show the strongest peak of enstatite in addition to the peaks of olivine. FTIR spectra also confirm the above observations.

The FTIR spectra of the samples heated at 650˚C and 700˚C were analyzed further to obtain the kinetics of crystallization of olivine from dehydrated serpentine. The absorbance ratio of the peaks at 10.4 and 11.4 mm, both of which are characteristic of olivine, was converted into the degree of olivine crystallization based on the results by [1]. The time evolution of crystallization degree at 650 and 700˚C were fitted by the Johnson-Mehl-Avrami-Kolmogorov equation with the Avrami exponent of 1.5 [1], and the crystallization rate constant k [$h^{-1.5}$] of 0.032 and 0.34 were obtained at 650 and 700˚C, respectively. The estimated activation energy for the crystallization is 356 kJ mol^{-1}.

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The TTT (time-temperature-transformation) diagrams for dehydration and recrystallization of serpentine were obtained. The dehydration timescale was adopted from [2]. Considering that the decay of ^{26}Al with a half-life of 0.72 My is a possible heat source within parent bodies of Ryugu and Bennu in the early Solar System, the heating time scale should be shorter than 10 Myr. The diagram indicates that Bennu, with a clear infrared feature of hydrous minerals should not have experienced heating at >350 K on its parent body. Ryugu, with a subtle feature of hydrous minerals may have been heated at >450 K on its parent body. Fujiya et al. (2012) [3] estimated that within a 60-km sized asteroid accreted 3.5 Myr after the Solar System formation, the highest temperature is about 400 –450 K that lasts for 2 –3 Myr at 3 km distance from the center. If this is the case, most part of the asteroid was kept below 350 K, which could be similar to Bennu. In order to dehydrate Ryugu, its parent body may have been larger than 60 km in diameter or may have accreted earlier than 3.5 Myr after the Solar System formation with a more available heat source (^{26}Al).

References: [1] Yamamoto D. and Tachibana S. (2018) ACS Earth Space Chem. 2, 778–786. [2] Yamamoto D. (2016) Master thesis. [3] Fujiya W. et al. (2012) Nat. Commun. 3, 627(6 pp).

Keywords: thermal metamorphism, asteroid

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[J] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[P-EM19] Frontiers in the solar physics

convener:Shinsuke Imada(Institute for Space-Earth Environmental Research, Nagoya University), Takaaki Yokoyama(School of Science, University of Tokyo), Toshifumi Shimizu(Institute of Space and Astronautical Science, JAXA), Yukio Katsukawa(National Astronomical Observatory of Japan, National Institute of Natural Sciences), Chairperson:Shinsuke Imada

To date, we have three Japanese satellite missions to observe solar atmosphere, i.e., "Hinotori", "Yohkoh", and "Hinode", and revealed very dynamic nature of the solar atmosphere.These satellite observations allow us to see magnetic activities in the corona in X-ray, which cannot be obtained by ground-based telescopes. Also, thanks to seeing free condition, "Hinode" continuously observes the magnetic field in the photosphere. From these experiences, we have learned following three important requirements for the future missions to solve "coronal heating" and "solar flare" problems;1) seamless and simultaneous observation covering all temperature regimes from the photosphere to the corona, 2) high spatial and temporal resolution to resolve elemental structures and to track their evolution, 3) plasma diagnostic capability to quantify the dynamics of elementary processes. Recently, solar physics community in Japan proposed Solar-C_EUVST mission which is intended to be launched in middle of 2020s. Further, next-generation instruments, such as Parker Solar Probe (PSP), the Daniel K. Inouye Solar Telescope (DKIST), and SUNRISE will appear even before Solar-C_EUVST. Several proposals, e.g., PhoENiX, are also appearing. We will discuss in this session what we should study for further understanding of solar physics from current observations and numerical simulations and what we must prepare before 2020s. We welcome participations and presentations especially from Solar Terrestrial Physics (STP) community.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[PEM19-01] The Sun-Geospace connection: toward the 25th solar cycle

★Invited Papers

*Yoshizumi Miyoshi[1], Shinsuke Imada[1] (1.Institute for Space-Earth Environmental Research, Nagoya University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[PEM19-02] Unsolved problems of the solar wind turbulence

★Invited Papers

*Munehito Shoda[1] (1.Graduate School of Science, University of Tokyo)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[PEM19-03] The Solar-C_EUVST Epsilon mission

*Toshifumi Shimizu[1] (1.Institute of Space and Astronautical Science, JAXA)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[PEM19-04] Advanced Observations of the Solar Atmosphere by a Balloon-Borne Telescope SUNRISE-3

*Yukio Katsukawa[1], Carlos Quintero Noda[2], Masahito Kubo[1], Hirohisa Hara[1], Toshifumi Shimizu[2] (1.National Astronomical Observatory of Japan, 2.ISAS/JAXA)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[PEM19-05] Radiation magnetohydrodynamic modeling of solar coronal dynamics

*Haruhisa Iijima[1] (1.Institute for Space-Earth Environmental Research, Nagoya University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[PEM19-06] Detection and energy derivation of nano-flares based on deep learning

*Toshiki Kawai[1], Shinsuke Imada[1] (1.Institute for Space-Earth Environmental Research, Nagoya University)

The Sun-Geospace connection: toward the 25th solar cycle

*Yoshizumi Miyoshi[1], Shinsuke Imada[1]

1. Institute for Space-Earth Environmental Research, Nagoya University

One of the major goals of solar-terrestrial physics is to understand how the transfer of Sun and solar wind energy into the Geospace and vice versa. In the last decade, there have been several flagship missions in Geospace; NASA/THEMIS, Van Allen Probes, and MMS, and JAXA/Arase, making important contributions to our understandings of how the Geospace responds on variations of Sun and solar wind. Solar atmosphere is also observed and monitored by modern satellite, such as Hinode, and Solar Dynamics Observatory. The present solar cycle (cycle 24) is one of the weakest cycles in these 100 years. Existing missions successfully observe several abnormal phenomena during weak solar cycle, such as extremely low-density solar wind, strong asymmetry for solar polar magnetic field, or relatively weak geomagnetic activities. For example, large flux enhancements of the outer belt associated with huge magnetic storms have not observed in cycle 24. Further, a lot of cycle prediction studies suggest that next solar cycle (cycle 25) is also as weak as cycle 24. There are also several preexisting and under-preparing missions which will be flagship missions during solar cycle 25. In this presentation, we briefly review highlights from these missions and discuss what subjects are important for the next decade, i.e, the 25th solar cycle to understand coupling process between Sun and Earth.

Keywords: Sun-Geospace Coupling, Cycle 25

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Unsolved problems of the solar wind turbulence

*Munehito Shoda[1]

1. Graduate School of Science, University of Tokyo

The solar wind is characterized by fluctuations extending from MHD to kinetic scales and therefore is a unique laboratory of plasma turbulence. Despite a number of spacecraft missions for solar wind observation and numerical simulations, the solar wind turbulence involves several unsolved problems. These problems are related to problems in solar physics, including coronal heating and solar wind acceleration. In this talk, I will review unsolved problems of the solar wind turbulence and the latest understandings on them. Predictions for (and results of) Parker Solar Probe would also be discussed.

Keywords: MHD turbulence, MHD waves, solar wind acceleration

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The Solar-C_EUVST Epsilon mission

*Toshifumi Shimizu[1]

1. Institute of Space and Astronautical Science, JAXA

Solar-C_EUVST (EUV High-Throughput Spectroscopic Telescope) is a solar physics mission which mission concept proposal has been selected as a candidate for JAXA competitive M-class missions in July 2018. As a fundamental step towards answering how the plasma universe is created and evolves, and how the Sun influences the Earth and other planets in our solar system, the proposed mission is designed to comprehensively understand how mass and energy are transferred throughout the solar atmosphere. The onboard science instrument EUVST is an EUV spectrometerwith slit-jaw imaging system that will simultaneously observe the solar atmosphere from the photosphere/chromosphere up to the corona with seamless temperature coverage, high spatial resolution, and high throughput for the first time. It is designed to provide an answer to the most fundamental questions in solar physics: how fundamental processes lead to the formation of the solar atmosphere and the solar wind, and how the solar atmosphere becomes unstable, releasing the energy that drives solar flares and eruptions. The mission will be launched and installed to a sun-synchronous polar orbit by a JAXA Epsilon vehicle in the first half of 2025. The paper will provide the overall description of the mission concept, science, and the latest status.

Keywords: Solar outer atmosphere, EUV Spectroscopy, New mission plan

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Advanced Observations of the Solar Atmosphere by a Balloon-Borne Telescope SUNRISE-3

*Yukio Katsukawa[1], Carlos Quintero Noda[2], Masahito Kubo[1], Hirohisa Hara[1], Toshifumi Shimizu[2]

1. National Astronomical Observatory of Japan, 2. ISAS/JAXA

The solar chromosphere interfacing the solar surface (i.e. photosphere) and the corona is not a simple intermediate atmospheric layer transmitting magnetic energy, but a region where strong non-linearity drives dynamic phenomena, such as turbulence, shocks, and jets. Because the dynamics are likely to be responsible for injection of non-thermal energies into the corona and the solar winds, the chromosphere is one of the most important targets in the solar and stellar physics. It is necessary to quantitatively observe 3D magnetic and velocity fields to cover the dynamics in the chromosphere together with energy generation in the photosphere. We plan to acquire high-quality 3D magnetic and velocity fields for the first time by the SUNRISE-3 balloon-borne solar telescope planned for 2021. We are building a high precision spectro-polarimeter called SCIP (SUNRISE Chromospheric Infrared spectro-Polarimeter) to be installed in SUNRISE-3 for precise spectro-polarimetric observation of near-IR spectral lines sensitive to magnetic fields in the photosphere and the chromosphere. To interpret the SUNRISE-3 data, we are developing numerical modeling of the dynamic phenomenon in the solar atmosphere as well as tools to interpret radiative transfer through the atmosphere. The goal is to understand the conversion process of magnetic energies in the astrophysical plasma based on spatially resolved observations of the Sun.

Keywords: Sun, Chromosphere, Corona, Magnetic field, Balloon observation

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Radiation magnetohydrodynamic modeling of solar coronal dynamics

*Haruhisa Iijima[1]

1. Institute for Space-Earth Environmental Research, Nagoya University

We present highly dynamic simulations of solar corona that exhibit intermittent heating and brightening based on the radiation magnetohydrodynamic model. The recent development of observational instruments allows us to access a large amount of remote-sensing image of the solar atmosphere. Because of the high nonlinearity of the solar atmosphere, the interpretation of the observational data is becoming more difficult. One approach to overcome this difficulty of the observational interpretation is to compare the observational data with synthesized realistic numerical simulations more directly. Realistic model of the solar corona should take into accout various physical processes like the radiative transfer, non-ideal equation of states, and thermal conduction. Our radiation magnetohydrodynamic model RAMENS is one of such solvers that can model the realistic solar dynamics from the upper convection zone to the corona. Recently, we further develop this code by including the semi-relativistic correction of the Alfven wave and thermal conduction to avoid severe time stepping near the active region. This new code allows us to simulate the highly dynamic solar corona within a moderate numerical cost. In the presentation, we will report our implementation of the semi-relativistic correction and present new energetic coronal simulations.

Keywords: Sun, Corona, Simulation

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Detection and energy derivation of nano-flares based on deep learning

*Toshiki Kawai[1], Shinsuke Imada[1]

1. Institute for Space-Earth Environmental Research, Nagoya University

Coronal heating is one of the long-standing problems in solar physics. So far, two primary mechanisms have been proposed to explain how the corona is heated, namely small-scale magnetic reconnection and wave dissipation. To estimate the contribution of small-scale magnetic reconnection, so called nano-flares, to heat the corona is crucial to solve the coronal heating problem. The purpose of this study is to develop a method which can accurately detect nano-flares and estimate their energies. Firstly, we carry out one-dimensional hydrodynamic simulations of coronal loops heated by nano-flares which have wide range of energy ($10^{23} < E < 10^{27}$ erg). Secondly, we calculate the temporal variation of EUV and soft X-ray spectra of coronal loops from the simulation results by using CHIANTI atomic database. We perform these procedures more than 1,000 times with randomized flare energy and occurrence time to produce various datasets. Finally, we train a Deep Neural Network (DNN) by using these datasets to estimate the energy distribution and occurrence times of flares from soft X-ray observation. Moreover, we apply trained DNN to actual soft X-ray observations. As a result, we obtain reasonable occurrence times and energies of flares comparing another method which regards flare energy as change amount of thermal energy of the loop.

Keywords: deep learning, nano-flare

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[J] Oral | P (Space and Planetary Sciences)：P-AE Astronomy & Extrasolar Bodies

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | 105 1F

[P-AE20] Exoplanet

convener:Masahiro Ikoma(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Norio Narita(University of Tokyo), Chairperson:Norio Narita(University of Tokyo), Masahiro Ikoma(The University of Tokyo)

Exoplanetary science, which began with the discovery of a hot Jupiter in 1995, has reached a major turning point by the discovery of countless super-Earths by the Kepler mission. More recently, planets that are similar in size to the Earth and also receive similar amounts of stellar radiation (namely, located in the so-called habitable zone) have been discovered around nearby stars such as Proxima Centauri and TRAPPIST-1. As a result, not only theoretical, but also observational studies on the atmospheres and surface environments of Earth-like exoplanets have been started. Moreover, the number of planets discovered around early-type and late-type stars has become large enough that the occurrence rate and orbital distribution of planets around a wide variety of host stars have become clear. Thus, new observational insights, which become the basis of pan-planet formation theory, are now gathering. While exoplanets have been mainly targeted for astronomy until recently, it can be said that earth planetary science is finally becoming a research field to make a central contribution. In this session, we aim to share cutting-edge research results in exoplanetary science which is in such a transition period.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[PAE20-01] Gravitational Microlensing Surveys for Exoplanets

★Invited Papers

*Daisuke Suzuki[1] (1.Institute of Space and Astronautical Science / Japan Aerospace Exploration Agency)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[PAE20-02] Doppler planet searches targeting stars in solar neighborhood

★Invited Papers

*Bunei Sato[1] (1.Tokyo Institute of Technology)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[PAE20-03] Development of MuSCAT3 for ground-based follow-up observations of TESS candidate exoplanets

*Norio Narita[1,2,3], Akihiko Fukui[2], Masahiro Ikoma[2], Motohide Tamura[1,2], Nobuhiko Kusakabe[1], Mayuko Mori[2], Tomoyasu Yamamuro[4] (1.Astrobiology Center, 2.University of Tokyo, 3.JST, 4.OptCraft)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[PAE20-04] Effect of metallicity and eddy diffusion on transmission spectra of hazy exoplanet atmospheres

*Yui Kawashima[1], Masahiro Ikoma[2] (1.SRON Netherlands Institute for Space Research, 2.The University of Tokyo)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[PAE20-05] Mineral clouds of fluffy aggregates: how they form in exoplanetary atmospheres and influence transmission spectra

*Kazumasa Ohno[1], Satoshi Okuzumi[1], Ryo Tazaki[2] (1.Department of Earth and Planetary Science, Tokyo Institute of Technology, 2.Astronomical Institute, Tohoku University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[PAE20-06] Orbital Architecture of Planetary Systems Formed by Giant Impacts

★Invited Papers

*Eiichiro Kokubo[1] (1.Division of Theoretical Astronomy, National Astronomical Observatory of Japan)

Gravitational Microlensing Surveys for Exoplanets

*Daisuke Suzuki[1]

1. Institute of Space and Astronautical Science / Japan Aerospace Exploration Agency

Gravitational microlensing can detect cold planets beyond the snow line. It is sensitive to the planets down to the Earth mass. Thus, it is only microlensing among the current exoplanet detection methods that can probe the outer planets orbiting other stars. In this talk, we present the recent microlensing statistical study which finds a disagreement between the observed planet mass-ratio function and the prediction from the population synthesis models based on the core accretion model. The models predict 7 - 10 times fewer planets at mass-ratios of $10^{-4} < q < 10^{-3}$ than found by the microlensing observations. This implies that the formation of gas giants may involve more complicated processes than assumed by the standard core accretion theory. Or, it implies that the planet formation process may vary significantly as a function of host star mass, because the population synthesis models have been calibrated for planets around solar-type stars while microlensing observations are biased toward lower-mass stars.

We also present recent planet discoveries with mass constraint and/or measurement by using the space-based observations or 10m class telescopes. Finally, we introduce future, infrared microlensing surveys, such as the PRIME (PRime-focus Infrared Microlensing Experiment) project and NASA’s WFIRST (Wide Field Infrared Survey Telescope) microlensing survey.

Keywords: Exoplanets, Gravitational Microlensing

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Doppler planet searches targeting stars in solar neighborhood

*Bunei Sato[1]

1. Tokyo Institute of Technology

A precise Doppler measurement is one of the powerful techniques to detect planets orbiting stars. The technique is applicable to the detection of planets with a wide range of orbital parameters, such as semimajor axis and eccentricity, mass, and host stars. The planets detected by the Doppler surveys can thus help us to gain a general understanding of planet formation and evolution. Furthermore, given the high detection efficiency of planets of the Doppler technique compared to transit ones, it is highly useful to search for planets around stars in solar neighborhood.

We have been conducting Doppler planets searches for planets around nearby giant stars, that is evolved intermediate-mass stars, for about 20 years with 188cm telescope and High Dispersion Echelle Spectrograph (HIDES) of Okayama observatory. We have also started intensive Doppler monitoring of nearby bright solar-type stars at Okayama aiming to explore low-mass planets in their habitable zones. Thanks to refurbishment of the HIDES last year, we can now achieve a Doppler precision better than 1 m/s. In this February, a new planet search program targeting nearby low-mass M-type dwarfs was launched with use of the new InfraRed Doppler instrument (IRD) of Subaru 8.2m telescope. The program aims at detecting earth-mass planets in their habitable zones as well as uncovering population of planets around them. Here we report the latest results from these planet-search programs and discuss future prospects.

Keywords: Doppler technique, nearby stars, habitable zone, earth-mass planets

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Development of MuSCAT3 for ground-based follow-up observations of TESS candidate exoplanets

*Norio Narita[1,2,3], Akihiko Fukui[2], Masahiro Ikoma[2], Motohide Tamura[1,2], Nobuhiko Kusakabe[1], Mayuko Mori[2], Tomoyasu Yamamuro[4]

1. Astrobiology Center, 2. University of Tokyo, 3. JST, 4. OptCraft

NASA's Transiting Exoplanet Survey Satellite (TESS), launched on 2018 April 18, will start its survey for northern sky from 2019 summer. TESS is expected to find a large number of candidate transiting exoplanets after 2019 autumn.
Toward the start of the northern sky survey, we are now developing a 4-color simultaneous camera MuSCAT3 for the 1.2m telescope located in the Fred Lawrence Whipple Observatory on Mt. Hopkins in Arizona, USA. This is a successor of existing multi-color simultaneous cameras MuSCAT1/2 on the 188cm telescope in Okayama, Japan and on the 1.52m telescope in Tenerife, Canaries, Spain. MuSCAT3 will work with MuSCAT1/2 and enable 24-hour multi-color simultaneous imaging/photometry in the northern hemisphere. This is the one and only multi-color transit observation network in the world as of 2019. Thereby, we can conduct intensive ground-based follow-up observations rapidly after TESS's data releases, and can lead in discriminating and finding true interesting transiting planets in the world.
In this presentation, we will introduce the specifications of MuSCAT3 and the 1.2m telescope, and present prospects of MuSCAT3 development and synergies with TESS and MuSCAT1/2.

Keywords: exoplanets, transit, instrument, TESS

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Effect of metallicity and eddy diffusion on transmission spectra of hazy exoplanet atmospheres

*Yui Kawashima[1], Masahiro Ikoma[2]

1. SRON Netherlands Institute for Space Research, 2. The University of Tokyo

Recently, properties of exoplanet atmospheres have been constrained via multi-wavelength transit observation, which measures an apparent decrease in stellar brightness during planetary transit in front of its host star (called transit depth). Sets of transit depths so far measured at different wavelengths (called transmission spectra) for some exoplanets are featureless or flat, inferring the existence of haze particles in the atmospheres. Previous studies that addressed theoretical modeling of transmission spectra of hydrogen-dominated atmospheres with haze used some assumed distribution and size of haze particles. In Kawashima & Ikoma (2018), we developed new photochemical and microphysical models of the creation, growth, and settling of haze particles for deriving their size and number-density distributions in close-in warm (< 1000 K) exoplanet atmospheres.

In this study, we explore the dependence of the production rate of haze and the resultant transmission spectra on metallicity and eddy diffusion coefficient. We find that the photodissociation rates of the hydrocarbons, which are related to the haze monomer production rate, are basically smaller for higher metallicity in spite of their increased abundances. This is because of the enhanced photon-shielding effect by the major photon absorbers, H_2O, CO, CO_2, and O_2, existing at higher altitudes than the hydrocarbons. Thus, the transmission spectrum for higher metallicity atmosphere is less affected by haze. We also find that the efficient eddy diffusion yields a steep Rayleigh-scattering slope in the optical and more prominent molecular-absorption features, which is the dependence opposite of condensation clouds.

Keywords: Atmospheres, Transmission spectra, Haze, Metallicity, Eddy diffusion

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Mineral clouds of fluffy aggregates: how they form in exoplanetary atmospheres and influence transmission spectra

*Kazumasa Ohno[1], Satoshi Okuzumi[1], Ryo Tazaki[2]

1. Department of Earth and Planetary Science, Tokyo Institute of Technology, 2. Astronomical Institute, Tohoku University

Observations of transmission spectra have suggested ubiquity of high-altitude clouds in exoplanetary atmospheres. Recent theoretical studies have examined the formation of high-altitude clouds; however, they usually need to assume vigorous vertical mixing to explain the observations, which is orders of magnitude stronger than that suggested from general circulation models. The discrepancy might be caused by an assumption of the compact spheres for cloud particles adopted in previous studies. Because the hot environment of exoplanets leads to the formation of mineral condensates, they potentially grow into fluffy aggregates with very low sedimentation velocity that can be easily transported to high altitude. In this study, we investigate the influences of the particle porosity on vertical profiles of the clouds using a microphysical model taking into account the vertical transport, particle growth, and porosity evolution of cloud particles. We will demonstrate that the particle density can be lower than the material density by 2–3 orders of magnitude. As a result, the vertical extent of the clouds is potentially much larger than that expected in previous studies. We also calculate synthetic transmission spectra with fluffy-aggregate clouds. The fluffy-aggregate clouds largely obscure molecular signatures in the spectra and produce a characteristic spectral slope in visible to near-infrared wavelength. Finally, we compare the synthetic spectra with the transmission spectrum of GJ1214b, a super-Earth suggested to have clouds at ~0.01mbar in pressure, and find that the observed spectra can be explained by the mineral cloud of fluffy aggregates if atmospheric metallicity is higher than 100 times solar abundance. The predicted high atmospheric metallicity might encapsulate information about the formation process of GJ1214b.

Keywords: Exoplanet, Cloud, Transmission spectrum

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Orbital Architecture of Planetary Systems Formed by Giant Impacts

*Eiichiro Kokubo[1]

1. Division of Theoretical Astronomy, National Astronomical Observatory of Japan

In the standard scenario, the final stage of terrestrial planet formation is giant impacts among protoplanets. In this stage protoplanets gravitationally scatter each other and collide until the system reaches a stable configuration. We investigate the final orbital architecture of planetary systems realized by this process by *N*-body simulation. We find that the ratio between the physical and Hill radii of protoplanets determines the system architecture and it becomes compact and dynamically cold as the ratio increases. We also compare the results with the oribital architecture of exoplanetary systems.

Keywords: terrestrial planets, giant impacts

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[J] Oral | P (Space and Planetary Sciences)：P-AE Astronomy & Extrasolar Bodies

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | 105 1F

[P-AE20] Exoplanet

convener:Masahiro Ikoma(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Norio Narita(University of Tokyo), Chairperson:Masahiro Ikoma(The University of Tokyo), Norio Narita(University of Tokyo)

Exoplanetary science, which began with the discovery of a hot Jupiter in 1995, has reached a major turning point by the discovery of countless super-Earths by the Kepler mission. More recently, planets that are similar in size to the Earth and also receive similar amounts of stellar radiation (namely, located in the so-called habitable zone) have been discovered around nearby stars such as Proxima Centauri and TRAPPIST-1. As a result, not only theoretical, but also observational studies on the atmospheres and surface environments of Earth-like exoplanets have been started. Moreover, the number of planets discovered around early-type and late-type stars has become large enough that the occurrence rate and orbital distribution of planets around a wide variety of host stars have become clear. Thus, new observational insights, which become the basis of pan-planet formation theory, are now gathering. While exoplanets have been mainly targeted for astronomy until recently, it can be said that earth planetary science is finally becoming a research field to make a central contribution. In this session, we aim to share cutting-edge research results in exoplanetary science which is in such a transition period.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[PAE20-07] Thermal convection in the mantle of super-Earths

★Invited Papers

*Takehiro Miyagoshi[1], Masanori Kameyama[2], Masaki Ogawa[3] (1.Japan Agency for Marine-Earth Science and Technology, 2.Ehime University, 3.University of Tokyo)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[PAE20-08] Atmospheric escape from M-dwarf exoplanets and implications for habitability

*Chuanfei Dong[1] (1.Princeton University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[PAE20-09] Theoretical emission spectra of hot rocky super-Earths: Lack of alkali metals due to atmospheric escape

*Yuichi Ito[1,2], Masahiro Ikoma[2] (1.Department of Cosmosciences, Graduate school of Science, Hokkaido University, 2.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[PAE20-10] Hot Rocky Super-Earths atmospheres, a revision of gas phase metal chemistry and the relevance of reverse chemistry

*Sebastian Danielache[1,2], Takahashi Yuta[1], Miguel Yamila[3], Simoncini Eugenio[4], Grassi Tommaso[5] (1.Department of Materials & Life Sciences, Faculty of Science & Technology, Sophia University, 2.Tokyo Institute of Technology, Earth-Life Institute , 3.Leiden Observatory, Leiden University, 4.Simoncini Telai Gambassi Terme, 5.University Observatory Munich, Ludwig-Maximilians-University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[PAE20-11] A Climate of tidally locked terrestrial exoplanets

*Takanori Kodama[1] (1.University of Bordeaux)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[PAE20-12] Current status of WSO-UV/UVSPEX for discovery of Earth-like planets

*Shingo Kameda[1], Osada Naoya[1], Takanori Kodama[2], Go Murakami[3], Keigo Enya[3], Masahiro Ikoma[4], Norio Narita[5], Naoki Terada[6], Hitoshi Fujiwara[7] (1.School of Science, Rikkyo University, 2.University of

Bordeaux, 3.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency,
4.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo,
5.National Astronomical Observatory of Japan, 6.Graduate School of Science, Tohoku University,
7.Faculty of Science and Technology, Seikei University)

Thermal convection in the mantle of super-Earths

*Takehiro Miyagoshi[1], Masanori Kameyama[2], Masaki Ogawa[3]

1. Japan Agency for Marine-Earth Science and Technology, 2. Ehime University, 3. University of Tokyo

Thermal convection in the mantle of super-Earths is one of the most important issues to understand their thermal history and surface environment. It is also linked to the habitability of planets because it controls the plate motion, material circulation, the vigor of core convection and planetary dynamos, and so on.

One of the most important differences between the Earth’s and super-Earth’s interior is that there is a strong adiabatic compression effect in super-Earths. Usually, this effect is ignored in modelling the dynamics in the mantle of the Earth because the effect is small in the Earth. However, this effect becomes strong as the size of planets increases so it cannot be ignored in large planets. In this paper we introduce our results of numerical simulation studies of thermal convection in super-Earths (up to ten times the Earth’s mass) with this effect (Miyagoshi et al., 2014; 2015; 2017; 2018). We also take account for high Rayleigh number which is relevant for super-Earths, and temperature-dependent viscosity contrast and depth-dependent thermal expansion coefficient.

We found that the activity of ascending hot plumes is lowered as the planetary size increases. In contrast, the activity of cold plumes is not lowered even in large planets. The efficiency of heat transport by thermal convection is significantly lowered compared with the results with Boussinesq approximation in which there is no adiabatic compression and which is often used in models for the Earth. We also found the convective regime diagram in massive super-Earths (ten times the Earth’s mass) and how the threshold between stagnant-lid regime and weak-viscosity-contrast regime is determined.

We also found the effects of adiabatic compression become substantial when the planetary mass exceeds about 4 times the Earth’s mass. The plate thickness increases and the convective velocity is almost constant as the planetary mass increases. These results are in a striking contrast with earlier predictions that are made by the Boussinesq approximation models.

We also explored the thermal evolution process in massive super-Earths (ten times the Earth’s mass). At initial the shallow mantle of the planet is hotter than expected from the adiabatic extrapolation from the deep mantle, as expected when the planet is formed from giant impact. We found that the influences of an initial temperature distribution continue extremely long in massive super-Earths. In our case, transient layered convection caused by the initial temperature distribution continues for as long as several to ten billion years before it yields to a whole layer convection.

Our results suggest that the tectonic activities such as plate motion and hot spot volcanisms hardly occur as planetary size increases. The planetary magnetic field is expected to be not so strong in massive super-Earths because of the weak efficiency of heat transport by the mantle convection. In addition, especially in massive super-Earths, special attention for the extremely long transient stage which is affected by the initial temperature distribution is necessary to discuss details of its interior and tectonic activities.

Keywords: super-Earths, mantle convection, adiabatic compression

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Atmospheric escape from M-dwarf exoplanets and implications for habitability

*Chuanfei Dong[1]

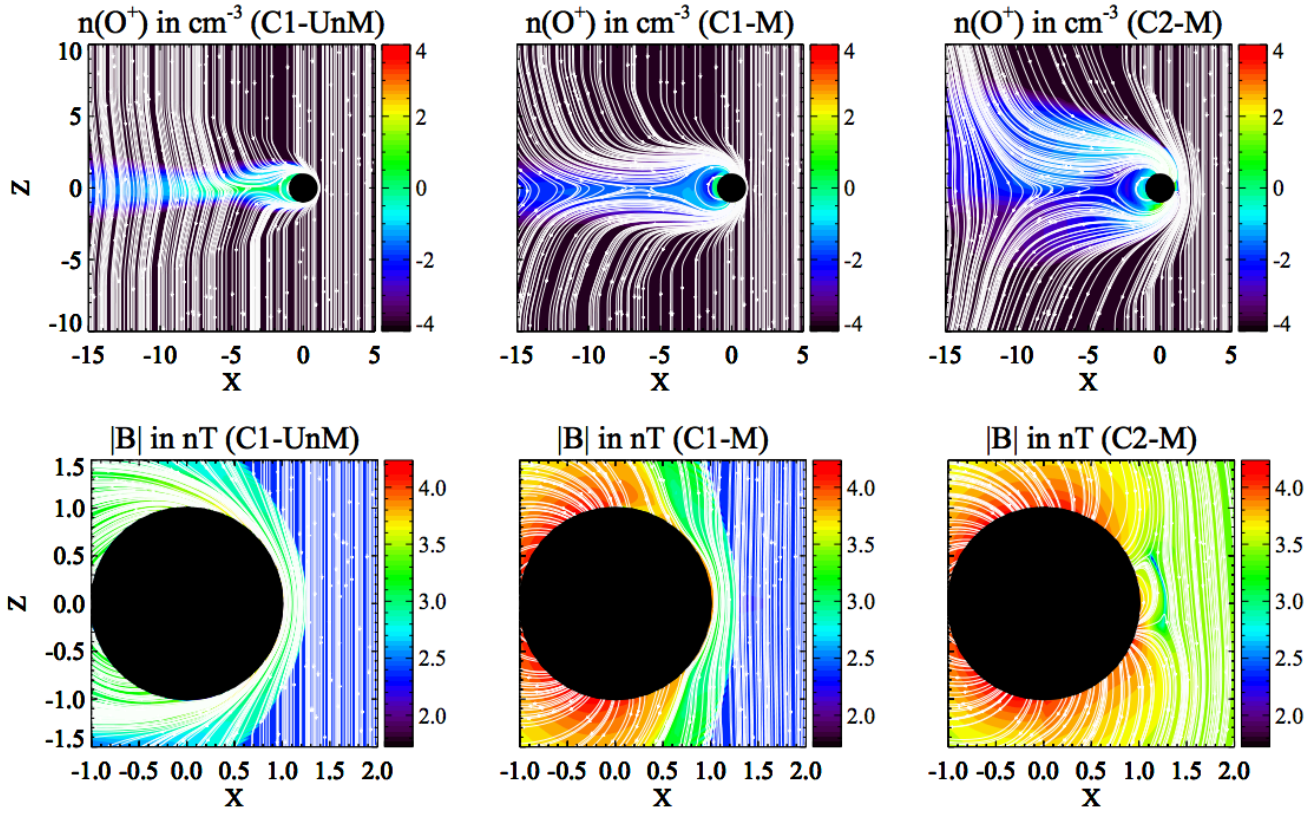
1. Princeton University

In the last two decades, the field of exoplanets has witnessed a tremendous creative surge. Research in exoplanets now encompasses a wide range of fields ranging from astrophysics to heliophysics and climate science. One of the primary objectives of studying exoplanets is to determine the criteria for habitability, and whether certain exoplanets meet these requirements. The classical definition of the Habitable Zone (HZ) is the region around a star where liquid water can exist on the planetary surface given sufficient atmospheric pressure. However, this definition largely ignores the impact of the stellar wind and stellar magnetic activity on the erosion of an exoplanet's atmosphere. Amongst the many factors that determine habitability, understanding the mechanisms of atmospheric loss is of paramount importance.

We will discuss the impact of exoplanetary space weather on the long-term climate evolution and habitability, which offers fresh insights concerning the habitability of exoplanets, especially those orbiting M-dwarfs, such as Proxima b and the TRAPPIST-1 planets. I will focus on a wide range of atmospheric compositions, ranging from exo-Venus candidates to ocean worlds; the latter being a unique class of planets with water-rich surfaces and atmospheres that do not currently exist in our Solar system. For each of these cases, we will demonstrate the importance of the exoplanetary space weather on atmospheric ion loss and habitability.

Keywords: atmospheric escape, planetary habitability, M-dwarf exoplanets, stellar wind and magnetic activity, Proxima b, the TRAPPIST-1 planets

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Theoretical emission spectra of hot rocky super-Earths: Lack of alkali metals due to atmospheric escape

*Yuichi Ito[1,2], Masahiro Ikoma[2]

1. Department of Cosmosciences, Graduate school of Science, Hokkaido University, 2. Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo

Until today, over 1000 exoplanets whose radii are less than 2 Earth radii have been discovered. About 50% of those planets have radiative equilibrium temperatures high enough to melt and vaporize rock. Thus, if rocky like CoRoT-7b, they likely have atmospheres composed of rocky materials (e.g., Schaefer & Fegley 2009, Ito et al.2015). We call such a rocky vapor atmosphere a mineral atmosphere in this study. In addition, previous studies showed that atmospheric loss processes such as atmospheric escape cause selective depletion of Na and K in the atmosphere and magma ocean, because of the high-volatility and low abundance of Na and K in rocks. Also, our new 1-D hydrodynamic model of the highly UV-irradiated mineral atmosphere (Ito & Ikoma, in prep) suggests that the hydrodynamic escape is massive enough to remove completely Na and K during the early stage of the host star. Thus, the detection of a mineral atmosphere would provide definitive evidence that the planet is rocky. Moreover, identifying the mineral atmosphere composition, especially the presence or absence of Na and K, would give constraints on the magma composition which could trace not only the interior but evolution of planets.

In this study, we focus on the temperature-pressure structure and detectability for emission spectra of the mineral atmosphere in hydrostatic equilibrium on a hot rocky super-Earth. Also, we investigate the impact of the selective depletion of Na and K on the thermal structure and emission spectra. In order to investigate it, we use the hydrostatic/radiative/chemical equilibrium atmospheric model for mineral atmospheres (Ito et al. 2015) which calculates the gas-melt equilibrium composition of the mineral atmosphere, vertical thermal structure and secondary eclipse depths. We show our results for higher planetary equilibrium temperature (2500, 3000K) such as CoRoT-7 b and Kepler-10 b. We find that the thermal inversion structure of the mineral atmosphere without Na and K is hotter than that of the atmosphere with Na and K. This is mainly because the atmosphere inefficiently emits photons in visible wavelength region due to the lack of Na and K. Our feasibility assessment demonstrates that identification of mineral atmospheres with and without Na and K on hot rocky super-Earths in secondary transit is possible via observation from space telescopes.

Keywords: Exoplanet, Atmosphere, Terrestrial planet

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Hot Rocky Super-Earths atmospheres, a revision of gas phase metal chemistry and the relevance of reverse chemistry

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1. Department of Materials & Life Sciences, Faculty of Science & Technology, Sophia University, 2. Tokyo Institute of Technology, Earth-Life Institute , 3. Leiden Observatory, Leiden University, 4. Simoncini Telai Gambassi Terme, 5. University Observatory Munich, Ludwig-Maximilians-University

There are approximately 2600 reported exoplanets. Among these celestial bodies there is a class of super-Hearts with an orbit smaller than Mercury (0.387 AU) know as Hot Rocky Super-Earths (HRSE). The proximity of this rocky type of planets to their parent start means that their surface can be similar to Bulk Silicate Earth (BSE) at high temperatures. Currently, there are few attempts to estimate the atmospheric composition and chemistry of a HRSE.

Keywords: Hot Rocky Super-Earths, Atmospheric Chemistry

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A Climate of tidally locked terrestrial exoplanets

*Takanori Kodama[1]

1. University of Bordeaux

Most of the studies for habitable planets focus on to determine the boundary of the habitable zone. From observation of exoplanet, planets with mass between the Earth and super-Earth around low-temperature star have been discussed. The rotation of such a planet is locked due to the tidal effect from the central star because they locate near the central star.

On most of the previous studies, they used one-dimensional climate models and estimated the habitable zone assuming water-rich planets, like the Earth. Recently, studies of habitable climate using a three-dimensional climate model have begun. They show that the habitable zone estimated by 3D GCM (three-dimensional general circulation model) is greatly different from that by the 1D climate model. The most important difference is the distribution of cloud in the planetary atmosphere. A terrestrial planet with liquid water on the surface around a low-temperature star has clouds in high altitude around the sub-stellar point, leading higher albedo. As a result, it can maintain a warmer climate if it is located out of the habitable zone estimated by a 1D climate model. However, when the rotation period of a planet is short enough, the pattern of the circulation changes to the super-rotation. In this case, no such clouds are formed around the sub-stellar point.

I investigate the pattern of the circulation and habitability for TRAPPIST-1 d and Proxima Centauri b. Additionally, I also investigate the effect of the distribution of water on the planetary surface on the formation of cloud.

Keywords: Habitable exoplanets

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Current status of WSO-UV/UVSPEX for discovery of Earth-like planets

*Shingo Kameda[1], Osada Naoya[1], Takanori Kodama[2], Go Murakami[3], Keigo Enya[3], Masahiro Ikoma[4], Norio Narita[5], Naoki Terada[6], Hitoshi Fujiwara[7]

1. School of Science, Rikkyo University, 2. University of Bordeaux, 3. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 4. Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 5. National Astronomical Observatory of Japan, 6. Graduate School of Science, Tohoku University, 7. Faculty of Science and Technology, Seikei University

The World Space Observatory for Ultraviolet (WSO-UV) is an orbital optical telescope with a 1.7-m diameter primary mirror currently under development. The WSO-UV is aimed to operate in the 115- to 310-nm UV spectral range. Its two major science instruments are UV spectrographs and UV imaging field cameras with filter wheels. The WSO-UV project is currently in the implementation phase, with a tentative launch date in 2023. As designed, the telescope field of view in the focal plane is not fully occupied by instruments. Recently, two additional instruments devoted to exoplanets have been proposed for WSO-UV, which are the focus of this paper. UVSPEX, a UV-spectrograph for exoplanets, aims to determine atomic hydrogen and oxygen abundance in the exospheres of terrestrial exoplanets. The spectral range is 115 to 130 nm, which enables simultaneous measurement of hydrogen and oxygen emission intensities during an exoplanet transit. A study of exosphere transit photometric curves can help differentiate among different types of rocky planets. The exospheric temper- ature of an Earth-like planet is much higher than that of a Venus-like planet because of the low mixing ratio of the dominant coolant (CO2) in the upper atmosphere of the former, which causes a large difference in transit depth at the oxygen emission line. Thus, whether the terrestrial exoplanet is Earth-like, Venus-like, or other can be determined.

Keywords: exoplanet, terrestrial planet, upper atmosphere

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[J] Oral | P (Space and Planetary Sciences)：P-CG Complex & General

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | 201B 2F

[P-CG23] Origin and evolution of materials in space

convener:Hitoshi Miura(Graduate School of Natural Sciences, Department of Information and Basic Science, Nagoya City University), Hideko Nomura(Department of Earth and Planetary Sciences, Tokyo Institute of Technology), Takafumi Ootsubo(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Aki Takigawa(Division of Earth and Planetary Science, Kyoto University), Chairperson:Ryo Tazaki, Aoi Takahashi

Recent progresses of astronomical observations, laboratory experiments, solar-system exploration, and theoretical work have enabled us to attempt to understand the origin and evolution of materials (dust and gas) in space in the context of material science. It is thus important to link further planetary material science and astronomy for comprehensive understanding of dust and gas in space and their role in evolution of galaxies, stars, and planetary systems. In this session, based on latest results on astronomical observations, experiments, and theoretical studies on materials in space, we discuss next steps in science for materials in space.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[PCG23-01] Origin of cosmic dust: Galaxy-scale perspective

★Invited Papers

*Akio Inoue[1,2] (1.Osaka Sangyo University, 2.Waseda University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[PCG23-02] SPICA and future infrared observations of cosmic matters

★Invited Papers

*Issei Yamamura[1] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[PCG23-03] Engineering first light of a new mid-infrared instrument MIMIZUKU

*Takafumi Kamizuka[1], Takashi Miyata[1], Shigeyuki Sako[1], Ryou Ohsawa[1], Masahito S. Uchiyama[1], Tomohiro Mori[1], Yutaka Yoshida[1] (1.Institute of Astronomy, School of Science, the University of Tokyo)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[PCG23-04] Properties and space exposure of Quenched Nitrogen-included Carbonaceous Composite (QNCC)

*Izumi Endo[1], Itsuki Sakon[1], Takashi Onaka[1], Yoko Kebukawa[2], Kensei Kobayashi[2], MITA Hajime[4], Hajime Yano[3] (1.University of Tokyo, 2.Yokohama National University, 3.ISAS/JAXA, 4.Fukuoka Institute of Technology)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[PCG23-05] Shape dependence of dust absorption opacity in the Rayleigh domain

*Ryo Tazaki[1], Hidekazu Tanaka[1] (1.Astronomical Institute, Tohoku University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[PCG23-06] Modeling of the H_2 ortho-para spin conversion on grain surfaces in star- and planet-forming regions

*Kenji Furuya[1], W. M. C. Sameera[2], Tetsuya Hama[2], Naoki Watanabe[2], Yuri Aikawa[3] (1.Center for Computer Sciences, University of Tsukuba, 2.Institute of Low Temperature Science, Hokkaido University,, 3.The University of Tokyo)

Origin of cosmic dust: Galaxy-scale perspective

*Akio Inoue[1,2]

1. Osaka Sangyo University, 2. Waseda University

Galaxies are the fundamental component of the Universe. In the Milky Way Galaxy and other galaxies in the present (i.e. nearby) Universe, the mass ratio of dust and stars integrated over a galaxy-scale is about 0.1%. On the other hand, in the Universe several hundreds million years after the Big Bang, some galaxies have been detected in dust with ALMA but others haven't. The dust-to-stellar mass ratio integrated in a galaxy-scale is distributed over more than an order of magnitude. In this talk, I will discuss the reason of this diversity in dust mass in the early Universe and the origin of dust in a galaxy-wide scale.

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SPICA and future infrared observations of cosmic matters

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1. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency

SPICA (Space Infrared Telescope for Cosmology and Astrophysics) is an ESA-JAXA joint mission for infrared astrophysics. The main goal of the mission is to make significant contribution to answer the essential questions; how the universe has evolved to the current state of being rich in metals and cosmic dust, and how our solar system involving life has formed and developed.
SPICA is equipped with a 2.5 m telescope operated at cryogenic temperature (8 K). Three scientific instruments on board are SPICA Mid-infrared Instrument (SMI), SPICA Far-infrared Instrument (SAFARI) and Magnetic field explorer with Bolometric Polarimeter (B-BOP). SMI covers 18-36 μm with spectral resolutions R~100 or 2000, and 12-18 μm with R~28000 and it is also capable of imaging at 34 μm. SAFARI observes 34-230 μm in four wavelength bands at spectral resolution of R~300 or 2000-11000. B-BOP carries out imaging polarimetry at 100, 200, and 350 μm.
Thanks to the cryogenic telescope and the cutting-edge sensor technique, SPICA will realize sensitivity two orders of magnitude better than that in the previous missions such as Herschel. Significant fraction of the observing time will be open to the committee as proposal-based observations. Various celestial objects can be targets for observation with SPICA. For instance, high-quality spectroscopic data of trans-Neptunian objects and planet-forming circumstellar disks may clarify detailed formation process of our solar system. Observation of circumstellar dust of mass-losing stars at various environments will inform us how the cosmic dust are provided into our universe.
SPICA was selected as one of three candidates for ESA Cosmic Vision M5 mission from 25 proposals in May 2018, and it is currently under conceptual design. JAXA is a major partner, and will provide cryogenic payload module (PLM) and SMI. SAFARI and B-BOP are provided by the European consortia. The final selection of M5 will be in mid 2021, and the launch is expected to be late 2020's.

Keywords: Infrared, Space Mission, Dust

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Engineering first light of a new mid-infrared instrument MIMIZUKU

*Takafumi Kamizuka[1], Takashi Miyata[1], Shigeyuki Sako[1], Ryou Ohsawa[1], Masahito S. Uchiyama[1], Tomohiro Mori[1], Yutaka Yoshida[1]

1. Institute of Astronomy, School of Science, the University of Tokyo

The University of Tokyo is currently constructing an observatory, the University of Tokyo Atacama Observatory (TAO), in the Atacama Desert in Chile. The site is located at the summit of Cerro Chajnantor, whose altitude is 5640 m. The high altitude and the dry climate decrease the water vapor in the atmosphere (Precipitable Water Vapor <0.5 mm) and improve the atmospheric transmittance in the infrared region. Therefore, the site is one of the most ideal places for infrared observations on the ground. By placing a large-aperture telescope (6.5 m in diameter) at the site, we make the TAO a cutting-edge facility for infrared observational astronomy. The Mid-Infrared Multi-field Imager for gaZing at the UnKnown Universe (MIMIZUKU) is the first-generation mid-infrared instrument for the TAO. The main features of MIMIZUKU are: 1) wide wavelength coverage from 2 to 38 microns, 2) high-spatial resolution, and 3) accurate calibration of the atmospheric absorption. The wide wavelength coverage is achieved by installing three optical channels, NIR, MIR-S, and MIR-L, covering 2.0-5.3, 6.8-26, and 24-38 microns, respectively. Each channel can perform imaging and low-resolution spectroscopic observations. The high spatial resolution is achieved by the large-aperture telescope, which determines diffraction-limited spatial resolution. The calibration accuracy of the atmospheric absorption is improved by installing a special optical device called Field Stacker. The Field Stacker has three movable mirrors and is placed on the telescope focal plane. The mirrors pick off the light from two sky regions and combines them into one field. Then, we can observe two different sky regions simultaneously. By using this function, we can perform simultaneous observations of scientific target and reference object. Simultaneous observations allow us to compensate the time variation of the atmospheric absorption and improve accuracy of its calibration. If this function successfully works, we can realize stable and accurate observations even in wavelength regions with low atmospheric transmittance, like ozone absorption region around 9.6 microns and long-wavelength mid-infrared regions in >20 microns.

Ahead of the completion of the TAO, planned around late-2020, engineering observations of MIMIZUKU were carried out at the Subaru telescope in July and December, 2018. In these observations, the functions of the MIR-S channel and the Field Stacker device were tested. As for the imaging functions, the spatial resolutions in the N- and Q-bands were confirmed to be 0.32 and 0.59 arcsec, respectively. It means that MIMIZUKU can achieve diffraction-limited images in the mid-infrared regions. As for the spectroscopic functions, spectral resolutions for the N- and Q-band modes were measured to be 180 and 100, respectively. These are consistent with the designed values. In addition, the effectiveness of the Field Stacker on the calibration of the atmospheric absorption were also confirmed. It was found that we can reduce the photometric uncertainty to a few percent even under the condition where the photometric count varies with >10 % (p-v) due to the atmospheric variation. As for the spectroscopy, Q-band spectroscopic observations, which have been difficult in ground-based observations, were realized. We found that the atmospheric absorption can be calibrated with the Field Stacker and that we can get spectra in 17-24.5 microns with fluctuations less than 5%.

These capabilities enable us to perform wide-wavelength spectroscopic monitoring observations. Such observations are useful to investigate time variation of temperature and amount of dust produced by dust-forming events around evolved stars like red giants and supernovae. In this presentation, we will

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report the results of the engineering observations and future prospects of the observational studies on dust formation process using MIMIZUKU.

Keywords: Ground mid-infrared observations, Monitoring observations, Dust formation, The University of Tokyo Atacama Observatory (TAO), MIMIZUKU

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Properties and space exposure of Quenched Nitrogen-included Carbonaceous Composite (QNCC)

*Izumi Endo[1], Itsuki Sakon[1], Takashi Onaka[1], Yoko Kebukawa[2], Kensei Kobayashi[2], MITA Hajime[4], Hajime Yano[3]

1. University of Tokyo, 2. Yokohama National University, 3. ISAS/JAXA, 4. Fukuoka Institute of Technology

Organics are abundant in the present universe. However, we have limited knowledge on their origin and how they have contributed to life in solar system. The Unidentified Infrared (UIR) bands are ubiquitously seen in the various astronomical environments and should be important signals to understand how the primitive form of organics has emerged in the universe because the carriers of the bands are generally believed to be organic species. We have, for the first time, succeeded in synthesizing laboratory organics called Quenched Nitrogen-included Carbonaceous Composite (QNCC) whose infrared properties successfully reproduce the characteristics of the UIR bands observed around classical novae. We have found that N/C ratio (atom) of QNCC is 3-5% based on the measurement with Elemental Analyzer/Isotope Ratio Mass Spectrometer (EA/IRMS). X-ray Absorption Near Edge Structure (XANES) analysis of QNCC have indicated that amine (C-N) structures are contained in the QNCC. We have concluded that amine structures contribute to the broad feature around 8μm which characterize the UIR bands observed around classical novae. The broad band around at 8μm seen in infrared absorption spectra of QNCC is also seen in those of insoluble organic matter (IOM) in carbonaceous chondrites. N/C ratio of QNCC is almost consistent with that of IOM (2-5%). Therefore, QNCC is an important material to investigate the origin of primitive organics in solar system.
Based on above results we have launched a new space exposure experiment of QNCC using ExHAM (Exposed Experiment Handrail Attachment Mechanism) on the International Space Station (ISS) / Japanese Experiment Module ‘Kibo’. This space exposure experiment aims to verify the hypothesis that organics which originates in evolved stars have delivered and contributed to primitive organics in solar system by investigating the changing in properties of QNCC exposed in solar neighborhood space environment and comparing with those of organic matter contained in meteorites. In this presentation, we will report the nature of QNCC which is the strong candidate of the carriers of the UIR bands observed around classical novae and the latest progress of space exposure experiment of QNCC.

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Shape dependence of dust absorption opacity in the Rayleigh domain

*Ryo Tazaki[1], Hidekazu Tanaka[1]

1. Astronomical Institute, Tohoku University

In various astrophysical environments, dust absorption opacity must be assumed to estimate dust mass by observations. Cosmic dust particles often have radii smaller than FIR or more longer wavelengths, and hence, they are typically in the Rayleigh domain at these observing wavelengths. It is known that absorption opacity in the Rayleigh domain sensitively depends on the shape of dust particles. In this study, we study how dust coagulation alters absorption opacity in the Rayleigh domain by using the T-Matrix Method. We find that higher-order terms of harmonic expansion of the electromagnetic field must be taken into account to reproduce strong field appearing around contact points between monomer particles. As a result, we show that coagulation can enhance dust absorption opacity by a factor of about 2 for silicate and about 5 for carbonaceous particles. We discuss appropriate approximate methods to mimic the shape effect of dust absorption opacity.

Keywords: Non-spherical dust particles, Absorption opacity, T-Matrix Method

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Modeling of the H_2 ortho-para spin conversion on grain surfaces in star- and planet-forming regions

*Kenji Furuya[1], W. M. C. Sameera[2], Tetsuya Hama[2], Naoki Watanabe[2], Yuri Aikawa[3]

1. Center for Computer Sciences, University of Tsukuba, 2. Institute of Low Temperature Science, Hokkaido University,, 3. The University of Tokyo

Hydrogen is the most abundant element in the universe. In star- and planet-forming regions, hydrogen is primary present in H_2, which has two nuclear spin configurations, ortho and para. As the internal energy difference between ortho-H_2 and para-H_2 (170 K) is much higher than the typical temperature of star-forming regions (around 10 K), the H_2 ortho-to-para ratio (OPR) can affect the chemical evolution, including deuterium fractionation, significantly.

H_2 molecules form on grain surfaces with the statistical OPR of three. The ortho-para spin conversion proceeds through proton exchange reactions with H^+ and/or with H_3^+ in the gas phase. Laboratory experiments have found that the H_2 spin conversion can also occur on bare grains and on amorphous water ice in laboratory timescales (around a few hours). Given this very short timescale, it has been thought that the spin conversion on surfaces affects the H_2 OPR evolution in star- and planet-forming regions. However, its efficiency in the astronomical conditions remains unclear; almost all H_2 is present in the gas phase rather than on grain surfaces, and thus the spin conversion timescale of overall H_2 (i.e., gas + solid) via the spin conversion on surfaces depends on how efficiently gaseous and solid H_2 interact.

We investigate the efficiency of the H_2 spin conversion on grain surfaces under physical conditions that are relevant to star- and planet forming regions. We utilize the rate equation model that considers adsorption of gaseous H_2 on grain surfaces which have a variety of binding sites with different potential energy depth, thermal hopping and desorption of adsorbed H_2, and the spin conversion. We find that the conversion efficiency depends on H_2 gas density and surface temperature. As a general trend, increased H_2 gas density reduces the conversion efficiency, while the temperature dependence is not monotonic; there is a critical temperature at which the efficiency is maximum. We will discuss whether the spin conversion on surfaces can dominates over that in the gas-phase in star- and planet-forming regions.

Keywords: H2 molecule, Ortho-to-para ratio, Star- and planet-forming regions

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[J] Oral | P (Space and Planetary Sciences)：P-CG Complex & General

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | 201B 2F

[P-CG23] Origin and evolution of materials in space

convener:Hitoshi Miura(Graduate School of Natural Sciences, Department of Information and Basic Science, Nagoya City University), Hideko Nomura(Department of Earth and Planetary Sciences, Tokyo Institute of Technology), Takafumi Ootsubo(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Aki Takigawa(Division of Earth and Planetary Science, Kyoto University), Chairperson:Kenji Furuya, Yuki Hibiya

Recent progresses of astronomical observations, laboratory experiments, solar-system exploration, and theoretical work have enabled us to attempt to understand the origin and evolution of materials (dust and gas) in space in the context of material science. It is thus important to link further planetary material science and astronomy for comprehensive understanding of dust and gas in space and their role in evolution of galaxies, stars, and planetary systems. In this session, based on latest results on astronomical observations, experiments, and theoretical studies on materials in space, we discuss next steps in science for materials in space.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[PCG23-07] Thermal processes of primary silicate dust in protoplanetary disk: Constraints from oxygen isotope exchange kinetics between amorphous silicate and water vapor

★Invited Papers

*Daiki Yamamoto[1], Shogo Tachibana[2], Noriyuki Kawasaki[1], Minami Kuroda[1], Naoya Sakamoto[3], Hisayoshi Yurimoto[1,4] (1.Department of Natural History Sciences ,Hokkaido University, 2.UTokyo Organization for Planetary Space Science, The University of Tokyo , 3.Creative Research Institution, Hokkaido University , 4.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[PCG23-08] Birth-place of comet 17P/Holmes from its mass fractions of minerals

★Invited Papers

*Shinnaka Yoshiharu[1], Takafumi Ootsubo[2], Hideyo Kawakita[1], Mitsuru Yamaguchi[1], Mitsuhiko Honda[3], Jun-ichi Watanabe[4] (1.Kyoto Sangyo University, 2.JAXA/ISAS, 3.Kurume University, 4.NAOJ)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[PCG23-09] Comparison of grain properties in interplanetary dust from different types of parent bodies by mid-infrared spectroscopic observations with AKARI

*Aoi Takahashi[1], Takafumi Ootsubo[2], Hideo Matsuhara[2], Fumihiko Usui[3], Itsuki Sakon[4], Hiroki Chihara[5] (1.The Graduate University for Advanced Studies, 2.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 3.Kobe University, 4.University of Tokyo, 5.Osaka Sangyo University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[PCG23-10] Formation of forsterite crystal induced by ultraviolet irradiation of water ice ice on amorphous Mg_2SiO_4 particles

*Akira Kouchi[1], Yuki Kimura[1], Yasuhiro Oba[1], Tetsuya Hama[1], Naoki Watanabe[1], Shogo Tachibana[2], Akira Tsuchiyama[3], Satomi Enju[3], Takafumi Ootsubo[4] (1.Institute of Low Temperature Science, Hokkaido University, 2.UTokyo Organization for Planetary and Space Science, University of Tokyo, 3.Graduate School of Science, Kyoto University, 4.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[PCG23-11] Condensation experiments in the sytem Fe-Mg-Si-O-S using induction thermal plasma: implication to GEMS forming condition

*Satomi Enju[1], Hayate Kawano[1], Hisashi Komaki[2], Akira Tsuchiyama[1] (1.Department of Earth and Planetary Sciences, Graduate School of Science, Kyoto University, 2.JEOL Ltd.)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[PCG23-12] The initial abundance of ^{92}Nb in the outer solar system.

*Yuki Hibiya[1,2], Tsuyoshi Iizuka[2], Hatsuki Enomoto[2] (1.Japan Agency for Marine-Earth Science and Technology, 2.The University of Tokyo)

Thermal processes of primary silicate dust in protoplanetary disk: Constraints from oxygen isotope exchange kinetics between amorphous silicate and water vapor

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Mass-independent oxygen isotope variations of extraterrestrial materials is considered to be a result of oxygen isotope exchange between ^{16}O-rich primitive materials and ^{16}O-poor gaseous reservoirs (Yurimoto & Kuramoto, 2004; Lyons & Young, 2005). Because the isotope exchange rate is controlled by the physicochemical condition of protoplanetary disks, oxygen isotopic compositions of extraterrestrial materials could be a good tracer for the disk conditions. However, little has been known about the kinetics of isotope exchange reaction for oxygen in the disks. We focused on oxygen isotope evolution of amorphous silicate dust, which is recognized as primitive material in protoplanetary disks, and investigated oxygen isotope exchange kinetics between amorphous silicates and water vapor.

A series of oxygen isotope exchange experiments between submicron-sized grains of amorphous silicate with forsterite and enstatite stoichiometry and ^{18}O-enriched water vapor (97% ^{18}O) were carried out at 803–1123 K and water vapor pressure (P_{H2O}) of 0.01–1 Pa using a gold-mirror vacuum furnace equipped with a gas flow system (Yamamoto & Tachibana, 2018). The run products were analyzed with FT-IR (JASCO FT-IR 4200), XRD (Rigaku SmartLab), and FE-SEM (JEOL JSM-7000F). The bulk oxygen isotope composition was determined as an average of multiple measurements for a pelletized sample by SIMS (Cameca ims-6f and -1280HR).

An infrared absorption peak of amorphous silicate at ~10 micron shifted to longer wavelengths with time by annealing with $H_2{}^{18}O$ vapor of 0.3 Pa at 803–883 K for amorphous forsterite and at 923–1003 K for amorphous enstatite, whereas such a shift was not observed for samples annealed in the presence of isotopically normal water vapor of 0.3 Pa. The relative peak shifts of the 10 micron feature of amorphous forsterite and enstatite correlate with their oxygen isotopic compositions, suggesting that the peak shift was caused by the isotope exchange of oxygen between amorphous silicates and $H_2{}^{18}O$ vapor. Temporal change of the degree of isotope exchange under these conditions was governed by diffusive isotope exchange with the isotope exchange rate of D ($m^2\ s^{-1}$) = (1.5 ±1.0) $\times 10^{-19}$exp[−161.5 ±14.1 (kJ mol^{-1}) R^{-1} (1/T−1/1200)] for amorphous forsterite and D ($m^2\ s^{-1}$) = (5.0 ±0.2) $\times 10^{-21}$exp[−161.3 ±1.7 (kJ mol^{-1}) R^{-1} (1/T−1/1200)] for amorphous enstatite. At P_{H2O}= 0.01 Pa, the isotope exchange reaction for amorphous forsterite is controlled by a supply of water vapor at 853 and 883 K, and the supply-controlled isotope exchange rate was evaluated. Crystallization of amorphous forsterite dominated over oxygen isotope exchange at a higher temperature of 1073 K because crystallization precedes the oxygen isotope exchange reaction. The oxygen isotope exchange timescales for amorphous forsterite and enstatite dust under protoplanetary disk conditions suggest that the primary oxygen isotope signatures of amorphous silicate dust would be erased by thermal annealing at temperatures above 500–650 K within the lifetime of protoplanetary disks.
Cometary silicate dust collected by the Stardust mission has ^{16}O-poor isotopic compositions close to the

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terrestrial value (McKeegan et al., 2006; Nakamura et al., 2008). If primitive silicate dust in the protosolar disk has the same ^{16}O-rich composition as the Sun, this observation implies that comets accreted silicate dust that was thermally processed at temperature above ~500–650 K in the inner Solar System and transported to the comet formation region (e.g., Nuth, 1999; Ciesla, 2007). This could also explain that presolar silicate grains are not a major component in cometary silicates (Floss et al., 2013). The effective radial transport of inner disk materials to the outer part of protoplanetary disks may provide some constrains on the dynamics of protoplanetary disks prior to planet formation.

Keywords: amorphous silicate, dust, oxygen, isotope exchange, protoplanetary disk

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Birth-place of comet 17P/Holmes from its mass fractions of minerals

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Comets are considered as the most pristine icy small objects in the solar system. They are likely to have kept the information about the solar system formation. Physical properties of cometary dust grains and composition of cometary volatiles are precious clues to physico-chemical conditions of the solar nebula. Comet 17P/Holmes is a Jupiter-family comet with an orbital period of ~7 yrs. Comet Holmes exhibited a great outburst starting on UT 2007 October 23 when the comet was 2.5 au from the Sun and five months after the perihelion passage. Because the observed relative abundance ratios of volatiles with respect to water in comet Holmes are enriched compared with other comets (Dello Russo et al. 2016, Icarus, 278, 301), it is thought that the nucleus of comet Holmes formed at a further distance from the Sun in the solar nebula (SN).

Silicate grains in the interstellar space are considered almost in amorphous form (only a few percent of mass or less is considered as crystalline for silicate; Kemper et al. 2004, ApJ, 609, 826). However, abundant crystalline silicate grains have often been found in cometary grains (up to ~80% by mass with large variety among comets; Hanner et al. 1994, ApJ, 425, 274; Wooden et al. 1999, ApJ, 517, 1034; Ootsubo et al. 2007, P&SS, 55, 1044, and references therein). It is thought that these crystalline silicates in comets formed by annealing of interstellar amorphous silicate grains or by direct condensation of gaseous materials in a hot region of the SN, and incorporated into cometary nuclei after they were transported to the cold comet-forming region (several to 30 au from the Sun). In this scenario, it is expected that mass fraction of the crystalline silicates in cometary dust grains tends to be smaller at further distances from the Sun.

We discuss the possibility that comet Holmes formed in a colder region in the SN rather than other comets based on the mass fraction of crystalline silicates in silicate grains. We derived mineral abundances in comet Holmes by applying the thermal emission model for cometary dust grains (Ootsubo et al. 2007, P&SS, 55, 1044; Shinnaka et al. 2018. AJ, 156, 242) to the mid-infrared spectra of comet Holmes taken with the COMICS on the Subaru Telescope from UT 2007 October 25 to 28. The derived mass fraction ratios of crystalline silicate of comet Holmes (~30%) is the almost smallest among comets studied in previous articles, supporting the hypothesis that comet Holmes formed at a further distance from the Sun in the SN compared with other comets. At such a cold region, hyper volatile ices like CO and amorphous water ices (possible energy sources for explosive sublimation) would be abundant.
This work was supported by JSPS grants (15J10864 and 17K05381).

Keywords: Comet, Mineral abundance, Mid-infrared

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Comparison of grain properties in interplanetary dust from different types of parent bodies by mid-infrared spectroscopic observations with AKARI

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Interplanetary dust (IPD) diffusely distributes in interplanetary space and is thought to be recently supplied from the inside of primordial planetesimals like asteroids or comets. The IPD’ s grain properties, such as compositions and crystal morphologies, depend on the types of parent bodies and can give us the information on the environment in the proto-solar system. The properties can be investigated in terms of silicate features around 10 μm seen in the zodiacal emission spectra. Since the IPD originating from different types of the parent bodies have different spatial distributions, it is important to survey the silicate features at various sky directions. For example, the asteroidal IPD locally distributes at low specific ecliptic latitudes and observed as band structures near the ecliptic plane. On the other hand, because of the variety of comets' inclinations, the cometary IPD distributes more globally than the asteroidal IPD does. The IPD from theJupiter Family Comets (JFCs) can form the dust cloud with a broad distribution in ecliptic latitudesaround the ecliptic plane, while the IPD from the Oort Cloud Comets (OCCs) is expected to distribute isotropically.

We obtained the high signal-to-noise zodiacal emission spectra at 74 different directions of the sky by using the mid-infrared slit-spectroscopic data obtained with the Infrared Camera on board the Japanese AKARI satellite. They exhibit the excess emission feature at the 9-12 μm range and even some sharp peaks. In order to identify the constituents, we compared the shape of spectral featureswith absorption coefficients of 4 types ofcandidate materials: amorphous with olivine composition, amorphous with pyroxene composition, forsterite (Mg2SiO4, one of olivine crystals), and ortho-enstatite (MgSiO3, one of pyroxene crystals).

The IPD was found to typicallyinclude small silicate crystals, especially enstatite grains with extreme crystal morphologies. We also found that the shape of spectral features slightly changesdependingon the sky directions.As the result of the investigation into peak wavelengths and the excess strength of each peak, the IPD at the higher ecliptic latitudes seems to have lower olivine/(olivine+pyroxene) ratio.At the sky directions toward the asteroidal dust band structures, the feature shapes show a difference which cannot be explained only by the difference in theolivine/(olivine+pyroxene) ratioand may indicate contamination of the hydrated minerals.

We will present the results of the grain properties of the IPD originating from some types of the parent bodies, and give the implications for the environment in the proto-solar system.

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Formation of forsterite crystal induced by ultraviolet irradiation of water ice ice on amorphous Mg_2SiO_4 particles

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In comets, both crystalline and amorphous silicates have been observed by infrared telescopes. It has been proposed that crystalline silicates were formed by annealing of amorphous silicates, direct condensation in hot region of proto-solar nebula, or heating due to radical recombination in organic refractory mantle. In the present study, we have experimentally investigated another possibility, heating due to radical recombination in water ice by ultraviolet (UV) irradiation.

Three amorphous silicate fine particles made by gas condensation using induction thermal plasma (ITP) were used as starting materials: Mg_2SiO_4, $MgSiO_3$, and GEM-like composition (SiO_2-rich). Amorphous fine particles were put on amorphous Si thin film (5 nm in thickness), and cooled to 10 or 82 K in ultra-high vacuum transmission electron microscope. Amorphous water ice was prepared by vapor-deposition on the sample, and irradiated with a D_2 lamp. During UV irradiation, structural change was observed by electron diffraction.

We observed the formation of forsterite crystals from amorphous Mg_2SiO_4 at 82 K, whereas the crystallization did not occur at 10 K. No crystalline phase was observed for amorphous $MgSiO_3$ and amorphous GEM-like silicate at 10 and 82 K.

These results could be explained by radical-radical recombination reactions following the photodissociation of water molecules by UV-rays, reactions (1) and (2),

$H_2O + UV \rightarrow OH + H.$ (1)

$OH + H \rightarrow H_2O + 4.8$ eV. (2)

The formation of forsterite crystals can be induced by the energy released by reaction (2) only for amorphous Mg_2SiO_4, because the value of 4.8 eV is sufficiently larger than the activation energy for crystallization of amorphous Mg_2SiO_4 (3-4 eV), but smaller than that of amorphous $MgSiO_3$ (9 eV) and amorphous GEM-like silicate. No forsterite formation at 10 K may be explained by the low mobility of H atoms and OH radicals at the ice/Mg_2SiO_4 interface at 10 K, which strongly decrease the efficiency of reaction (2) compared with 82 K.

From these results, we propose a new route for the formation of crystalline forsterite in cometary coma by solar UV irradiation with ice-covered amorphous Mg_2SiO_4 particles. Comparison with observation will be presented.

Keywords: Amorphous silicate, Photochemical reaction, Crystallzation, Forsterite

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Condensation experiments in the sytem Fe-Mg-Si-O-S using induction thermal plasma: implication to GEMS forming condition

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GEMS (Glass embedded metal and sulfides) are the major component of CP-IDPs, which are thought to be one of the most primitive materials in the solar system [1]. Synthetic experiments based on the condensation model [1] are performed to form GEMS analogue particles [2, 3], but systematic experiments including sulfur are not performed so far. In this study, synthetic experiments are performed in the system Fe-Mg-Si-O-S, with systematic change in redox condition, to understand the GEMS forming condition.

Induction thermal plasma (ITP) system was used for the condensation experiment. This system creates high temperature plasma (up to 10^4 K) which evaporates the starting material, and forms condensates in the rapid cooling environments. Plasma gas is Ar and He, with chamber pressure 70 kPa. Starting material are mixture of powder regents (SiO_2, Si, MgO, Fe, FeS_2) with GEMS mean composition [1]. Redox condition change by SiO_2/Si ratio and feeding rate (fd) of the starting material. 10 experiments are performed in total. Products were analyzed by X-ray diffraction, scanning electron microscope and transmission electron microscope.

Products were composed of fine grained condensates and coarse grained evaporation residues (1-100 μm). All condensates were formed of amorphous silicate (AS) spheres, 10-100 nm in diameter. They coexist with Fe bearing particles (<30 nm), inside and on the surface of the AS. Condensates were categorized into the following five types.

A: Fe-rich AS, including Fe metal particles

B: Fe-rich AS, with FeS particles on the surface

C: Fe-rich AS showing biphasic separation texture, with FeS particles on the surface

D: Fe-poor AS showing biphasic separation texture, with Fe particles coexisting with FeS on the surface

E: Fe-poor AS showing biphasic separation texture, with Fe_3Si (gupeiite) particle coexisting with MgS (niningerite) or FeS particles on the surface

Type A, B and C were observed in the oxidative experiment, type A and D in the intermediate experiment and type E in reductive experiment.

Formation process was considered, taking into account the grain formation process model [4]. As a basic process, AS condensates first, followed by Fe particles and finally formation of sulfides. In oxidative condition, some Fe are taken into AS as FeO (type A, B), and for the lack of Fe in gas, Fe particles did not condensate or minor condensates sulfidated into FeS (Type B, C). If there was abundant Fe in gas, Fe particles condensates on the surface of AS at relatively high temperature above glass transition temperature, and moves inside the melt before sulfidation due to surface energy (type A). In reductive

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condition, Fe is scarcely included in AS (type D, E). In type D, Fe metal particles condensates on the surface of the AS glass and partially sulfidized. Type E is the most reductive condition, Fe_3Si occurring instead of Fe metal, with MgS and FeS.

In this study, synthesized condensates had some of the features of GEMS, but condensates completely similar to GEMS (Fe-poor AS including many Fe metal particles, with FeS on the surface) was not observed. Considering the formation model in the study, GEMS is thought to be formed in the redox condition similar to type C-D. In their formation, Fe particles condensates at relatively high temperature on the surface of AS and moves inside the melt (like type A), and condensation of Fe particles continues at the surface of the AS below glass transition temperature, which is followed by sulfidation.

[1] Keller and Messenger (2011) GCA, 75, 5336-5365. [2] Matsuno (2015) Ph.D. thesis. [3] Kim et al. (2017) ISPC, 23, P2-33-7, abstract. [4] Yamamoto and Hasegawa (1977) Progress of Theoretical physics vol. 58, No. 3.

Keywords: GEMS, condensation, Induction thermal plasma

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The initial abundance of ^{92}Nb in the outer solar system.

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Introduction: The *p*-process radionuclide niobium-92 (^{92}Nb) decays to zirconium-92 (^{92}Zr) by electron capture with a half-life of 37 million years (Ma). The system is a promising chronometer for addressing the early solar system evolution and planetary differentiation [1, 2]. Thus, the initial abundance of ^{92}Nb and its distribution in the early solar system provide valuable constraints on the time-scale of our solar system evolution, and on the origin of *p*-process nuclides. The initial ^{92}Nb abundance at the solar system formation was previously determined to be $(^{92}Nb/^{93}Nb)_0 = (1.7 \pm 0.6) \times 10^{-5}$, applying the internal isochron approach to the NWA 4590 angrite (U–Pb age: 4557.93 ±0.36 Ma) [2]. This value is consistent with those obtained from eucrites, ordinary chondrites, and mesosiderites [1, 3], indicating that ^{92}Nb was homogeneously distributed among their source regions. Yet, all samples previously studied for ^{92}Nb are thought to have originated from the inner solar system. Here we report internal Nb–Zr isochron dating of Northwest Africa (NWA) 6704.
NWA 6704 is a primitive achondrite having a fresh igneous texture [4] with a U–Pb age of 4562.76 ±0.30 Ma [6]. This meteorite underwent melting above liquidus temperature and subsequent rapid cooling (> 10^{-1} °C/yr; [4]), making the effect of differing closure temperatures between the U–Pb and Nb–Zr systems insignificant. Furthermore, this meteorite has $\Delta^{17}O$, $\varepsilon^{50}Ti$, $\varepsilon^{54}Cr$ and $\varepsilon^{84}Sr$ values similar to those of carbonaceous chondrites [4-6], indicating that it samples the same reservoirs in the solar nebula as the carbonaceous chondrite parent bodies (i.e., the outer solar system). Thus, NWA 6704 enables us to evaluate the distribution of ^{92}Nb between the inner and outer solar system for the first time.

Results & Discussion: We prepared mineral and whole rock fractions from five fragments of NWA 6704. All Nb–Zr isotopic data were obtained by the ICP mass spectrometry. The isochron defines an initial $^{92}Nb/^{93}Nb$ of $(2.8 \pm 0.3) \times 10^{-5}$ at the time of NWA 6704 formation. By combining this value with the U–Pb age of NWA 6704, an initial $^{92}Nb/^{93}Nb$ of $(3.0 \pm 0.3) \times 10^{-5}$ at the time of solar system formation is derived. The obtained value is distinctly higher than the initial value in the inner solar system of $(1.7 \pm 0.6) \times 10^{-5}$ [2]. This indicates that ^{92}Nb was heterogeneously distributed in the protoplanetary disk before the formation of NWA 6704, and was relatively enriched in the outer solar system. The difference between these two initial values causes the apparent Nb–Zr age difference of ~30 Ma, demonstrating that the current canonical value of $(^{92}Nb/^{93}Nb)_0 = (1.7 \pm 0.6) \times 10^{-5}$ should not be used for the Nb–Zr dating of planetary materials from the outer solar system. The newly obtained initial $^{92}Nb/^{93}Nb$ value is clearly higher than the expected value in the model of ^{92}Nb synthesis by Type Ia supernova (SNIa) [7]. Thus, our results require another production site to be invoked for selectively producing ^{92}Nb. At the moment, only the ν-process in Type II supernova (SNII) [8] satisfies such requirement. If so, our finding suggests that the time-interval from the last SNII explosion to the formation of our solar system needs be <100 My and that nuclides synthesized by the last SNII were preferentially implanted or preserved in the outer solar system. Such enrichment of the last SNII components in the outer solar system may account for the isotopic dichotomy between carbonaceous and non-carbonaceous meteorites [e.g., 9].

References: [1] Schönbächler et al. (2002), [2] Iizuka et al. (2016), [3] Haba et al. (2017), [4] Hibiya et al. (2019) *GCA.*, [5] Amelin et al. (2019), [6] Hibiya et al. (2019) *GGR.*, [7] Lugaro M. et al. (2016), [8] Hayakawa et al. (2013), [9] Warren (2011).

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Keywords: niobium-92, short-lived radionuclide, p-process, ν-process, Type II supernova, isotopic dichotomy

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | 301A 3F

[A-AS06] Progress in dense observation and numerical modeling of micro-scale meteorology

convener:Junshi Ito(Atmosphere and Ocean Research Institute, The University of Tokyo), Kentaro Araki(Meteorological Research Institute), Jun-ichi Furumoto(Research Institute for Sustainable Humanosphere, Kyoto University), Kuniaki Higashi(Research Institute for Sustainable Humanosphere, Kyoto University Metroweather Co., Ltd.), Chairperson:Junshi Ito(The University of Tokyo), Kentaro Araki(Meteorological Research Institute)

Recent progresses in observations and numerical simulations enable to unveil details in micro- or sub-kilometer scale meteorology. Low level convergences and heat island effects in the micro-scale may be sometimes associated with extreme atmospheric phenomena such as wind gusts and torrential rainfalls. Numerical simulations with very fine resolution may even predict occurrences of such phenomena. This session is welcome to researches and future scopes in the field of micro-scale meteorology.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[AAS06-01] A Linear Array of Wind and Pressure Sensors for High Resolution in situ Measurements in Winter Tornadoes

★Invited Papers

*Kusunoki Kenichi[1], Hanako Inoue[1], Naoki Ishitsu[2], Chusei Fujiwara[3] (1.Meteorological Research Institute, 2.Alpha-denshi Co., Ltd. / Meteorological Research Institute, 3.East Japan Railway Company)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[AAS06-02] Mesoscale fixed point weather observation architecture by Drone fleet

*Yuichi Yaguchi[1], Masayuki Itaha[4], Shuzo Nakano[3], Kazuhiko Yamagishi[2], Tatsuya Iyobe[5] (1.The University of Aizu, 2.e-Robotics Fukushima Co., Ltd., 3.East-Japan Accounting Center Co., Ltd., 4.Japan Environment Research Co., Ltd., 5.Iyobe Shoji Ltd.)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[AAS06-03] Potential of dense weather event observation using surface optical fiber cable and DAS technology

*Tsunehisa KIMURA[1] (1.Schlumberger)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[AAS06-04] Case study of environmental conditions and cloud microphysical properties of winter convective clouds developed in the Kanto plain

*Kentaro Araki[1], Shinsuke Satoh[2], Takuya Tajiri[1] (1.Meteorological Research Institute, 2.National Institute of Information and Communications Technology)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[AAS06-05] Numerical simulation of the urban effect on the atmospheric boundary layer structure in Tokyo using the SPUC urban canopy scheme

*Naoko Seino[1] (1.Meteorological Research Institute)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[AAS06-06] Surface layer model for instantaneous wind speeds designed by deep learning

*Junshi Ito[1,2], Hideaki Mouri[2] (1.Atmosphere and Ocean Research Institute, The University of Tokyo , 2.Meteorological Research Institute)

A Linear Array of Wind and Pressure Sensors for High Resolution in situ Measurements in Winter Tornadoes

*Kusunoki Kenichi[1], Hanako Inoue[1], Naoki Ishitsu[2], Chusei Fujiwara[3]

1. Meteorological Research Institute, 2. Alpha-denshi Co., Ltd. / Meteorological Research Institute, 3. East Japan Railway Company

The Shonai area railroad weather project has investigated fine-scale structure of wind gust dynamics and kinetics such as tornadoes, downbursts, and gust fronts. As part of the project, in order to improve our understanding of near-surface tornadic features, we developed a linear array of wind and pressure sensors (**LAWPS**: **L**inear **A**rray of **W**ind and **P**ressure **S**ensors) for high resolution in situ measurements in winter tornado cores. The wind and pressure sensors were deployed along a 1.2-km-long linear array that is located parallel to and about 100m from the shoreline. Wind data are obtained using 12 two-dimensional fast-response ultrasonic anemometers placed at a height of 5 m at intervals of 100 m. Pressure data are obtained using 25 barometers placed at a height of 50cm at intervals of 50 m. The pressure ports are designed and loaded to the barometers to reduce the dynamic pressure associated with wind and turbulence. Sampling intervals for both wind and pressure measurements are 100 msec and the sampling are synchronized by the external trigger from data logging computer. In this presentation, the system overview and the measurement technique will be described.

Keywords: winter tornado, A Linear Array of Wind and Pressure Sensor

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Mesoscale fixed point weather observation architecture by Drone fleet

*Yuichi Yaguchi[1], Masayuki Itaha[4], Shuzo Nakano[3], Kazuhiko Yamagishi[2], Tatsuya Iyobe[5]

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To know the generation mechanism of low clouds in the troposphere, we need to place a weather sensor with a certain density in the space of the radius from 2 to 20 km and from 1000 to 2000 meters altitude as the mesoscale meteorological observations. Such the studies of meteorological observations such as Mesonets (Rezaul. MAHMOOD, et. al., 2017) in the United States, and also studied in Japan (Kazuo SAITO, 2012), measure the weather information from the ground and satellites as the mesoscale meteorological observations. For practically, this information is used as a high-precision weather forecast with simulation (Kazuo SAITO, 2016). However, SODAR and LIDAR used for observation from the ground have limitations on the degree to measure wind direction and wind power (Dimitrios V. KANELLOPOULOS, 2016, Yoshiki ITO, 2009). Radiosonde is possible to measure the wind direction and force, but it has also limitation to sense from 2000 to 10000 meters because it cannot be placed directly at a specific point and can only obtain point information in chronological order. Although observations using aircraft can obtain temperature and humidity, it is difficult to correctly obtain wind direction and force based on the moving speed of the aircraft and turbulence of air current caused by the aircraft itself. The satellite sensor is one of the strong tool for large-scale meteorological measurement, but the spatial resolution is about 1.5 km and it is very difficult to sense a small area (Ryosuke NIWA, 2009).

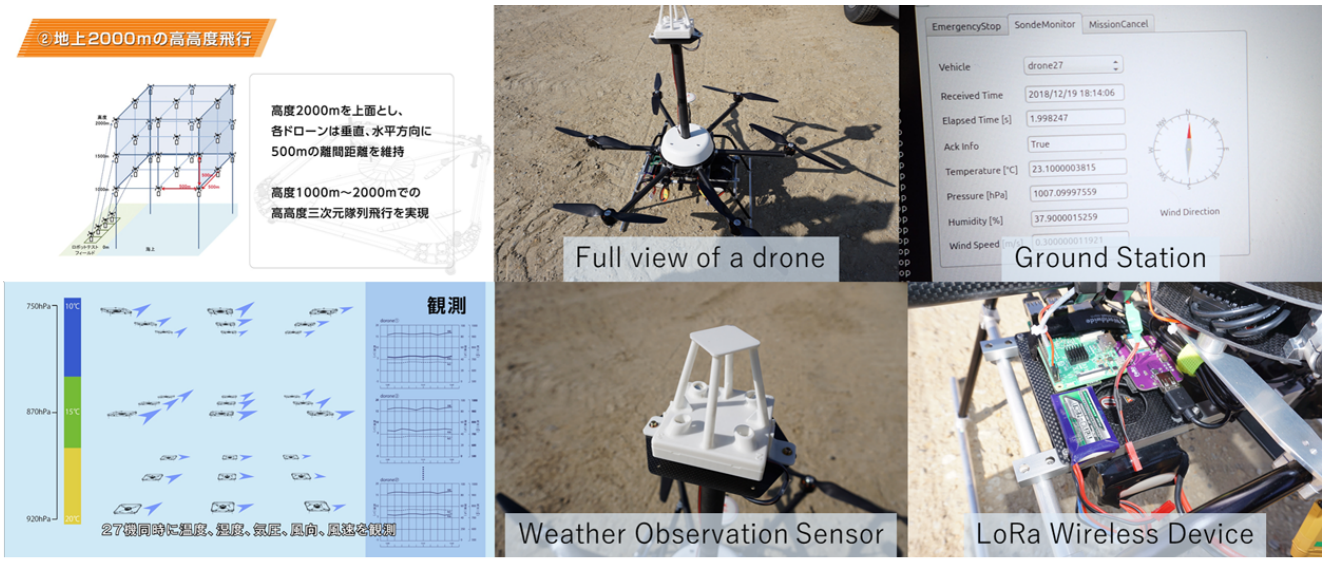
In this research, in order to solve these problems by direct measurement, we propose a technique to measure using unmanned aerial vehicles at the same time. Specifically, six-propellers multicopter, generally called a drone which can hover for about 30 minutes per one and has a wind resistance of 20 m/s is manufactured, and a portable weather observation device utilizing ultrasonic wave is installed here. This meteorological observation device calculates the wind direction and wind force by calculating biaxial wind force by using ultrasonic waves. In addition, we install atmospheric temperature, humidity and barometer on weather observation equipment, and store on the payload computer a drone a measurement that is equal to or higher than the radiosonde. This meteorological observation device is raised by a mast to a height that does not affect disturbance of draft airflow measured in advance and measures it. In addition, the data accumulated in the payload computer are organized at about once every second, and it is transmitted to the ground from the 920 MHz compact power-saving radio station based on the LoRa modulation method and it is possible to display in real time. We can sense weather information at a fixed point on the mesoscale by aggregating this data at the same time at multiple sites through the Internet. In addition, since multi-copiers are out of the category of light aircraft of the aeronautical law up to 25 kg weight, we can easily skip to the altitude prescribed by the aeronautical law at the present time. However, since the altitude aimed for this research is to fly at a height where the clouds can reach from 1000 m to 2000 m, it is necessary to negotiate with the Ministry of Land, Infrastructure and Transport and air traffic control in advance.

As an actual demonstration, it was verified whether the drone of a single machine can be raised to an altitude of 500 m, 1000 m, 1500 m, 2000 m, respectively, and real time measurement can be performed. In the experiment conducted between 6:30 and 7:00 in the morning on 20, 21, 22 December 2018, the wind speed on the ground was about 3 to 5 m/s, but at the altitude of 1500 m it was 13 m / s For the first time. In addition, we confirmed that such information is transmitted to the ground in real time and can be

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viewed directly. Moreover, using another drone equipped with the equivalent system, 27 drones flying into mesh type of 3 x 3 x 3 at intervals of 30 m in a space up to 100 m in height, verified to stay at the fixed point, succeeded doing. Using these combinations makes it possible to observe a fixed point in a wide area.

Keywords: Drone fleet, Simultaneous fixed point observation, Mesoscale weather observation



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Potential of dense weather event observation using surface optical fiber cable and DAS technology

*Tsunehisa KIMURA[1]

1. Schlumberger

Distributed acoustic sensing (DAS) technology is introduced in the oil and gas industry from around 2011 for monitoring pipelines and sensing intruders. In recent years, application of the latest optical fiber sensing technology using differential phase data called heterodyne distributed vibration sensing (hDVS) has made it possible to acquire the seismic data including the Vertical Seismic Profile (VSP)[1)]. Three-dimensional imaging can also be performed by a 3DVSP method[2)]. We have described the observation of natural earthquakes and waves, targeting the detection of tsunamis, using the hDVS device at recent JpGU and the seismological society of Japan (SSJ)[3)].

In September 2017, in cooperation with the Engineering Advancement Association of Japan (ENAA), we conducted a demonstration experiment of DAS technology including earthquake observation using optical fiber cable buried at depth of about 20 cm. Of the 400 m long optical fiber cables, 300 m was set back and forth in a 100 m long trench and the remaining 100 m was made to run along the ground surface, and then connected to a hDVS Tier-3 acquisition device. In other words, the optical fiber cable of about 50 m section that caused the ground to travel was under an environment susceptible to changes in weather. On the second day of the 4-day observation period, there was also a time zone in which rain fell and occasionally intense. Especially during the nighttime, continuous observation was carried out, so the fiber optic cable that crawled on the ground surface has not only accidental phenomena such as car traffic ground noise and natural earthquake, but also stationary phenomenon which seems to be the influence of rain fall was recorded. An example is shown in Fig 1.

This suggests that DAS technology using optical fiber as a vibration sensor may be used for weather observation. The hDVS/DAS records with GPS time stamp; the maximum observation length is depending on the type and state of fiber, but using low-loss single mode fiber a range of 40 km is achievable. If we can observe meteorological conditions over a range of tens of kilometers with a resolution of several tens of meters with a single device, we could issue more detailed warnings.

Installation of optical fiber for communication in Japan is often installed in the air such as utility pole and iron tower, except for the trunk communication network in the metropolitan area. Such optical fibers are directly influenced by rain and wind, however influence of noise sources generated on the surface such as vehicles, railways, factories, etc. is small. In other words, if you connect an hDVS/DAS device to an optical fiber on a transmission line called OPGW (optical fiber composite overhead ground wire), there is a possibility that weather network can be constructed in a short period of time. In the case of rain, when the rain is calm, the rate at which rain strikes the OPGW decreases, vibration or the dynamic strain of the optical fiber appears less, that is, the signal of hDVS/DAS is small. When the rain intensifies, the rate at which rain hits OPGW increases, vibration appears greatly, the signal of hDVS/DAS is large. So, it is possible to quantitatively observe local rainfall at intervals of several tens of meters. It would be possibly quantifying the size of rain drops as well as state of rain drops whether liquid or icy.

If rainfall and wind volume are large and change at the same time as a typhoon, it will be possible to take a method to separate each event. In the case of rain, raindrops collide with the fiber-optic cable, causing

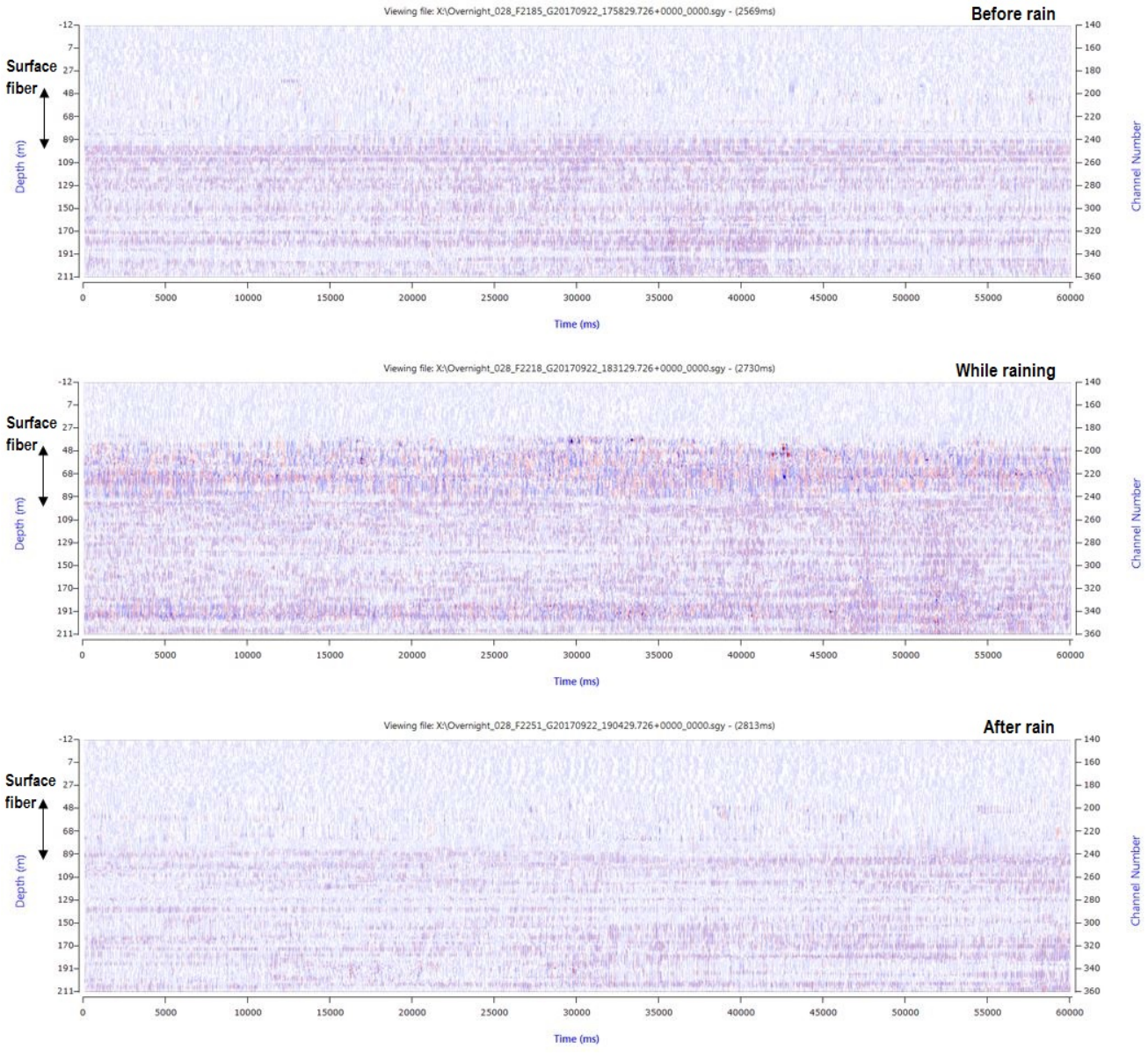
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vibration, which is supposed to be more microscopic vibration and the frequency range of vibration is higher. On the other hand, in the case of wind, it seems that the frequency range is low due to macro vibration which affects the entire fiber optic cable between towers. When observing the ocean bottom earthquake using JAMSTEC owned submarine optical fiber cable, we observed the wave at the same time, but it is possible to separate two different events by changing the gauge length, which was presented at SSJ 2018[4]. Reprocessing the raw data for different gauge length is a capability that is unique to hDVS amongst the available DAS techniques. Real-time simultaneous observation of rainfall and wind will be possible by improving the hDVS system.

By connecting hDVS to underground, ocean floor, and terrestrial optical fiber networks, the possibility of constructing a comprehensive disaster prevention observation network of earthquakes, volcanoes, tsunamis, and observation of typhoons and Guerrilla rainstorm, has come to be seen.

Acknowledgements: We thank ENAA for permission to show recorded the hDVS data.

Keywords: DAS, hDVS, optical fiber, micro-scale meteorology, dense observation, typhoon



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Case study of environmental conditions and cloud microphysical properties of winter convective clouds developed in the Kanto plain

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1. Meteorological Research Institute, 2. National Institute of Information and Communications Technology

In winter, convective clouds sometimes develop and cause local snowfalls and lightning strikes in the Kanto plain in Japan. To understand and forecast these winter convective clouds, detailed observations of environmental conditions and cloud microphysical properties are required. In this study, we performed a case study on the winter convective clouds on 26 January 2019, and examined the temporal variation of environmental conditions and properties of cloud and precipitation by using Japan Meteorological Agency (JMA) analysis data, dense surface meteorological observation data, Himawari-8 data, JMA operational radar data, photograph data of precipitation particles derived from citizen science, disdrometer and microwave radiometer data obtained at the Meteorological Research Institute in the Tsukuba, Ibaraki.

On 26 January, the surface pressure pattern was the winter monsoon type and the upper cold vortex moved to the northern Japan. Since the Kanto plain was located on the southeastern side of the cold vortex, synoptic condition was favorable for convection development in the Kanto plain. In respect of the mesoscale environments, the low-level convergence line was formed in the Kanto plain by west-northwesterly and northerly airflows that crossed the mountain areas. The Himawari-8 infrared images captured the cloud street associated with the convergence line from 13:30 JST (=UTC+9h), and radar echoes of convective clouds were observed by JMA Tokyo radar from 14:40 JST. Two convective clouds developed in the convergence line and passed over Tsukuba from about 15:30 to 16:30 JST. From the results of one-dimensional variational (1DVAR) analysis combined with numerical weather model and microwave radiometer data, it was found that thermodynamic environments significantly got unstable at 15 JST because of increases of low-level atmospheric temperature and influence of upper cold air flow.

Disdrometer in Tsukuba observed precipitation of two convective clouds from 15:34 to 15:44 JST and from 16:03 to 16:32 JST. Results of zenith-looking observation by micro rain radar showed the existence of echo at the altitude of 3-5 km 5-10 minutes before the surface precipitation at 15:34. Liquid water path (LWP) derived by the microwave radiometer significantly increased about 20 minutes before the surface precipitation by the first convective cloud, and the value of LWP in the case of second convective cloud was smaller than that of the first one. Results of disdrometer observation showed characteristics of the precipitation particles were similar to that of typical lump graupel, and fall velocity of the particles from the first convective cloud was significantly greater than that of second one. Photograph data by citizen science revealed that the graupel particles from the first convective cloud had densely rimed structures compared with those of second one. These differences of cloud microphysical properties would be due to the difference of the life stages of the convective clouds.

Keywords: convective clouds, snowfall, Kanto plain

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Numerical simulation of the urban effect on the atmospheric boundary layer structure in Tokyo using the SPUC urban canopy scheme

*Naoko Seino[1]

1. Meteorological Research Institute

Seino et al. (2018) investigated the influence of urbanization in the Tokyo area and showed that about one degree temperature rise in the central urban area in Tokyo can lead to 10% precipitation increase in August. We examined new method of the initial temperature field preparation in the model simulation, in which previously predicted temperatures of urban canopy elements were used as their initial temperatures in the succeeding simulation. Simulation results for one month in summer showed that the implementation of this forecast-cycle procedure improved the surface air temperature representation. On the other hand, comparisons with the winter observation results indicated that the atmospheric boundary layer height was underestimated in the model results. We will validate the model performance in other observation cases for the better understanding of finer scale features of urban effect.

Keywords: urbanization, numerical simulation , atmospheric boundary layer

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Surface layer model for instantaneous wind speeds designed by deep learning

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parameterizations consider the Monin-Obukhov similarity law for diagnosing momentum transports between the lowest atmosphere and ground. This law was found in the relations between temporally averaged (typically periods of 10 minutes) wind speeds and momentum fluxes. We have suggested that it is inappropriate to apply the law for the parameterization in large eddy simulations in which turbulence fluctuation is involved in resolved wind speed at each grid point. However, we do not know a good alternative to the law.

In this study, we perform a preliminary attempt to apply the deep learning technique for the parameterization. Results of wind tunnel experiments are used for the date to be learned: the relationship between wind speeds and momentums fluxes in a short time scale (1 second, typically) was obtained in the condition with steady external winds and neutral stratification over ten hours.

Nine-tenth of the wind tunnel data for three kinds of different external wind speeds was inputted to the routine of the TensorFlow library. Then the validation is performed by the left of the data. The result shows that diagnoses of the momentum fluxes through the trained network show far better performances than those of the misused Monin-Obukhov law.

If the wind speed is inputted in training, the network overfits the other wind speed that has not been used for the training. It would be better to consider normalize wind speeds for the training to apply a wide range of wind speeds.

Keywords: Surface layer, Deep learning, Surface flux, Monin-Obkuhov law, Law-of-the-wall

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | 303 3F

[A-OS21] Physical, biogeochemical, and ecological aspects and their mutual relations in the Indian Ocean

convener:Yukio Masumoto(Graduate School of Science, The University of Tokyo), Hiroaki Saito(Atmosphere and Ocean Research Institute, The University of Tokyo), Iwao Ueki(JAMSTEC Japan Agency for Marine-Earth Science and Technology), Chairperson:Yukio Masumoto

Recent discovery of new climate modes and development of basin-scale and regional
observing systems in the Indian Ocean advance researches on physical, biogeochemical,
and ecological aspects of ocean variations. In addition, international and interdisciplinary
research programs in the Indian Ocean, such as IIOE-2 and EIOURI, are now being
conducted in earnest, under which the R/V Hakuho-maru cruise in the eastern Indian
Ocean will be took place in Nov./Dec. 2018, for better understanding of eastern Indian
Ocean conditions through multi-disciplinary approaches. This session invites papers on
physical, biogeochemical, and ecological aspects in the Indian Ocean and relations
among these elements of the ocean variations, to facilitate integrated understanding of
the Indian Ocean variability, as well as to stimulate collaborative researches among the
relevant scientists. Preliminary results from observation campaigns, a new perspective
on research collaboration, and/or sharing information on future observing activities are
also welcome.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[AOS21-01] Coastal upwelling events and barrier layer observed along the southwestern coast of Sumatra

*Takanori Horii[1], Iwao Ueki[1], Kentaro Ando[1] (1.Research and Development Center for Global Change (RCGC), Japan Agency for Marine-Earth Science and Technology (JAMSTEC))

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[AOS21-02] Mechanisms of the sea surface temperature cooling in the Somalia-Oman upwelling region during the summer monsoon

*Kusumi Takahiro[1], Shoichiro Kido[1], Tomoki Tozuka[1], Yukio Masumoto[1] (1.the Unversity of Tokyo)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[AOS21-03] Generation of meso-scale eddies in the southern Indian ocean

*Takuro Matsuta[1], Yukio Masumoto[1] (1.Graduate School of Science, The University of Tokyo)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[AOS21-04] Summary of R/V Hakuho-Maru observations (KH-18-6) for Integrated physical, biogeochemical, and ecosystem research in the eastern Indian Ocean

*Yukio Masumoto[1], Hiroaki Saito[2] (1.Graduate School of Science, The University of Tokyo, 2.Atmosphere and Ocean Research Institute)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[AOS21-05] Distribution and photodegradation of fluorescent dissolved organic matter in the eastern Indian Ocean

*Shigenobu Takeda[1] (1.Nagasaki University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[AOS21-06] Observed subsurface Chlorophyll maximum in the tropical eastern Indian Ocean during KH18-6 Leg3 cruise

*Iwao Ueki[1], Kosei Sasaoka[1] (1.JAMSTEC Japan Agency for Marine-Earth Science and Technology)

Coastal upwelling events and barrier layer observed along the southwestern coast of Sumatra

*Takanori Horii[1], Iwao Ueki[1], Kentaro Ando[1]

1. Research and Development Center for Global Change (RCGC), Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Coastal upwelling along the southwestern coast of Sumatra during the boreal summer monsoon is closely linked to the El Nino/Southern Oscillation and the Indian Ocean Dipole. To understand the coastal upwelling system, we investigated ocean temperature and salinity variations obtained from Argo floats. During 2013-2017, two Argo floats observed vertical structure of temperature and salinity every 10 days within 100 km from the coast of Sumatra. The floats observed intraseasonal-scale subsurface temperature cooling events with significant upward movements of thermocline. Anomalous local southwesterly winds and equatorial easterly winds explained the temperature cooling and thermocline variations, suggesting that the Argo observation captured coastal upwelling signal. Although these subsurface temperature cooling signals were significant, local sea surface temperature (SST) variations were relatively small. We found that during coastal upwelling events, local SST tended to be disconnected with subsurface cooling by the presence of upper-layer salinity stratification and thick barrier layer which suppressed entrainment cooling.

Keywords: Coastal upwelling, Sumatra, Barrier layer, Indian Ocean Dipole

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Mechanisms of the sea surface temperature cooling in the Somalia-Oman upwelling region during the summer monsoon

*Kusumi Takahiro[1], Shoichiro Kido[1], Tomoki Tozuka[1], Yukio Masumoto[1]

1. the Unversity of Tokyo

Alongshore southwesterly winds in the western Arabian Sea associated with the Indian summer monsoon induce coastal upwelling and cool sea surface temperature (SST) along the coast of Somalia and Oman. Since the upwelling region is a moisture source of the Indian summer monsoon rainfall, understanding of the SST variations in this region is crucial for the prediction of the Indian summer monsoon precipitation. In this study, an on-line mixed layer heat budget analysis is conducted to clarify the mechanisms of the SST cooling using the Regional Ocean Modeling System (ROMS) simulation. It is revealed that causes of the SST cooling in the upwelling region are different between the onset (May) and mature phases (June-July) of the Indian summer monsoon. The horizontal advection, surface heat flux, entrainment and vertical diffusion terms contribute to the cooling in the former phase, while the vertical diffusion term plays a dominant role in the latter phase.

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Generation of meso-scale eddies in the southern Indian ocean

*Takuro Matsuta[1], Yukio Masumoto[1]

1. Graduate School of Science, The University of Tokyo

A Leeuwin Current region off the coast of western Australia is known as an area of strong meso-scale eddy activity among the midlatitude eastern boundary current regions. While these eddies are believed to be generated through mixed barotropic and baroclinic instability associated with the poleward-flowing Leeuwin Current, their relative importance as well as interactions between eddies and large-scale circulations need to be investigated in detail. Motivated by the above, an analysis on energy conversion between eddy field and mean flow is conducted. Results revealed detailed spatial distributions of large baroclinic energy conversion. The interactions between density anomalies and the thermal front near 30˚ S play an important role in making the baroclinic energy conversion.

Keywords: meso-scale eddies, Leeuwin Current, eddy-mean flow interactions

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Summary of R/V Hakuho-Maru observations (KH-18-6) for Integrated physical, biogeochemical, and ecosystem research in the eastern Indian Ocean

*Yukio Masumoto[1], Hiroaki Saito[2]

1. Graduate School of Science, The University of Tokyo, 2. Atmosphere and Ocean Research Institute

R/V Hakuho-Maru cruise (KH-18-6) was conducted from Nov. 6 (leaving from Phuket) to Dec. 29 (Arriving at Fremantle) to facilitate integrated physical, biogeochemical, and ecosystem researches in the eastern Indian Ocean, which is a core research project under EIOURI and IIOE-2. The first leg occupied the 88E section from the Bay of Bengal down to 20S, while the second leg observed the region between the Java Island and northwestern Australia. During these legs, measurements of physical, chemical, biological, and ecological parameters were taken place by multiple equipment such as CTD casts, water sampling, LADCP, net observations, turbulence measurements. This presentation introduce summary of observations conducted during the cruise and highlights some preliminary results, together with the basic conditions during the observations.

Keywords: Eastern Indian Ocean, Observations

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Distribution and photodegradation of fluorescent dissolved organic matter in the eastern Indian Ocean

*Shigenobu Takeda[1]

1. Nagasaki University

Dissolved organic matter (DOM) is one of the major carbon reservoirs in the ocean, and a fraction of DOM fluoresces blue light when excited by UV light. Two main components of fluorescent dissolved organic matter (FDOM) are protein- and humic-like fluorophores. The environmental dynamics of FDOM in the open ocean has been reported to include photodegradation at surface layers and production through microbial decomposition of organic matters in deeper layers. Humic-like FDOM may playing a role as natural organic ligands for several dissolved trace metals such as iron in intermediate and deep waters, and therefore studies on the distribution and dynamics of FDOM are also important for better understandings of trace-metal cycles in the ocean.

During a KH-18-6 cruise by the R/V Hakuho-maru in November 2018, observations were conducted along a transect at 88ºE in the eastern Indian Ocean, where changes in biological activities of organic matter production and decomposition are remarkable in the north-south direction. Vertical distributions of FDOM fluorescence intensity were obtained at 9 stations along the transect from 16.5ºN to 20ºS. Seawater samples collected using Niskin-X bottles on a CTD-Carousel system were filtered through a filter unit having 0.2 μm pore-size and fluorescence intensity of FDOM was measured onboard by Trilogy Laboratory Fluorometer (Turner Designs) equipped with UV module (7200-067W, Excitation 350/80 nm; Emission 410-450 nm) using the 4 ppb quinine sulfate solution as a standard. In order to evaluate photodegradation of FDOM, selected filtered seawater samples were placed in 500 ml quartz bottles and these bottles were exposed to sunlight in an on-deck running seawater tank. Changes in fluorescent intensity of FDOM were monitored every 24 hours for 5 days.

The vertical distributions of FDOM fluorescence intensity showed nutrient-type profile; very low values at the surface, enrichment at intermediate depth, and gradual decrease in deep layers. A distinct peak of fluorescence intensity was also observed at the oxygen minimum layer just below the subsurface chlorophyll maximum. Along the N-S transect, fluorescence intensity of FDOM in the water column was highest at 15ºN in the Bay of Bengal, and there was a decreasing trend to the southward direction. The FDOM fluorescence intensity generally correlated with apparent oxygen utilization (AOU) in the intermediate and deep layers. However, high fluorescence intensities deviate from the FDOM-AOU relationship were measured below the subsurface chlorophyll maximum layer in the Bay of Bengal, suggesting that characteristics of fluorophores produced by microbial decomposition of organic matters might varies depending on the depth and area of the sea. In the solar irradiation experiments, a significant photobleaching was observed within 24 hours followed by gradual decrease in FDOM fluorescence intensity during the remaining period of the experiments. It indicate the existence of fluorophores having different photolability in the FDOM. One of the experiments also showed control of FDOM photodegradation by the irradiation level. These results suggest that light field and vertical mixing process near the sea surface as well as vertical difference in quality and quantity of organic matter for decomposition by diverse microbial community could have a strong influences on dynamics of FDOM in the eastern Indian Ocean.

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Keywords: Indian Ocean, FDOM, Photodegradation

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Observed subsurface Chlorophyll maximum in the tropical eastern Indian Ocean during KH18-6 Leg3 cruise

*Iwao Ueki[1], Kosei Sasaoka[1]

1. JAMSTEC Japan Agency for Marine-Earth Science and Technology

To enhance interdisciplinary understanding of the eastern Indian Ocean upwelling study, R/V Hakuho-Maru KH18-6 cruise has been conducted in November-December 2018. During the Leg-3 cruise; started from Jakarta in 06 December and arrived at Fremantle in 29 December, physical, chemical and biogeochemical observations at more than 30 stations along 3 sections have been conducted. During the Leg 3 cruise, climate condition of the Indian Ocean became a neutral condition after positive Indian Ocean Dipole event. At the eastern section from the station 22 (12°S, 112.5°E) to station 34 (24°S, 111° E), we can capture predominance of eddy activity at around 16°S. In terms of chlorophyll distribution, subsurface maximum were recognized at the all stations. However, the distribution was modified in associated with the eddy activity. The details will be shown in the presentation.

Keywords: The eastern Indian Ocean, Chlorophyll, Eddy

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | 301A 3F

[A-CG43] Adaptation for climate change and social implementation

convener:Yoichi Ishikawa(JAPAN Agency for Marine-Earth Science and Technology), Shingo Watanabe(Japan Agency for Marine-Earth Science and Technology), KOJI DAIRAKU(National Research Institute for Earth Science and Disaster Resilience), Chairperson:KOJI DAIRAKU(National Research Institute for Earth Science and Disaster Resilience), Yoichi Ishikawa(JAPAN Agency for Marine-Earth Science and Technology)

Adaptation for climate change is urgent issue since increasing risk of natural disaster, such as typhoon and heavy rain and harmful effect of high temperature on agriculture are expected. "Climate change adaptation law" has passed the National Diet in 2018, in which the vision are given to build a secure, safe and sustainable society that is able to minimizing and avoiding damage. These actions to formulate the adaptation plan are expected to rapidly spread for local governments.
For this purpose, simulation of climate change projection, downscaling technique to obtain the detailed estimation of climate change in local scale, the evaluation of risk to contribute the formulation of adaptation plan are necessary, as well as the issue for social implementation such as co-design working with stakeholders.
We will discuss the current status of the simulation modeling and knowledge gap between the scientists and stakeholders.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[ACG43-01] Effects of afforestation and climate warming on evapotranspiration and river discharge in the upper Chao Phraya River basin

*Kumiko TAKATA[1], Naota Hanasaki[1] (1.National Institute for Environmental Studies)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[ACG43-02] Hybrid downscaling using high-resolution RCM information and rainfall-runoff-inundation model simulations

*Yasutaka Wakazuki[1,2], Shiori Abe[4], Yosuke Nakamura[3,4] (1.Ibaraki University, 2.Japan Agency for Marine-Earth Science and Technology, 3.Public Works Research Institute, 4.Mitsui Consultants Co., Ltd.)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[ACG43-03] Development of a global water risk assessment tool to support investigation of adaptation to climate change in the private sector: Calibrating parameters of a global water resources model by Approximate Bayesian Computation

*Naota Hanasaki[1] (1.NIES National Institute of Environmental Studies)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[ACG43-04] Verification of SI-CAT ocean products around Japan

*Goro Yamanaka[1], Hideyuki Nakano[1], Kei Sakamoto[1], Takahiro Toyoda[1], Shogo Urakawa[1], Hiroyuki Tsujino[1], Shiro Nishikawa[2], Tsuyoshi Wakamatsu[2,3,4], Yoichi Ishikawa[2] (1.Meteorological Research Institute, 2.JAMSTEC, 3.Nansen Environmental and Remote Sensing Center, 4.Bjerknes Centre for Climate Research)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[ACG43-05] Downscaling and Reanalysis of Coastal Current System on the Ibaraki Coast with Included Freshwater Impact

*Josko Troselj[1], Yuki Imai[2], Junichi Ninomiya[3], Nobuhito Mori[1] (1.Coastal Engineering Laboratory, Disaster Prevention Research Institute, Kyoto University, 2.Graduate School of Engineering, Kyoto University, 3.Kanazawa University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[ACG43-06] Estimation of the Japanese sardine stock in relation to the future Kuroshio variability

*Haruka Nishikawa[1], Shiro Nishikawa[1], Tsuyoshi Wakamatsu[2,3], Yoichi Ishikawa[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Nansen Environmental and Remote Sensing Center, 3.Bjerknes Center for Climate Research)

Effects of afforestation and climate warming on evapotranspiration and river discharge in the upper Chao Phraya River basin

*Kumiko TAKATA[1], Naota Hanasaki[1]

1. National Institute for Environmental Studies

In the Chao Phraya River basin (hereafter as CP), deforestation has been proceeding in the upper mountainous regions; and in the uppermost tributary of the Nan River the increasing trend in low flow was observed, that could potentially be related to deforestation in the basin (Tebakari et al., 2018). Besides, runoff in CP is projected to increase under the global warming particularly in the rainy season (Kotsuki et al., 2014), that would enhance the risks of floods which regularly occur in the late rainy season. Since afforestation has effects to decrease the annual runoff and its peak amount, it is considered as an adaptation measure. However, it also has effects to increase evapotranspiration, that would enhance the water scarcity in the dry season.

In this study, offline experiments were conducted with a land surface model, MATSIRO (Takata et al, 2003; Nitta et al., 2014) that explicitly considered the processes of vegetation canopy to examine the effects of afforestation on river discharge and evapotranspiration in the upper CP under a warmed climate. The meteorological conditions for the 20th century (1981-2004; Kotsuki et al., 2013) and the future (2040-2059 and 2080-2099, Watanabe et al., 2014) with two warming scenarios and three climate models were used. Three experiments were conducted at the horizontal resolution of 5 arc-minutes: the first one is with the vegetation distribution in 2000 (control, CTL), the second one is with that in 1970 (AFR20) in which cropland is 20% less than CTL, and the third one is with that in 1950 (AFR100) in which most of the land is covered with natural vegetation (AFR100).

The annual precipitation, runoff, and evapotranspiration were increased by the warming. About 80% of the precipitation increase turned into the runoff increase, and the remaining 20% into evapotranspiration. The annual increase in runoff was reduced by 3-5% with AFR20 and 10-15% with AFR100 in the mid-21st century. The reduction shrinks with the progress of the warming which agrees with the report by Chacuttrikul et al. (2018), though the simplified simulation for changes in soil properties by afforestation suggested an enhancement of the reduction. The runoff reduction by forest-cover increase was due to the enhancement of evapotranspiration increase. Looking into the seasonal pattern of the changes, the runoff increase corresponds to about 75% of the precipitation increase in the rainy season. The evapotranspiration increase in the rainy season was about 10%, and the remaining 15% turned into the evapotranspiration increase in the dry season. In conclusion, the effect of runoff reduction by forest-cover increase was marked in the rainy season, while the effect of evapotranspiration enhancement was marked in the dry season. It is therefore necessary to take note the both effects of runoff reduction in wet season and evapotranspiration enhancement in dry season, in considering afforestation for an adaptation measure for water management issues.

Acknowledgements: This research was supported by Science and Technology Research Partnership for Sustainable Development (SATREPS) program by Japan Science and Technology Agency (JST) and Japan International Cooperation Agency (JICA), and by the Environment Research and Technology Development Fund (S-14-5) of the Environmental Restoration and Conservation Agency.

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Keywords: Afforestation, Runoff, Evapotranspiration, Chao Phraya River basin

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Hybrid downscaling using high-resolution RCM information and rainfall-runoff-inundation model simulations

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The statistical downscaling is calculated with lighter computational costs for various patterns of climate states in future which are needed to estimate uncertainty of regional climate change. However, the estimation accuracy is low in areas of poor observations. On the other hand, dynamical downscaling with high-resolution regional climate model (RCM) use huge computational costs, whereas climatological features are well reproduced even in areas of poor observations. A statistical downscaling method as a hybrid-downscaling making use of the advantage of super high-resolution dynamical downscaling is proposed in previous JPGU annual meeting. In addition, the reproducibility of intense precipitation was improved by introducing a new precipitation correction method applying PDF for hourly precipitation. Downscaling results of climate change projections had been used for simulations of rainfall-runoff-inundation (RRI) model with the target area of Kinu and Kokai river basins, Kanto, Japan. The regional climate projection showed almost 6 % increase of precipitation in the river basins. In a simulation, the yearly maximum of daily precipitation was predicted to increase about 15 %, which is almost the same as the increase rate of yearly maximum of river discharge, 12 %. On the other hand, the increase rate of yearly maximum of peak water level was estimated to be only 1 %. In Japan, several high-risk water levels are configured at observation points. The frequencies of moderate high-risk water levels were projected to significantly increase. On the other hand, the changes in the frequencies of severe high-risk water levels were projected to be small. The small increase rate was due to structure of cross sections of the river and the dam control model. The inundation areas and depths were also calculated. The increase rate of the inundation area was estimated to be about 35 %. The risk of large inundation is regarded to increase in the future climate.

Keywords: Downscaling, Regional climate model, rainfall-runoff-inundation model

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Development of a global water risk assessment tool to support investigation of adaptation to climate change in the private sector: Calibrating parameters of a global water resources model by Approximate Bayesian Computation

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Private companies need to avoid the harmful impacts on their business and express their plans and actions toward climate change. To support climate change adaptation planning of private sectors, an open global water risk assessment tool is being developed.

The global hydrological model H08 can simulate not only natural hydrological cycle but also human water use simultaneously at a daily interval at a spatial resolution of 0.5 degree. By feeding future climate scenarios and socio-economic assumptions to H08, one can analyze the change in hydrological cycle and water requirement/use due to global change with spatiotemporal details. Although these features are useful to investigate the risks of flood and drought in the future, the uncertainty in the model hampers effective interpretation. In particular, the simulation performance at the places where production bases are located is crucial for private companies. Therefore, parameter calibration was performed which has been seldom carried out at a global scale.

In this study, we applied the Approximate Bayesian Computation (ABC) to calibrate four key hydrological parameters of H08. Altogether 5000 simulations were conducted by changing four parameters randomly. By identifying the range of each parameter that showed the best performance in reproducing the past, we systematically calibrated the ranges of four parameters. This approach was applied for 64 basins with more than 500,000km2 of catchment area in the world. The results showed that calibrated parameters produced reasonable simulation results for most of the basins in the world. In the presentation, the results for smaller catchments and daily simulations will be presented.

Keywords: Adaptation, Climate Change, Water resources

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Verification of SI-CAT ocean products around Japan

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We examined SI-CAT ocean products around Japan, such as sea surface temperature (SST) and sea level, Kuroshio, and sea-ice in the Sea of Okhotsk. We used the SICAT10 Version 2 data, in which the North Pacific Ocean model with a resolution of 10 km was driven by JRA-55 and CMIP5 (MIROC5, MRI-CGCM 3, GFDL-ESM2M, IPSL-CM5A-MR) atmospheric forcing under the present climate (1960-2005). Observation data used for verification are COBE-SST2 and CMEMS. We made a t-test for the mean difference between the observed and simulated fields, as well as a f-test for the ratio of the observed variance to the simulated. The p-value was taken as a measure of the reliability of the model. The simulated SSTs generally capture the dominant low-frequency modes in the North Pacific in each run. In the sea around Japan, the reliability of the variability is relatively high except for the regions where eddy activity is enhanced, such as off the east of Tohoku and off the south of Japan. The regional averaged SSTs show a long-term upward trend as in the observation. Compared to the reliability of the simulated SST, that of the simulated sea level is relatively low, but the average sea level around Japan shows low-frequency variability associated with PDO as well as long-term upward trends related to the global warming. The average Kuroshio flow path and the position of Kuroshio Extension are generally well captured by the 10 km model. The latitudes of the simulated Kuroshio Extension show no remarkable trend like observation. In the Sea of Okhotsk, the simulated sea ice area during the winter is captured in the IPSL run, but is underestimated (overestimated) in the MIROC run (the MRI and GFDL runs). The long-term trend in winter shows a statistically significant decrease in the GFDL run, which is similar to the observation.

Keywords: SI-CAT, climate change adaptation, high-resolution ocean general circulation model

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Downscaling and Reanalysis of Coastal Current System on the Ibaraki Coast with Included Freshwater Impact

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Introduction and Objective

Global mean sea level, surface temperatures and extreme precipitation amounts are expected to increase in 21st century under the climate change impact. It will especially affect coastal zones which are sensitive to all of these factors because extreme freshwater inflow, inundation levels, erosion as well as fishery industry nearshore are expected to be largely impacted. Coastal processes, such as variabilities of shallow water temperatures, cannot be precisely reproduced by coarse scale global climate models and therefore downscaling the coastal current system to fine resolution scales is needed.

Objective of the study is providing fine scale 7-years ocean circulation reanalysis and assessment of natural variabilities of physical processes of the coastal ocean by downscaling of coastal current system for Ibaraki prefecture in Japan from 10 km scale parent dataset to related projections of 222 m scale on the Ibaraki coast, particularly taking into account freshwater outflow impact from 3 major rivers (Tone, Naka and Kuji). Our results can be used for adaptation of countermeasures for climate change impact assessment.

Methods

We continued the study from Troselj et al. (2018) with improved downscaling model methodology and extended analyzed period into 7 years (2000-2006). We applied better vertical transformation equation (Vtransform=2, new formulation developed by A. Shchepetkin) and different vertical stretching function (Vstretching=4, where A. Shchepetkin improved double stretching) compared to Troselj et al. (2018). River forcing conditions were applied as observed river temperature and discharge (MLIT, 2017) with constant salinity of 0.5 PSU for Tone, Naka and Kuji rivers.

Discussions

We validated our modelled results with observed sea surface temperature data from Hasaki point (PARI) and satellite images from MGDSST for winter and spring seasons (Figure 1). Results for all seasons will be presented on the conference. The modelled results corresponded well with Hasaki observations in winter and with MGDSST observations in spring season and their mean and variabilities were improved compared to FORA results. Reason for that might be because vertical mixing in spring and summer seasons is lower than in autumn and winter seasons. We expect that Hasaki observations, which are located 2-3 meters below sea level, will have better fit with the modelled results during colder seasons when vertical mixing is higher. Similarly, we expect that MGDSST observations of sea surface layer will

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have better fit with the modelled results during warmer seasons when vertical mixing is lower.

We showed that reproducibility of coastal natural variabilities of physical processes is increased compared to parent dataset FORA when using downscaling, both for sea surface temperature and salinity. Our model reproduced bigger variabilities of both temperature and salinity in vicinity of the coast than in the offshore zone, and it was not well reproduced in FORA.

We showed monthly, seasonal and inter-annual trends in magnitudes and directions of coastal currents. The reproducibility of the trends was improved compared to FORA, because our model provides more precise fine scale representation of coastal currents.

Summary

We conducted dynamic downscaling and reanalysis of coastal current system on the Ibaraki coast particularly considering freshwater outflow impact, with improved methodology and extended targeted period from previous study. We showed that variability of sea surface temperatures in coastal shallow waters is better represented with the downscaling than with the coarser parent model.

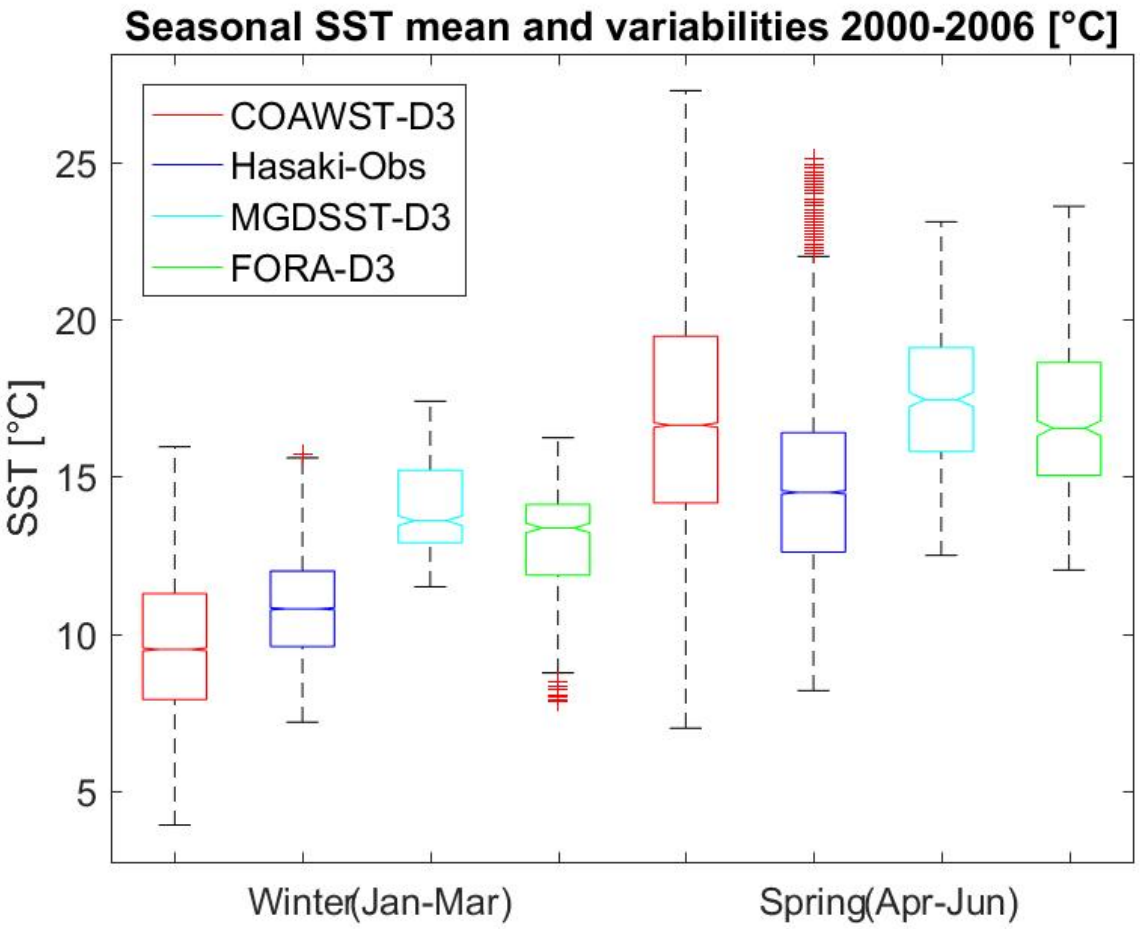
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Keywords: downscaling, coastal current, natural variability, freshwater impact, COAWST, climate change

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Estimation of the Japanese sardine stock in relation to the future Kuroshio variability

*Haruka Nishikawa[1], Shiro Nishikawa[1], Tsuyoshi Wakamatsu[2,3], Yoichi Ishikawa[1]

1. Japan Agency for Marine-Earth Science and Technology, 2. Nansen Environmental and Remote Sensing Center, 3. Bjerknes Center for Climate Research

Stock of the Japanese sardine (*Sardinops melanostictus*) shows a drastic variation. The principal driver of the stock variation is the Kuroshio velocity, and the second important driver is sea surface cooling. The Japanese sardine spawn in the Kuroshio water of south of Japan during winter and the larvae grow during the transportation by the Kuroshio. Lower the temperature of the Kuroshio water, the nursery ground, more favorable the condition is for feeding and growth of the larvae and consequently the sardine stock becomes higher. Thus the Japanese sardine stock level is strongly affected by the Kuroshio variation. The Kuroshio water temperature in winter tends to be lower during the year of low Kuroshio velocity. This is because, the Kuroshio water from subtropical region can have enough cooling by the time its arrival to near Japan. The Kuroshio velocity has a decadal to multi-decadal scale variation. The past sardine stock variation tended to be higher in the low Kuroshio velocity regime. Since the Japanese sardine is an important commercial fish in Japan, the future sardine stock, especially under the influence of the climate change, is one of the social concerns. The nursery grounds of the Japanese sardines are distributed in the very narrow area along the Kuroshio path and its analysis requires high resolution data. However, the spatial resolutions of the current climate projection products, CMIP5, are generally too coarse to reproduce the narrow Kuroshio path. Recently, we have succeeded at dynamical downscaling of multiple CMIP5 ocean products to 0.1º horizontal resolution products. In this study, we first develop a sardine stock estimation model that reproduce the past stock fluctuation based on the temperature in the nursery grounds. Then we input the future temperature from the downscaled simulation into the sardine stock model to project its future stock. We’ll discuss how the sardine stocks fluctuate in future especially in relation to the Kuroshio variability.

Keywords: Japanese sardine, Kuroshio, Global warming

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | 301A 3F

[A-CG43] Adaptation for climate change and social implementation

convener:Yoichi Ishikawa(JAPAN Agency for Marine-Earth Science and Technology), Shingo Watanabe(Japan Agency for Marine-Earth Science and Technology), KOJI DAIRAKU(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Yoichi Ishikawa(JAPAN Agency for Marine-Earth Science and Technology), KOJI DAIRAKU(National Research Institute for Earth Science and Disaster Resilience)

Adaptation for climate change is urgent issue since increasing risk of natural disaster, such as typhoon and heavy rain and harmful effect of high temperature on agriculture are expected. "Climate change adaptation law" has passed the National Diet in 2018, in which the vision are given to build a secure, safe and sustainable society that is able to minimizing and avoiding damage. These actions to formulate the adaptation plan are expected to rapidly spread for local governments.
For this purpose, simulation of climate change projection, downscaling technique to obtain the detailed estimation of climate change in local scale, the evaluation of risk to contribute the formulation of adaptation plan are necessary, as well as the issue for social implementation such as co-design working with stakeholders. We will discuss the current status of the simulation modeling and knowledge gap between the scientists and stakeholders.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[ACG43-07] Recent progress of Japan's regional downscaling project (SI-CAT) and CORDEX Asia Empirical-Statistical Downscaling (ESD)

*KOJI DAIRAKU[1] (1.National Research Institute for Earth Science and Disaster Resilience)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[ACG43-08] Assessment of Flood Risk in Hokkaido, northern Japan, Associated with Climate Change

*Hoshino Tsuyoshi[1], Tomohito J Yamada[1], Dzung Nguyen-Le[1], Masaru Inatsu[1], Tomonori Satou[1], Hiroaki Kawase[2] (1.Hokkaido University, 2.Meteorological Research Institute)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[ACG43-09] Intensification of sub-daily and daily rainfall extremes from densely distributed records for Japan

*Megumi Watanabe[1], Sayaka Yoshikawa[1], Shinjiro Kanae[1] (1.Tokyo Institute of Technology)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[ACG43-10] A Content-Based Database System for Large Ensemble Future Climate Simulations

*Yujin Nakagawa[1], Shintaro Kawahara[1], Fumiaki Araki[1], Daisuke Matsuoka[1], Yoichi Ishikawa[1], Mikiko Fujita[1], Shiori Sugimoto[1], Yasuko Okada[1], Sho Kawazoe[1], Shingo Watanabe[1], Masayoshi Ishii[2], Ryo Mizuta[2], Akihiko Murata[2], Hiroaki Kawase[2] (1.Japan Agency for Marine-Earth Science and Technology, 2.Meteorological Research Institute)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[ACG43-11] Climate change impact assessment in Shikoku with the ensemble climate prediction database d4PDF

*kouhei yoshimura[1], Nasu Seigo[1], Patricia Sanchez[2] (1.Kochi University of Technology, 2.University of the Philippines Los Baños)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[ACG43-12] Caution zone quantification risk to sediment disaster adaptation due to climate change

*SEIKI KAWAGOE[1], YOSUKE SAITO[1], HIROMICHI SUZUKI[1] (1.Fukushima university)

Recent progress of Japan’s regional downscaling project (SI-CAT) and CORDEX Asia Empirical-Statistical Downscaling (ESD)

*KOJI DAIRAKU[1]

1. National Research Institute for Earth Science and Disaster Resilience

As a Japan’s national project, SI-CAT develops reliable technologies to find climate change adaptation measures in collaboration with researchers of geoscience, social science and humanities, and officials of local governments from the beginning of the project to avoid and reduce various threats of climate change.

We conducted dynamical downscaling experiments with horizontal grid spacing of 5km and 2km to reproduce regional climate information. We examine the performance of the regional climate model (NHRCM) to represent severe precipitation events occurred around Gifu and Nagano region. To examine the performance in ungauged mountainous regions, the runoff analysis was conducted. It indicates the overestimation of precipitation. We conduct the ensemble downscaling experiments using database for Policy Decision making for Future climate change (d4PDF) to detect the climate change impact in this region.

Multi-model large ensemble regional climate scenarios over Japan and CORDEX Asia are developed by using CMIP5 GCMs (RCP2.6 and RCP8.5) and a statistical downscaling (Bias Corrected Spatial Disaggregation (BCSD)) to investigate uncertainty of projected change associated with structural differences of the GCMs for the periods of historical climate (1950-2005) and near future climate (2026-2050). Uncertainty range information of the regional climate scenarios support various regional adaptation measures and informed decision making. Based on the SI-CAT experiences, the CORDEX Asia ESD group enhances and integrates the science and application of downscaling activities in Asia by sharing and exchanging data, knowledge, and techniques.

Keywords: Dynamical downscaling, Statistical downscaling, Multi-model ensemble, CORDEX, Asia

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Assessment of Flood Risk in Hokkaido, northern Japan, Associated with Climate Change

*Hoshino Tsuyoshi[1], Tomohito J Yamada[1], Dzung Nguyen-Le[1], Masaru Inatsu[1], Tomonori Satou[1], Hiroaki Kawase[2]

1. Hokkaido University, 2. Meteorological Research Institute

In August 2016, 4 typhoons sequentially attacked Hokkaido region (Northern part of Japan) within 2 weeks and caused severe flood damage. Because this sequential typhoon attack is the first time in recorded history and remarked maximum rainfall amount on many observatories in Hokkaido region and this heavy rainfall caused various flood disaster (inundation caused by dyke break, damaged to load and farmland), it became one of a trigger that led river administrators (Hokkaido regional development bureau of the Ministry of Land, Infrastructure and Transport (MLIT) and Hokkaido prefectural government) to consider flood risk change associate with climate change. Actually, they organized a committee in order to project future flood risk in Hokkaido. MLIT has also organized a committee since fiscal 2018 in order to consider flood prevention plan associate with climate change. As can be seen these backgrounds, projection of future flood risk became important and urgent issue. This study quantified flood risk under both historical and warmer climate condition by using a large ensemble simulation dataset.

In this study, we analyzed characteristics of annual maximum rainfall over river basins in Hokkaido region under historical and warmer climate conditions in order to evaluate flood risk change. This research used d4PDF (database for Policy Decision making for Future climate change) which consists of large ensemble climate data (historical climate: total 3,000 years, 2K warmer climate: total 3,240 years, 4 K warmer climate: total 5,400 years). This research conducted dynamical downscaling (DS) using a regional climate model for annual maximum rainfall events detected from d4PDF (convert from 20 km to 5 km) in order to take into account topographic effect and shapes of the target river basin more precisely. This research focus on not only rainfall amount but also weather pattern which caused heavy rainfall. We classified weather patterns based on SOM (Self Organizing Map) and evaluated their return period.

The rainfall after DS under historical climate condition and rainfall obtained from observation results have similar frequency in terms of rainfall amount and include many events which exceed maximum recorded rainfall. These results show that DS is effective way to make many possible heavy rainfall patterns. The comparison between historical and future climate showed that rainfall amount significantly increase. Especially, low probability rainfall (e.g. 99 percentile value) become much heavier. Because of the increase of rainfall amount, estimated inundation area become larger and estimated fatalities increase under same occurrence probability. Climate change caused not only increase of rainfall amount but also concentration of heavy rainfall in spatiotemporally. Because heavier and more concentrated rainfall causes increase of peak discharge and change of characteristics of flood damage, the change of rainfall characteristics must be considered for flood disaster prevention plan. Classification of weather pattern shows the factor of heavy rainfall changes in warmer climate.

These results show necessity of flood protection plan considering climate change and large ensemble climate dataset can be greatly helpful for planning. This study became the core of the discussion at the committee related to future flood risk in Hokkaido, Japan which was held in fiscal 2017, future flood control measures are going to be discussed based on these results.

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Keywords: Climate change, Flood risk, d4PDF, adaptation

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Intensification of sub-daily and daily rainfall extremes from densely distributed records for Japan

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1. Tokyo Institute of Technology

Rainfall intensity is projected to increase in most regions under warmer climates, and the increase in heavy rainfall will be larger than that in the mean rainfall. The increase in rainfall intensity caused by global warming was often predicted by studies with climate models. There is an argument that climate models tend to underestimate the observed changes in heavy rainfall intensity. Meanwhile, it has been suggested that, to first order, the intensification of heavy rainfall in a warmer climate could follow the Clausius-Clapeyron (CC) relationship which states that warmer air has a higher water vapor holding capacity. According to the C-C relationship a rainfall intensities are estimated to increase by ~7% per degree warming. However, observed evidence that detects CC-related changes both in daily and sub-daily (e.g., hourly) rainfall extremes between two periods (namely the past and the present) is limited. A comprehensive result derived from observed data confirmed that the intensification rate of daily precipitation is close to the rate of CC in Europe, but their analysis was done for daily precipitation only and limited observation data over a large region was used. Another recently published analysis for Australia shows on average a CC-like response for daily extremes and a super-CC (double to triple CC) response for hourly extremes which is also suggested in temperature-rainfall scaling. Nevertheless, large regional variability in their results derived from sparsely distributed observations from the tropics to mid-latitude calls for an analysis of densely-distributed observations in a single climatic zone. In this study, we try to analyze whether the CC relationship, or super-CC, can be applied to the intensification of both daily and sub-daily rainfall extremes over Japan. We also try to show the sensitivity of the estimated intensification of rainfall extremes caused by setting of the past and present period, referenced stations. We used rainfall data at more than 700 stations with less than 1% missing data for the entire area of Japan. We divided whole observation period into the past and present period. We then defined extreme precipitation criteria in the previous period at each individual observation point and counted the number of the event of extreme precipitation. Finally, we calculated the intensification rate of rainfall extremes from the past to present period. In the results, we show that the intensification rate of sub-daily extremes is higher than that of daily extremes. However, the magnitude of intensification rate greatly differs depending on referenced period, the number of stations and rate of increase in temperature.

Keywords: Clausius-Clapeyron, observations, warmer climate

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A Content-Based Database System for Large Ensemble Future Climate Simulations

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1. Japan Agency for Marine-Earth Science and Technology, 2. Meteorological Research Institute

Analyses of large ensemble data of future climate are quite useful in order to produce probabilistic future projection of climate change in various interdisciplinary fields related to, e.g., hydrology, civil engineering, adaptation planning for global warming. Ensemble data of "+2K future climate simulations" are currently generated by "Social Implementation Program on Climate Change Adaptation Technology" (SI-CAT) as a part of a database for Policy Decision making for Future climate change (d4PDF; Mizuta et al. 2016) produced by Program for Risk Information on Climate Change. Those data consist of global warming simulations and regional downscaling simulations around Japan. Considering that those data volumes are too large, i.e. a few petabytes, to download to a local computer of users,
a user-friendly system is required to search and download data which satisfy requests of the users.
In order to provide functions to extract necessary data from +2K future climate simulations to the users, we developed “System for Efficient content-based retrieval to Analyze Large volume climate data (SEAL)”. Existing web-based search systems for climate simulations are designed to find data files using metadata associated with a data file itself. On the other hand, the SEAL allows the users to extract necessary data using metadata associated with contents of a data file such as physical values. The SEAL mainly consists of a relational database, a data download function and web-based user interface. Among the three main features, a key role is provided by the relational database using PostgreSQL which is designed to be registered temporally and spatially compressed data. The data download function allows the users to download temporally and spatially extracted data based on search results obtained by the relational database. In addition, the web-based user interface allows the users to easily use the relational database without knowledge about PostgreSQL. We also prepare a guidebook for usage of the SEAL. The SEAL is currently in test operation on our local server for SI-CAT members.
The SEAL and the guidebook will be released on Data Integration and Analysis System Program (DIAS) after end of fiscal year 2018. Techniques of the SEAL might be quite useful for simulation, experimental and observational data in other research fields. We report functions and some case studies of the SEAL.

Keywords: Climate Change, Relational Database

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Climate change impact assessment in Shikoku with the ensemble climate prediction database d4PDF

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1. Kochi University of Technology, 2. University of the Philippines Los Baños

In considering water disaster prevention as a climate change adaptation policy, it is necessary to utilize the climate change projection model. However, the projection model output has some problems mainly in spatiotemporal resolution, bias and uncertainty. When preparing countermeasures according to disaster risks in each region, these problems and characteristics of these GCMs must be taken into consideration. In the presentation of last year, we evaluated the impact in the Yoshino River basin climate change prediction model output CMIP 5 with statistical downscaling, but some problems were clarified.It is important to apply dynamical downscaling including a large number of outputs for appropriate impact assessment.

We used the ensemble climate prediction database d4PDF to evaluate the impact of climate change in the Yoshino River Basin in this study. We made a comparison with the grid near Sameura Dam in the Shikoku mountain area, Tokushima and Kochi. In the Shikoku mountains, the observation rainfall amount are close to members with a lot of rain ,and in Tokushima it was close to members with little rainfall. In Kochi, the model output can not reproduce heavy rainfall caused by typhoon or special factors that occurred in the past. As a result, it is clear that it can be utilized without bias correction for the risk assessment if the scale and rainfall characteristics of the Yoshino river basin area, but it can not be used as it is in smaller rivers and rivers with localized rainfall.

In Sameura Dam, a renewal project to expand the drainage channel is planned. This project makes it possible to release dam water more quickly and increase flood control capacity. At the same time, dam operator are planning to revise the operation rules and increase the ability to respond to large floods.
In order to develop climate change adaptation measures utilizing Sameura Dam, which is a key to flood control and water use in the basin, we should optimize the dam operational rule according to not only flood flow rate but also the trend of the dam reservoir volume of the long term. In order to estimate the dam water level at the time of large scale flooding, we compared the relationship between the discharge rate into the dam and the amount of monthly rain in April to June. GCM greatly differed from non-global warming experiments in each GCM, GCM increased the occurrence of floods from low rain, and GCM tended to have more precipitation in the year when flooding occurred. Compared with the non-global warming experiment, the trend greatly differs in each GCMs. A GCM has the trend increasing the occurrence of floods in drought condition, and other GCM tended to have more precipitation in the year when flooding occurred. For this reason, it is difficult to fixedly change the operational rules of the dam, and it is considered that an "adaptive" approach is required according to changes in rainfall characteristics due to climate change.
In addition, as a result of interviews with local government in the downstream section, it became clear that they are concerned about the risk of complex disasters of flooding in and out of water. Due to heavy rain caused by typhoons and the like, inundation flooding occurred, there is a possibility that evacuation routes in urban areas will be disrupted. In addition, the rainfall in the upstream generated flood and it reaches the downstream section after several hours, and is exposed to the risk of flooding the outside. For this reason, the flood flow rate in the downstream section and the time difference from the rainfall occurrence to the flood arrival were analyzed. The time from heavy rain to flood reached fluctuated

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stronger than the current reproduction. As a result, it became clear that diversification of complex disaster scenario is necessary.

Keywords: climate change adaptation, d4DPF, river management

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Caution zone quantification risk to sediment disaster adaptation due to climate change

*SEIKI KAWAGOE[1], YOSUKE SAITO[1], HIROMICHI SUZUKI[1]

1. Fukushima university

Heavy rainfall disaster is predicted by extermination metrological condition due to climate change. We must estimate future risk based on trend in the future. It's necessary to manage sustainable counter measures to shift smoothly from present to future. In this study, risk evaluation is obtained to apply climate model outputs. We developed high resolution landslide risk model (Saito et al, 2017), and showed risk distribution information. These risk distribution indicate to pay attend some scenario conditions (Rain condition: directly rain outputs, and probable maximum precipitation condition, Time scale: near future and future, RCP scenario: 2.6 and 8.5). Especially, this study result indicate potential risk by probable maximum precipitation. This result predict to target of upper limit to disaster mitigation. It is useful of mitigate planning at regional area. Therefore, this risk outputs target to sediment disaster caution zone. Sediment disaster caution zones set high risk area, and it is a set area to give priority to a disaster prevention measure as an area in present.

As results, it was possible to specify about 10000 points of high dangerous area. Therefore, An adaptation method to these point group was planned.

Keywords: Probable maximum precipitation, disaster, adaptation

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[J] Oral | H (Human Geosciences)：H-GG Geography

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | 102 1F

[H-GG02] Use, change, management of natural resources and environment: Interdisciplinary perspectives

convener:Yoshinori OTSUKI(Institute of Geography, Graduate School of Science, Tohoku University), Gen Ueda(Graduate School of Social Sciences, Hitotsubashi University), Takahisa Furuichi(Graduate School of Science, Hokkaido University), Toru Sasaki(Miyagi University of Education), Chairperson:Yoshinori OTSUKI, Gen UEDA

In this session, the situation and history of use, changes and management of natural resources and environment from various regions under diverse socio-economic and natural conditions are reported. Findings from local-scale fieldwork and feedbacks on their methodology and/or research concepts are particularly encouraged to be shared and discussed. A variety of research topics are covered through both human-ecological and earth-scientific perspectives, including local knowledge of natural resources and environment, environmental and climatic history, environmental geography, environmental degradation through resource use and/or management, effects of climate change, related socio-economic changes and adaptation for livelihood security, political ecology, and issues for overcoming gaps in linking between local and broader-scale (national, regional and global) studies.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[HGG02-01] Source identification of pottery based on chemical analysis of volcanic glass contained in ceramic paste
- Example for Usultan pottery in Chalchuapa, El Salvador, Central America -

*Shigeru Kitamura[1], Masakage Murano[2] (1.Faculty of Social Welfare, Hirosaki Gakuin University, 2.The Museum of Kyoto)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[HGG02-02] Preliminary magnetic biomonitoring study of the spatial distribution of roadside pollution using *Cryptomeria japonica* tree bark

*Nagisa Sawada[1], Kazuo Kawasaki[1] (1.University of toyama)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[HGG02-03] Preliminary environmental magnetic results from heavy metal contamination around the Erdenet Cu-Mo deposit, Mongolia.

*Kazuo Kawasaki[1], Ryuki Tonami[2], Solongo Tsetsgee[3], Baasansuren Gankhurel[3], Keisuke Fukushi[4] (1.Graduate School of Science and Engineering for Research, University of Toyama, 2.Department of Earth Sciences, University of Toyama, 3.Kanazawa University, 4.Institute of nature & Environmental Technology, Kanazawa University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[HGG02-04] Sediment and its movement as natural resources and environment

*Takahisa Furuichi[1], Sachi Wakasa[2], Shigeru Mizugaki[3], Masanori Nunokawa[3] (1.Graduate School of Agriculture, Hokkaido University, 2.Graduate School of International Resource Sciences, Akita University, 3.Civil Engineering Research Institute for Cold Region)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[HGG02-05] Reutilization of waste bamboo from oyster farming

*KIYOSHI SAIJO[1] (1.Miyagi University of Education)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[HGG02-06] Regional Impacts of Globally Important Agricultural Heritage Systems in Osaki City, Miyagi Prefecture

*Toru Sasaki[1] (1.Miyagi University of Education)

Source identification of pottery based on chemical analysis of volcanic glass contained in ceramic paste - Example for Usultan pottery in Chalchuapa, El Salvador, Central America -

*Shigeru Kitamura[1], Masakage Murano[2]

1. Faculty of Social Welfare, Hirosaki Gakuin University, 2. The Museum of Kyoto

In volcanic area, volcanic ash is generally utilized for making pottery as one of materials. Then the chemical analysis of the volcanic glass contained in the paste of the pottery can provide available data to clarify the production and the distribution of the pottery. This approach, which is recently being developed in Japanese archaeology, is supposed to be valuable also in El Salvador, Central America, because chemical composition of volcanic glass from the late quaternary tephras in the area has been previously obtained by using a wave-length-dispersive electron microprobe analyzer (WDS).
The present preliminary work aims at illustrating chemical composition of volcanic glass contained in the paste of Usulutan pottery, which is a kind of mesoamerican pottery style in the period from 400 B. C. to 600 A. D. and has been found out in a broad area of Central America. Chemical analyses for two samples, both of which are Usulutan-type ceramic pieces and are collected in Chalchuapa, El Salvador, were performed using the WDS (JEOL JXA-8800RL) in the Department of Global Environment and Disaster Prevention Sciences, Hirosaki University. As a result, the volcanic glass in the both samples is chemically similar to the Arce tephra, ejected from Coatepeque Caldera in 72 ka, particularly to the middle unit of the tephra. This result indicates that the Usulutan potteries analyzed in the study would be produced in the distribution area of the Arce tephra including Chalchuapa. Moreover, volcanic grains with particular size were possible to be collected selectively to make the potteries, because the middle unit of the Arce tephra is finer than the other units around Chalchuapa.

Keywords: a wave-length-dispersive electron microprobe analyzer , analysis of ceramic paste, Arce tephra

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Preliminary magnetic biomonitoring study of the spatial distribution of roadside pollution using *Cryptomeria japonica* tree bark

*Nagisa Sawada[1], Kazuo Kawasaki[1]

1. University of toyama

Magnetic biomonitoring methods have been shown to be effective for monitoring roadside pollution. Most such studies have focused on tree leaves and only a few systematic magnetic investigations have reported on tree barks. However, tree barks could be an effective candidate for biomonitoring because tree barks can be sampled at any height above the ground. Our aim is test the efficiency of using the magnetic properties of *Crypotomeria japonica*, Japanese cedar tree, bark for monitoring roadside pollution and estimating the tree-dimensional distribution of roadside pollution. One bark sample was collected from the road-facing side of the tree and second from the forest-facing side. The samples were collected at heights of 0.5, 1.0, and 1.5 m from the ground at 18 sites along a local road in Suzu-city, Ishikawa, resulting in 108 samples in total. Stepwise isothermal remanent magnetization(IRM) acquisition and subsequent alternative field demagnetization tests indicate that the main magnetic minerals attached to the bark are pseudosingle-domain(PSD) magnetite and maghemite. The maximum saturation IRM intensities occur near the roadside and the intensities decrease rapidly by ~2 m from the roadside. Also, the higher the height above the ground, the lower is the observed SIRM intensity. Therefore, likely the magnetic minerals in tree barks are derived from passing vehicles. The results show that environmental magnetic measurements on tree barks are an effective method for estimating roadside pollution in three-dimensional space.

Keywords: magnetic biomonitoring, roadside pollution, tree bark, Ishikawa

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Preliminary environmental magnetic results from heavy metal contamination around the Erdenet Cu-Mo deposit, Mongolia.

*Kazuo Kawasaki[1], Ryuki Tonami[2], Solongo Tsetsgee[3], Baasansuren Gankhurel[3], Keisuke Fukushi[4]

1. Graduate School of Science and Engineering for Research, University of Toyama, 2. Department of Earth Sciences, University of Toyama, 3. Kanazawa University, 4. Institute of nature & Environmental Technology, Kanazawa University

The Erdenet Cu-Mo porphyry deposit in Mongolia is one of the largest mines in the world and it has been operating since 1978. The ore processing waste is pumped into a tailings pond that contains ~400 million tons of tailings and 15 million m^3 of supernatant water. Environmental magnetic results are reported here for surrounding topsoils, stream sediments and sediments from the pond. The rock magnetic analyses indicate that the main magnetic minerals are pseudosingle domain magnetite and/or partially oxidized magnetite with minor pyrrhotite. This magnetic mineralogy is consistent through all samples, indicating that the observed fluctuations of magnetic susceptibility and saturation isothermal remanent magnetization (SIRM) intensity record the abundance of magnetic minerals in the samples. Based on geochemical analyses of the topsoils and stream sediments, positive correlations are found between susceptibility and SIRM intensity with heavy metal concentrations such as Cr and Zn. Further, SIRM intensity showed a more positive correlation with heavy metal concentration than susceptibility, implying that some of magnetite may be substituted by metal ions. These results indicate that environmental magnetic monitoring, especially the SIRM intensity, can be a rapid and cost-effective method for studying the spatial distribution of heavy metals in the Erdenet area.

Keywords: Environmental magnetism, Heavy metal contamination, Erdenet Cu-Mo deposit, Mongolia

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Sediment and its movement as natural resources and environment

*Takahisa Furuichi[1], Sachi Wakasa[2], Shigeru Mizugaki[3], Masanori Nunokawa[3]

1. Graduate School of Agriculture, Hokkaido University, 2. Graduate School of International Resource Sciences, Akita University, 3. Civil Engineering Research Institute for Cold Region

1. Introduction

Sediment is not well recognized as a natural resource, compared with, for instance, forest and water. Sediment is also an important constituent of the environment but is not fairly acknowledged. In this paper, we identify benefits derived from sediment as a natural resource as well as a constituent of the environment. Problems caused by sediment movement are also located in various environmental settings. Then, we review an effective analytical framework of sediment movement and give research perspectives on sediment and its movement as natural resources and environment.

2. Terminology of ‘sediment’

‘Sediment’ refers to basically unconsolidated collection of solid particles in the size from clay to boulder consisting of rock clasts, mineral fragments, volcanic materials, weathering residual materials, biological remains etc. Solid particles may be coated by materials from different origins through adsorption and/or precipitation processes. ‘Debris’ is a synonym of ‘sediment’ but tends to be used when cobbles and boulders are included. ‘Deposit’ is also a synonym of ‘sediment’ but may be used particularly for settled sediment. ‘Sediment’ is a useful term which can be used for collection of solid particles in transport and after deposition, regardless of its particle size distribution.

3. Benefit and problems of sediment as natural resources and the environment

Sediment is a resource material for buildings and civil engineering structures. In some areas, humus-rich sediment is collected and distributed to agricultural fields as natural fertilizer. Sediment develops landforms, such as alluvial plains, river banks and beds, coastal banks and beaches, which provide the essential places for human life, agriculture and ecological habitats. On the other hand, sediment can cause various problems. 1) Sediment disaster is one of the most serious sediment-causing problems around the world. Other issues include 2) the problems in water quality and local water transportation in Lake Inle of Myanmar, 3) the problem in water quality by suspended sediment being delivered from many coastal catchments into the Great Barrier Reef lagoon in northwestern Australia, 4) heavy metal pollution by discharge of mine tailing (polluted sediment) from the Bor Mine into the Danube River in Serbia, 5) river incision and/or coastal erosion due to local deficit of sediment, and 6) deterioration of ecological habitat environments due to changes in landforms along rivers and coasts as well as in particle size distribution. Thus, sediment-causing problems commonly occurs by human interventions or extreme events (rain and earthquake) and extreme events (rain) are partly but importantly related to climate change.

4. Sediment budgets as an analytical framework

Many sediment-causing problems are commonly induced by rapid or sudden change in rates of erosion (or discharge) and deposition (or inflow) of sediment. ‘Sediment budgets’ are a quantitative, schematic

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account of sediment movement in the target area, in which erosion (source) and deposition (sink) as well as outflow from the target area (output) are linked. It is displayed in the form of a simple diagram, which makes a sediment budget considerably useful in planning countermeasures for sediment-causing problems.

5. Research perspectives

Given that sediment is clearly a constituent of the environment, it should be better recognized, even in the academic arena, as an important natural resource, like forest and water. Scientific research will objectively analyze both benefits and problems concerning sediment and its movement. Such research encourages the multidisciplinary approach with earth, ecological and social sciences.

Keywords: Land, Agriculture, Habitat, Mine tailing, Sediment disaster, Sediment budgets

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Reutilization of waste bamboo from oyster farming

*KIYOSHI SAIJO[1]

1. Miyagi University of Education

The shelves for oyster farming in the Matsushima Bay, Miyagi Prefecture are made of many Moso bamboos. Those bamboos, as being soaked in sea water, become degraded within about three years and be replaced by new ones. As the result, the used bamboos change into waste. It is estimated that about 40 to 50 thousands waste bamboos per year appear from oyster farming in the Matsushima Bay. This study presents that the author's attempts to reutilize these waste bamboos as resources which may contribute to local agriculture and environmental improvement.

Keywords: oyster farming, waste bamboo, local resource, environmental improvement

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Regional Impacts of Globally Important Agricultural Heritage Systems in Osaki City, Miyagi Prefecture

*Toru Sasaki[1]

1. Miyagi University of Education

In this report, I would like to discuss how Globally Important Agricultural Heritage Systems could affect local agriculture, especially the use and management of natural resources.

Keywords: Globally Important Agricultural Heritage Systems, Paddy Field Agriculture, Osaki City, Sustainability

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[J] Oral | H (Human Geosciences)：H-QR Quaternary research

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | 102 1F

[H-QR05] Quaternary, Diachronic dynamics of human-environment interactions

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Ken Ikehara(Institute of Geology and Geoinformation, National Institute of Advanced Industrial Science and Technology), Masayuki Hyodo(Research Center for Inland Seas, Kobe University), Chairperson:Ken Ikehara(AIST), Kaori Aoki

Humans have attained their specific development by indigenous cultures and evolved through environmental adaptation. The session raises issues of human-environmental interactions, views from diverse changes of climate, ocean, land and biota having made striking influence on humans. It welcomes various fields from human-environment change and their chronometric dating among Quaternary disciplines.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[HQR05-01] Disturbance of sea floor by large earthquake and formation of earthquake-induced event deposit: Where is a suitable location for deep-sea turbidite paleoseismology

★Invited Papers

*Ken Ikehara[1] (1.Institute of Geology and Geoinformation, National Institute of Advanced Industrial Science and Technology)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[HQR05-02] The Diatom Assemblages as the Indicators for Huge Tsunami Sedimentations and Recover Processes of Environment at Kesennuma Bay, Tohoku, Japan

*Kaoru Kashima[1], Ryozo Shiomi, Yu Fukumoto[3], Tsuyoshi Haraguchi[2] (1.Department of Earth and Planetary Sciences, Kyushu University, 2.Department of Geosicneces, Graduate School of Science, Osaka City University, 3.Ritsumeikan University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[HQR05-03] **Niger Delta dynamic phase in the Gulf of Guinea during the last 20 ka: Panacea for the sustainable development of the region**

*Onema Christopher Adojoh[1], Marret-Davies Fabienne[2], Tetsuji Muto[3] (1.Missouri Univetrsity of Science and Technology, Rolla, USA, Dept of Geoscience, Geological and Petroleum Engineering, 1400 North Bishop, Post Code 65401, 2.School of Environmental Sciences, University of Liverpool, L69 7ZT, UK, 3.Nagasaki University, Japan, Dept of Environmental Science and Fisheries, 1-14 Bunkyomachi, Nagasaki, 8528521)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[HQR05-04] K-feldspar post-IR IRSL ages suggest the presence of MIS 5a–c marine terraces in the eastern margin of the Kanto Plain, central Japan

★Invited Papers

*Toru Tamura[1,2], Hiroko Okazaki[3], Hiroomi Nakazato[4], Tomonori Naya[1], Rei Nakashima[1] (1.Geological Survey of Japan, AIST, 2.Graduate School of Frontier Sciences, University of Tokyo, 3.Natural History Museum and Institute, Chiba, 4.National Agriculture and Food Research Organization)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[HQR05-05] Tephrostratigraphy of drilled core C9010E off the Boso Peninsula: as a preliminary report

*Kaori Aoki[1], Makoto Kobayashi[1], Masanori Murata[1], Takehiko Suzuki[1] (1.Research Center for Volcanic Hazards and Their Mitigation, Tokyo Metropolitan University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[HQR05-06] Late Quaternary fluvial terraces and piracies in the Tanagura area, along the upper reaches of Kuji River, NE Japan

*Yuichi Kato[1], Takehiko Suzuki[1] (1.Graduate school of Urvan Environmental Sciences, Tokyo Metropolitan University)

Disturbance of sea floor by large earthquake and formation of earthquake-induced event deposit: Where is a suitable location for deep-sea turbidite paleoseismology

*Ken Ikehara[1]

1. Institute of Geology and Geoinformation, National Institute of Advanced Industrial Science and Technology

Surface sediment remobilization is a relatively new idea for generating earthquake-induced fine-grained turbidites. It is important for repeated deposition of fine-grained turbidite by every earthquake to deposit enough amounts of sediments, which are resuspend and redeposit by the next earthquake, on the slope. Remobilized sediment may move downslope gravitationally, and deposit in a depression at the base of slope. Sediment accumulation between earthquake events should be large enough for distinguishing each event deposits (fine-grained turbidites). Thus, the basin at the foot-of-slope with high sedimentation rate is a suitable location for deep-sea turbidite paleoseismology.

Keywords: turbidite, paleoseismology, surface sediment remobilization

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The Diatom Assemblages as the Indicators for Huge Tsunami Sedimentations and Recover Processes of Environment at Kesennuma Bay, Tohoku, Japan

*Kaoru Kashima[1], Ryozo Shiomi, Yu Fukumoto[3], Tsuyoshi Haraguchi[2]

1. Department of Earth and Planetary Sciences, Kyushu University, 2. Department of Geosicneces, Graduate School of Science, Osaka City University, 3. Ritsumeikan University

Kesennuma Bay is located north of Sendai, Miyagi Prefecture, and is an enclosed bay along the Pacific Ocean. It was damaged by the Tsunami at 2011 East Japan Tsunami (March 11, 2011). About 1500 persons were killed and 10,000 houses were broken by the tsunami along the bay. The oil from the broken oil flowed into the bay, and fired for several days at the north part of the bay. The oil fire left the serious influences for the plankton flora, and took huge damage for the fishery production of the bay for several years.

The tsunami currents occurred huge scale of sedimentation and erosion within the bay. Dr. Tsuyoshi Haraguchi, Osaka City University, compared the detail measurements of the submarine topography of the bay between in 2010 (one year before the tsunami), 2011 (one month later the tsunami) and in 2013 (two years later the tsunami) and presumed the distributions of erosion and deposition areas in the bay by the tsunami current. The maximum sedimentation by the tsunami current reached more the 3m, at north and east part of the bay. He also took core samplings of the tsunami deposits where the sedimentary parts, and made clear that almost of the tsunami deposits were consisted of clay or silt materials. The sand material (the Tsunami Sand) distribution was very limited in the bay (the margin of the bay).

Diatom are clay or silt size (less than 100 μm), and we tried to trace the transportation processes by the tsunami of silt and clay materials using diatom assemblages in the sediments. The samples for diatom analysis in the Kesennuma Bay were as follows:

(a)The surface deposits at 26 sites in the bay, taken in 2010 (one year before the tsunami), in 2012 (one year after the tsunami) and in 2014 (three years after the tsunami)
(b)Three drilling cores at the tsunami deposits in the bay taken in 2013 (two years after the tsunami).
(c)Three drilling cores at the Tsunami deposits at 1960 Chilli Tsunami (1960 Valdivia Earthquake Tsunami) taken 2009, two years before the 2011 Tsunami.

At the tsunami currents in 2011, a lot of inland deposits along the coasts flowed into the bay by the back current of the tsunami. The ratio of the freshwater diatom assemblages in the bay surface deposits increased about 50%, and it presumed the strong sedimentation of freshwater materials from inland coasts by the tsunami.

The 1960 Chilli Tsunami (1960 Valdivia Earthquake Tsunami) had long-period waves (about 100 minutes interval). The waves looked gently moved on the surface, but the strong erosion and sedimentation processes were occured at the submarine floor of the bay.

The fluctuations of “go” and “back” currents of tsunami were kept as the laminated structures in the core deposits in the bay clearly. Diatom assemblages also fluctuated according to the laminated

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structures. Ratio of off shore marine diatoms increased at the “go” stages, and freshwater diatoms from inlands increased at the “back” stages.

Keywords: Diatom Assemblages, 1960 Valdivia Earthquake, 2011 Earthquake off the Pacific Coast of Tohoku, Kesenunuma Bay, Submarine Topography

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Niger Delta dynamic phase in the Gulf of Guinea during the last 20 ka: Panacea for the sustainable development of the region

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The Niger Delta is ideally located in a region of great sensitivity to climate change and sea level fluctuations and offers the possibility to provide insights on Late Quaternary environmental change in Equatorial West Africa. In comparison with other major tropical deltas, this deltaic system’ s response to past climate change and sea level fluctuations during the last 20 ka is poorly understood due limited studies in the basin. This presentation documents the detailed analyses of a multi-proxy dataset collected from three gravity cores obtained from the shallow margin of the Niger Delta to fill this scientific knowledge gap. The dataset included sedimentology, grain size, geochemistry, calcareous nannoplankton, foraminifera, and palynomorphs. The study hypothesised that the dynamics of the Intertropical Convergence Zone (ITCZ) and sea level fluctuation played a major role in shaping the landscape in the Niger Basin and adjacent coastal regions.

The palynological sequences defined in the three gravity cores show very similar fluctuations; afromontane forest (Podocarpaceae), freshwater swamp (Cyperaceae), savannah (Poaceae) and lowland rainforest (Polypodiaceae) dominated the late glacial and deglaciation periods, followed by the development of mangrove vegetation (Rhizophoraceae) during the interglacial in Early to mid-Holocene. These records suggest dry conditions and lower sea level during the late glacial and deglaciation periods, and warm conditions leading to the rise of the sea level during the interglacial.

The two stages of evolution at different periods has resulted in an improved understanding of the paleoenvironmental dynamics for the sustainable development of the region.

Keywords: Niger Delta, Deltaic Environment, Late Quaternary, Sustainable Development

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K-feldspar post-IR IRSL ages suggest the presence of MIS 5a–c marine terraces in the eastern margin of the Kanto Plain, central Japan

*Toru Tamura[1,2], Hiroko Okazaki[3], Hiroomi Nakazato[4], Tomonori Naya[1], Rei Nakashima[1]

1. Geological Survey of Japan, AIST, 2. Graduate School of Frontier Sciences, University of Tokyo, 3. Natural History Museum and Institute, Chiba, 4. National Agriculture and Food Research Organization

There has been a long-standing question about the Late Quaternary tectonics of the Kanto Plain nearby the triple junction of the plate boundaries. The Last Interglacial (MIS 5e) raised marine terrace has been widely correlated over the Kanto Plain and supposed to represent a general uplift trend associated with local variations. However, a thick accumulation of Quaternary sediments indicates the Kanto Plain had been subsided in the longer-term, and it is unclear when and how the recent uplift trend started. Fragmentary evidences have been recently presented for revising the tectonic history of the Kanto Plain. In the Iioka Plateau, at the eastern end of the plain, a part of the marine terrace formerly correlated with the MIS 5e was constrained to have ages of the MIS 5a or 5c by the composite chronology. As sea levels in the MIS 5a and 5c were much lower than MIS 5e, this revision poses a question about the consistent uplift of the Kanto Plain since the MIS 5e.

K-feldspar post-IR IRSL (pIRIR) ages are presented here to examine the marine terrace in the Kashima Plateau, eastern Kanto Plain, which has also been exclusively correlated as the MIS 5e. The sediment succession of the Kashima Plateau is characterized by marine to brackish deposits with pIRIR ages of the MIS 7 or 9, overlain by the succession of shallow-marine deposits. The shallow-marine succession is variable; in the landward section it is exclusively fine to medium sands overlain by a several meters thick aeolian unit, while the seaward section is gravelly coarse sands with negligible aeolian capping. This variation is corroborated with pIRIR ages. The landward and seaward sections are dated as 137±14 to 155±12 ka, and 86±9 to 105±8 ka, respectively. pIRIR ages are likely to be overestimated by several thousand to ten thousand years. Therefore, the Kashima Plateau represents a composite marine terrace that is correlated with the MIS 5e and MIS 5a or 5c in the landward and seaward sections, respectively. Along with the Iioka Plateau, this composite marine terrace occurs throughout the eastern margin of the Kanto Plain, which requires the Late Pleistocene tectonic history of the Kanto Plain to be reconsidered.

Keywords: OSL dating, Quaternary, Kanto Plain

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Tephrostratigraphy of drilled core C9010E off the Boso Peninsula: as a preliminary report

*Kaori Aoki[1], Makoto Kobayashi[1], Masanori Murata[1], Takehiko Suzuki[1]

1. Research Center for Volcanic Hazards and Their Mitigation, Tokyo Metropolitan University

We investigate the history of volcanic activities in north Izu Islands, and try to establish the high-resolution tephrochronology (Aoki *et al.,* 2019). Today, we present a part of the result of tephra correlations intervening in the sediment core off the Boso Peninsula, on the basis of the geologic, petrographic and geochemical characters of tephra samples collected at the reference sites on land. The sedimentary core C9010E was drilled at the site (34˚33.46'N, 139˚53.38'E, water depth: 2027.25 m) of about 40 km south of Boso Peninsula by the D/V *Chikyu* in 2009. The length of all core is 190.38 m. We collected 314 samples for tephra analysis from this core, including 161 tephra samples described (Tsuchiya *et al.*, 2009). The major-element chemistry of volcanic glass shards in the fraction of 63-125 μm for all samples have been determined by EPMA of the Center for Advanced Marine Core Research, Kochi University.

Firstly, all samples were checked roughly, and some fine glassy samples which might be correlated to widespread marker tephras were picked up and analyzed. As a result, correlatives for Aso-4 (87.1 ka; Aoki, 2008) at the depth 149.08 mbsf, On-Pm1 (95.7 ka; Aoki *et al.*, 2008) at 158.244 mbsf, and Aso-ABCD at 25 cm below On-Pm1 were found, respectively. Secondly, it is summarized the result of analysis for 28 samples (No.1~28) from the top of core to approximately 30 mbsf. Ten samples consist of mainly scoria clasts. Another 20 samples are rich in felsic volcanic glass shards, and including plagioclase, quartz (including beta-quartz), orthopyroxene, hornblende, cummingtonite, and occasionally biotite. The content of SiO_2 in felsic volcanic glass shards is 77.9-78.8 wt% generally, and it is so much. Except No.18 (16.722-16.772 mbsf), the contents of FeO* (0.59-0.74 wt%) and CaO (0.34-0.70 wt%) in felsic volcanic glass shards are remarkably low, on the other hand, the contents of Na_2O (4.12-4.25 wt%) and K_2O (3.45-4.15 wt%) are relatively high. These characters of major-element composition are resembled to them of felsic tephras provided from Niijima and Kozushima during late Quaternary. Furthermore, we tried to correlate each tephra bed in the core C9010C to each eruptive event based on the major-element composition. The probabilities that No.1 (1.15-1.17 mbsf) as the highest layer correlates to Niijima Mukaiyama tephra (AD886), and No.2 (1.63-1.66 mbsf) correlates to Kozushima Tenjyosan tephra (AD838) are high. No.8 (9.36-9.48 mbsf), No.12 and No.13 (14.32-14.65 mbsf), and No.14, No.15 and No.16 (No.14.65-15.54 mbsf) will correlate to the eruptive events of Miyatsukayama SW, Shikinejima, and Miyatuskayama on the Niijima main island, respectively (Kobayashi *et al.*, 2019a). The petrographic and geochemical characters of No.19 and No.20 (19.90-19.00 mbsf), No.21 (19.31-19.34 mbsf), and No.28 (29.49-30.66 mbsf) are resemble to the events of Akasakimine on Niijima main island. There are hemipelagic ooze of 11 m thick, including several scoria layers, between No.19 and No.28. Kobayashi *et al.* (2019a) report Akasakimine events are several eruptions at ca.15-20 ka, therefore it would make sense for the time interval of 11 m-thick sediment between No.19 and No.28. Above-mentioned correlatives to tephras provided from Niijima island consists of felsic volcanic glass shards mainly, only a small amount of scoria grains is included. No.18 (16.72-16.78 mbsf) is sorted glassy tephra mainly, with gray to beige fine bubbled pumices, which maximum diameter is 7 mm. There are almost volcanic glass shards including a small amount of plagioclase, quartz and orthopyroxene, not scoria grains and lithic fragments in the fraction of 63-250 μm. The content of SiO_2 is 78.8 wt%, FeO* is 1.24 wt%, CaO is 1.25 wt%, Na_2O is 4.76 wt%, and K_2O is 1.22 wt%. We consider that No.18 would be correlated to tephra provided from the submarine volcano Oomurodashi at 13.4 ka (Hamuro *et al.*, 1983; Saito and Miyairi, 2008; Tani *et al.*,

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2017).

Keywords: CK09-03, C9010E, late Quaternary, Niijima, Kozushima, Oomurodashi

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Late Quaternary fluvial terraces and piracies in the Tanagura area, along the upper reaches of Kuji River, NE Japan

*Yuichi Kato[1], Takehiko Suzuki[1]

1. Graduate school of Urvan Environmental Sciences, Tokyo Metropolitan University

In the Tanagura area, the upper reaches of Kuji River and the Yashiro River (a tributary of the Abukuma River), both river basins are in contact with each other. In this area, landforms showing piracies by the Kuji River exist. Previous studies have also suggested the occurrence of capturing. However, ages of piracies have not yet been determined. For determination of ages occurring piracies, chronology of terraces was established in the Tanakura area.
In this area, three landforms showing piracies exist. Timing of occurring piracies can be divided into two. In this paper, we named three paleo-rivers captured by Kuji River, that is, Ko-Uwadai River captured in the former and Ko-Mukaihara River and Ko-Shimohabara River in the later.
Fluvial terraces formed with the base level of erosion by the Abukuma River are classified into Yashiro River High terrace (YH), ditto Middle 1 terrace (YM1), ditto Middle 2 terrace (YM2) in descending order. Those by Kuji River are classified into Kuji River High 0 terrace (KH0), ditto High 1 terrace (KH1), ditto High 2 terrace (KH2), ditto Middle 0 terrace (KM0), ditto Middle 1 terrace (KM1), ditto Middle 2 terrace (KM2), ditto Low 0 terrace (KL0), ditto Low 1 terrace (KL1) and ditto Low 2 terrace (KL2) in descending order. YH formed by Ko-Uwadai River and YM2 by Ko-Mukaihara River and Ko-Shimohabara River displays characteristic topographies that indicate piracies.
KM1 consists of terrace deposits with a thickness of 2 m was covered with a tephric loess of which thickness is 3 m. This tephric loess includes AT tephra (30 ka) just above flood loam. Therefore, it is concluded that KM1 was formed at shortly before 30 ka.
KM2 consists of terrace deposits with a thickness of ca 4 m, and tephric loess or sediment covering terrace deposits was not recognized. Terraces identified as KM2 are broadly distributed in transitional zone from mountain to major valleys, terrace gravels of KM2 are coarser and are not well sorted. This suggests KM2 gravel have been deposited under the glacial stage environment. Because glacial stage after the deposition of AT is only MIS2, KM2 gravel have been deposited in 20–15 ka.
KL1 consists of terrace deposits consisted of sub-rounded gravels with a thickness of 1–2 m. There is no tephric loess on this gravel bed. KL1 where the last stage of the Jomon Period site situated on is younger than KM2. This show that KL1 was emerged at 15 ka to 2 ka.
YH consists of terrace sediment with a thickness of 4 m and it is covered by tephric loess of 8 m in thickness. This tephric loess includes two scoria fall deposits possibly correlated to be one of Ns-Sr6 (150 ka) to Ns-Sr12 (200 ka). Considering the age of YH, that is 150–200 ka.
YM2 consists of terrace sediment with a thickness of 2–3 m. Tephric loess or this sediment was not recognized. It seems that there is no tephric loess or at most 1 m in thickness. Geology and landform of YM2 is similar to those of KM2. This show that these terraces have been formed simultaneously. Considering the emergence of YM2 with piracy by Kuji River basin, the age of YM2 is around 20–15 ka.
Then, we consider when these piracies were occurred. Considering Ko-Uwadai river, the older limit of age in capturing is the formation of YH. YH would have been dissected by valley formed in an interglacial epoch, however, there is no valley. This suggests piracy occurred in MIS6 to MIS5e (200–125 ka).
Considering Ko-Mukaihara River and Ko-Shimohabara River, the older limit of age in capturing is the formation of YM2. In addition, the younger limit is KL1 because profiles of tributaries of Kuji River formed by capturing Ko-Shimohabara River are continual to KL1. Thus, piracy probably occurred in 20–2 ka.
Both piracies were occurred in glacial stage to interglacial stage condition. In conclusion, these piracies

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occurred under the influence of climate change.

Keywords: Kuji River, Yashiro River, fluvial terrace, piracy

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[J] Oral | H (Human Geosciences)：H-QR Quaternary research

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | 102 1F

[H-QR05] Quaternary, Diachronic dynamics of human-environment interactions

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Ken Ikehara(Institute of Geology and Geoinformation, National Institute of Advanced Industrial Science and Technology), Masayuki Hyodo(Research Center for Inland Seas, Kobe University), Chairperson:Mamoru KOARAI(Ibaraki University), Tomonori Naya(産業技術総合研究所)

Humans have attained their specific development by indigenous cultures and evolved through environmental adaptation. The session raises issues of human-environmental interactions, views from diverse changes of climate, ocean, land and biota having made striking influence on humans. It welcomes various fields from human-environment change and their chronometric dating among Quaternary disciplines.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[HQR05-07] Landform features of Okinoshima of Munakata city

*Takahito Kuroki[1] (1.Faculty of Education, Univ. of Teacher Edu. Fukuoka)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[HQR05-08] Revision of geomorphology and geology of Tokyo Upland and Lowland, based on boring data and precise landform analysis

★Invited Papers

*Kunihiko Endo[1], Yusuke Suginaka[2], Shinzaburo Hori[2], Toshihiko Sugai[3], Takehiko Suzuki[4], Shigeko Ishiwata, Yo Uesugi, Reisuke Kondo[5], Tatsuro Chiba[6], Toshio Nakayama[7], Shigeto Osato[8], Marie Noguchi[9], Akio Sato[3], Takato Takemura[10] (1.Nihon University, 2.Research Center of Computational Mechanics, Inc., 3.Graduate School of Frontier Science, The University of Tokyo, 4.Faculty of Urban Environmental Sciences, Tokyo Metropolitan University, 5.Educational Development Center, Kogakkan University, 6.Asia Air Survey, 7.Civil Engineering Support & Training Center, Tokyo Metropolitan Government,, 8.Doshitsu Research Corporation, 9.Paleo Labo co.,ltd., 10.College of Humanities and Sciences, Nihon University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[HQR05-09] Sedimentological characteristics of the Ome Formation exposed on the western margin of Musasino Upland, central Japan

*Takako UTSUGAWA[1], Masaaki Shirai[2], Hiroka Kato[2], Sayuri Kato[3] (1.Department of Geography, Rissho University, 2.Department of Geography, Tokyo Metropolitan University, 3.Hamura City)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[HQR05-10] Stratigraphy of Tokyo Formation: re-examination of Kita-Ku Central Park core

*Tomonori Naya[1], Kentaro Sakata[1], Tsutomu Nakazawa[1], Takehiko Suzuki[2], Toshio Nakayama[3] (1.Geological Survey of Japan, AIST, 2.Tokyo Metropolitan University, 3.Tokyo Metropolitan Government)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[HQR05-11] S-wave veolocity structure and ground motion characteristics of "loam terraces": Examples from the eastern part of Utsunomiya City, Tochigi Prefecture, central Japan

★Invited Papers

*Tsutomu Nakazawa[1], Ikuo Cho[1], Kentaro Sakata[1] (1.Geological Survey of Japan, AIST)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[HQR05-12] The relationship between liquefaction distribution and microtopography classification during the 1948 Fukui earthquake - Toward improvement of liquefaction hazard map -

*Haruka Tani[1], Masanobu Shishikura[2] (1.Housei University, 2.Institute of Earthquake and Volcano Geology, National Institute of Advanced Industrial Science and Technology)

Landform features of Okinoshima of Munakata city

*Takahito Kuroki[1]

1. Faculty of Education, Univ. of Teacher Edu. Fukuoka

The Sacred Island of Okinoshima and Associated Sites in the Munakata Region was registered as a World Heritage in July 2017. Okinoshima located about 70 km northwest of Kyushu main island is a small island with maximum altitude above sea level of about 240 m and an area of about 960,000 m^2. The island consists of a steep cliff and gentle slope and the area of the plain is small. It consists of shale in the southwest part, quartz porphyry in the northwest part, and talus deposit in the southeast part, which has a unique landform distribution. Many historical relics were discovered and investigated there. Many precious votive offerings were conducted to pray for safety ocean voyages from the 4th to the 9th centuries and a sacred place, Okitsu-miya of Munakata Taisha is settled on the gentle slope on the south side of this island. Residents have unwritten taboos that forbid actions such as removing anything from the island, or revealing anything seen or heard there.
From the GIS analysis of various kinds of geographic information, I created maps of land and seabed of it and examined the features of the landforms. Furthermore, I carried out morphological and geological surveys on site. Fundamental geospatial data of GSI, map information related to isobaths of JHA and airborne laser scanner data of Munakata city are used as the geographic information. Basic ground elevation maps, slope maps, relief maps and 3D images were created. A landform classification map of land was made by interpretation of each basic map and field survey. Especially in the southwest part, the distribution of steep cliff and landslip lobe, which indicates the existence of landslides, is distinctive. In addition, the three groups of lineaments that trend west-southwest can be interpreted on the ground. From the 3D images etc., it can be identified that the altitude of Okinoshima is about 340 m above the flat seabed. The topography of seabed in the southern part of Okinoshima, is a shallow flat table in the west side and a concave area inclining to the east in the east side. Other landform features that should be investigated in the future are also confirmed in Okinoshima.
In this presentation, I would like to introduce features of the landforms clarified from the analysis of maps by GIS on Okinoshima where access is restricted.

Keywords: Okinoshima, map, landform, landslide

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Revision of geomorphology and geology of Tokyo Upland and Lowland, based on boring data and precise landform analysis

*Kunihiko Endo[1], Yusuke Suginaka[2], Shinzaburo Hori[2], Toshihiko Sugai[3], Takehiko Suzuki[4], Shigeko Ishiwata, Yo Uesugi, Reisuke Kondo[5], Tatsuro Chiba[6], Toshio Nakayama[7], Shigeto Osato[8], Marie Noguchi[9], Akio Sato[3], Takato Takemura[10]

1. Nihon University, 2. Research Center of Computational Mechanics, Inc., 3. Graduate School of Frontier Science, The University of Tokyo, 4. Faculty of Urban Environmental Sciences, Tokyo Metropolitan University, 5. Educational Development Center, Kogakkan University, 6. Asia Air Survey, 7. Civil Engineering Support & Training Center, Tokyo Metropolitan Government,, 8. Doshitsu Research Corporation, 9. Paleo Labo co.,ltd., 10. College of Humanities and Sciences, Nihon University

Musashino Uplands in Tokyo and the southern Saitama Prefecture, had been investigated by many researchers for the last 90 years. The uplands, with wide area of 45km E -W and 25km N-S, are composed of Musashino and Tachikawa alluvial fans of MIS 5c to MIS 3 and Shimo-sueyoshi marine terraces of MIS 5e, as a type area in the Late Quaternary in Japan.
Recently great advancement in technology changes the research condition also in geomorphology and Quaternary geology.
First, GSI digital elevation model of 5m, is recently opened to the public. It is strongly useful data and tools to analyze precise classification of landforms in densely-developed urban areas like Tokyo. It provides us new maps as Red Relief Map (designed by T. Chiba), new type erosion depth map (by T. Chiba), and Rainbow Color Contour Map (Suginaka et al., 2018), all of them contributed to make a new division of landforms in Musashino Uplands with accuracy of 1 meter.
Second, a great number of digitized boring data and analyzing tools have been opened to the public. We have used more than 50 thousands data in the Musashino Uplands and Tokyo Lowland. These data revealed the underground geology in shallow part (20 to 100 meters in depth) continuously.
Third, tephrochronological studies in southern Kanto Plain have been established. However, in Tokyo area, distant from the source volcanoes, tephra studies were not enough. Moreover, the studied sites located only at the margin of the uplands. Recent progress in tephrochronology brings us to analyze cryptotephra for the age determination of the older fan gravels of research boring cores at the important site of the fan surface.
Those three new research conditions enable us to renew the division of landforms in Musashino Upland and Tokyo lowland.
Fourth, we created a new system using an automated program analyzing geological sequence from a vast number of boring data.
Main characteristics of this approach is to combine new results of computer-supported geomorphological and shallow geological data, with field-based knowledge and analog-type analyses such as a number of geologic profiles.

Keywords: boring data, geomorphology and geology in Tokyo, landform division in Musashino Upland

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Sedimentological characteristics of the Ome Formation exposed on the western margin of Musasino Upland, central Japan

*Takako UTSUGAWA[1], Masaaki Shirai[2], Hiroka Kato[2], Sayuri Kato[3]

1. Department of Geography, Rissho University, 2. Department of Geography, Tokyo Metropolitan University, 3. Hamura City

The Ome Formation defined on the middle 20th century has not been understood enough due to various facies of the formation reported by previous studies and destruction of the outcrops by urbanization. We examined sedimentological characteristics of the Ome Formation distributed in Ome and Hamura cities, Tokyo, central Japan.

Musashino Upland, a large alluvial fan located in the southwestern part of Kanto Plain were formed by the Tama River (ca. 100-20 ka). Along the Tama River, multiple fluvial terraces have formed since the last interglacial (e.g., Ueki and Sakai, 2007). Juen (1964) reported a sandy conglomerate being distinguishable from the upper terrace deposits and the lower Onita (Kasumi) Formation in Kazusa Group, exposed at the terrace cliff along the Tama River. Based on the boring core investigation, it was revealed that the similar sediments have been buried under the western part of Musashino Upland (e.g., Yamazaki, 1978).

A surviving outcrop of the Ome Formation, 20 m thick clast-supported sandy conglomerate has exposed at the terrace cliff located around the boundary between Ome and Hamura cities. The formation is mainly composed by cobbles (5-20 cm in diameter). Boulders (20-40 cm in diameter) make channel-like structures in the basal part of the formation. Microscopic observation revealed that shale fragments were abundant as much as sandstone fragments. Sandstone gravels were the major component followed by chert and shale gravels derived from the Kanto Mountains (accretionary complex). Weathered granitoid gravels were also a few included.

The ratio of chert gravel in the Ome Formation shows downward increase. Chert gravel abundance of the basal Ome Formation is almost equal to one of the Onita Formation, it may imply that hard and durable chert gravels composing the Onita Formation had been reworked and included in the basal Ome Formation. The averaged imbrication of gravels of the Ome Formation indicated NNW direction. It means that the palaeocurrent was similar with the present Tama River current.

Ueki and Sakai (2007) hypothecated that Ome Formation is an aggregation of multiple channel deposits during several interglacial-glacial periods. Based on the sedimentological characteristics of Ome Formation as described above and the established boring core information, we also estimated the distribution of Ome Formation buried around the western part of Hamura City.

Acknowledgement
A part of this study is supported by Municipal history compilation office in Hamura-city (2014-2018).

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Municipal history compilation office in Hamura-city. 2019. *The book of materials –Nature– in Hamura-city*

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Yamazaki, H. 1978. *The Quaternary Research* 16: 231-246. (in Japanese with English abstract)

Keywords: Ome Formation, Tama River, imbrication, gravel, buried valley, Musashino Upland

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Stratigraphy of Tokyo Formation: re-examination of Kita-Ku Central Park core

*Tomonori Naya[1], Kentaro Sakata[1], Tsutomu Nakazawa[1], Takehiko Suzuki[2], Toshio Nakayama[3]

1. Geological Survey of Japan, AIST, 2. Tokyo Metropolitan University, 3. Tokyo Metropolitan Government

We re-examined the Kita-ku Central Park core to examine the stratigraphy of Tokyo Formation. Several depositional cycles consistent with gravels, sands and mud were observed at shallower than the depth 30 m of this core. A pumice layer was found at about 15 m depth of this core, which can be correlated with Km2 tephra of the Kamiizumi Formation of Shimosa Group, suggesting that the Middle Pleistocene sediments corresponding to MIS 7e is distributed in shallow subsurface at this area.

Keywords: Tokyo Formation, stratigraphy, drill core

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S-wave veolocity structure and ground motion characteristics of "loam terraces": Examples from the eastern part of Utsunomiya City, Tochigi Prefecture, central Japan

*Tsutomu Nakazawa[1], Ikuo Cho[1], Kentaro Sakata[1]

1. Geological Survey of Japan, AIST

S-wave velocity structure and ground motion characteristics of “loam terraces” are examined in the eastern part of Utsunomiya City, Tochigi Prefecture, northern Kanto Plain, central Japan. The microtremor array observations reveal that the average S-wave velocitity in the upper 30 m (AVS30) becomes lower and the peak frequency in the H/V spectrum sifts to the lower value in higher terraces. These are considered to be influenced by the thickness of the loam bed (S-wave velocity: ~150 m/s) covering gravelly terrace deposits. We should note that the relatively low frequency (1.5–2 Hz) ground motion would be more largely amplified in the higher terraces and hills compared with the lower terraces.

Keywords: S-wave velocity structure, ground motion characteristics, loam terraces, microtremor array observation, Utsunomiya City, Kanto Plain

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The relationship between liquefaction distribution and microtopography classification during the 1948 Fukui earthquake - Toward improvement of liquefaction hazard map -

*Haruka Tani[1], Masanobu Shishikura[2]

1. Housei University, 2. Institute of Earthquake and Volcano Geology, National Institute of Advanced Industrial Science and Technology

Introduction
In most of the cases of recent large-scale natural disasters, it seems that the present hazard maps cannot have forecasted its damages precisely (Wakamatsu et al., 2017; Une et al., 2015). This is because the specific method for establishing a hazard map is not defined nationally and it is entrusted to each local government. For further disaster prevention and reduction, it is important to establish a more reliable hazard map with a low cost and simple method. Forecast of liquefaction occurrence from a geomorphological point of view can respond to such demand. Nakao et al. (2015) proposed a method for creating a liquefaction hazard map based on the liquefaction hazard evaluation criteria and corresponding geomorphic classification from past liquefaction cases in the Kanto region. However, even in regions other than the Kanto region with different geomorphic development histories, it is not certain whether these criteria are effective. This study treats the case of the liquefaction caused by the 1948 Fukui earthquake (M 7.1) in the central part of Fukui City and examines the issues of present hazard map. Then we would like to propose the direction for creating more precise liquefaction hazard map.

Method
To clarify the liquefaction distribution of the Fukui earthquake, I obtained old air-photographs of the survey area taken by GHQ immediately after the earthquake published by the Geospatial Information Authority Japan (GSI). This study independently defined the criteria of air-photo interpretation to identify the traces of liquefaction. The results of air-photo interpretation were drawn on the map by vector data using QGIS and compared to present hazard map and various geomorphic classification maps published by GSI.

Results and Discussion
Comparison results of the liquefaction distribution of the 1948 Fukui earthquake revealed from air-photo interpretation in this study with various maps suggest that the geomorphic classification defined by Nakao et al. (2015) can apply to this study area. And also our results can newly propose some geomorphic features relating to liquefaction. For example, liquefaction occurred intensively near the old artificial bank overlapped with the former river channel, and also old bank at the adjacent point with the natural levee located on the outer shore of the former meandering river. Because beneath such areas are composed of thick loose sand, liquefaction can easily occur and geomorphic condition triggered lateral flow.
From the above results, it can be regarded that the risk of liquefaction occurrence varies depending on the combination with surrounding microtopography. Therefore, consideration of microtopography is indispensable for establishing liquefaction hazard map.
The liquefaction hazard map of Fukui City is hardly consistent with the liquefaction distribution due to the 1948 Fukui earthquake and does not reflect the actual liquefaction risk, because the present hazard map does not only refer to liquefaction history but also does not consider microtopography.For more precise forecast the liquefaction damages, we propose that the liquefaction hazard map should be established by

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considering liquefaction history and microtopography.

Remained Issues
Because this study uses old black and white air-photographs, there is some difficulty part to detect details of liquefaction. To reveal the relationship between the liquefaction distribution and microtopography, it is necessary to conduct a field survey and interview to victims. The relationship between the distance from the seismic source of the 1948 event and the reaction of each microtopography is not yet resolved because this study focused on only in the central part of Fukui City. Therefore, it is also necessary to conduct air-photo interpretation in whole areas of the liquefaction damage caused by the 1948 event.

Keywords: 1948 Fukui Earthquake, liquefaction , microtopography classification, liquefaction hazard map

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[J] Oral | H (Human Geosciences)：H-CG Complex & General

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | 104 1F

[H-CG30] Safety of nuclear power plants against inland earthquakes

convener:Daisuke Suetsugu(Department of Deep Earth Structure and Dynamics Research, Japan Agency for Marine-Earth Science and Technology), Satoshi Kaneshima(Department of Earth and Planetary Sciences, Kyushu University), Takeshi Sagiya(Disaster Mitigation Research Center, Nagoya University), Kohta Juraku(Department of Humanities, Social and Health Sciences, School of Engineering, Tokyo Denki University), Chairperson:Daisuke Suetsugu, Kohta Juraku

We have organized sessions in the JpGU meeting on nuclear power plants in Japan mainly from a viewpoint of earthquake science since 2013. Topics in the sessions include risks of nuclear power plants related to earthquakes, volcanic activities and tsunamis, as well as the problem of communication gap between scientists and engineers on those risks.
In the 2019 JpGU meeting, we propose the session that focuses mainly safety against inland earthquakes. For a last decade, strong inland earthquakes occurred, such 2007 Off Niigata-Chuetsu earthquake (M6.8), 2008 Iwate-Miyagi earthquake (M6.9), 2016 Kumamoto earthquake, which did damage to regions near the earthquakes. Recently, 2018 Hokkaido east Iburi earthquake (M6.7) gave devastating effects to the epicentral area. Considering the high activity of inland earthquakes, it is important to reconsider the safety measures of nuclear power plants against strong inland earthquakes.
We would encourage discussions from a broad viewpoint across science and engineering, such as evaluation of strong motion due to inland earthquake and anti-seismic capability of nuclear power plants.
We welcome papers of other topics relevant to relationship of earthquake science and nuclear power plants, too.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[HCG30-01] Thickness of the seismogenic layer beneath the Japanese Islands and its relation to crustal earthquakes

*Junichi Nakajima[1] (1.Department of Earth and Planetary Sciences, Tokyo Institute of Technology)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[HCG30-02] Problems with active fault evaluation in nuclear safety regulation

*Yasuhiro Suzuki[1] (1.Nagoya University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[HCG30-03] The longer active fault is, is the larger ground motion generated? – Surface and buried rupture earthquakes-

*Takao Kagawa[1] (1.Tottori University Graduate School of Engineering)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[HCG30-04] Seismic safety of nuclear power plants against inland crustal earthquakes and the "science vs. engineering problem"

*Katsuhiko Ishibashi[1] (1.Emeritus Professor, Kobe University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[HCG30-05] Challenges to Seismic Safety of Nuclear Power Plants

*Tatsuya Itoi[1] (1.The University of Tokyo)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[HCG30-06] Strong motion at Ooi nuclear power plant

*Kunihiko Shimazaki[1] (1.University of Tokyo)

Thickness of the seismogenic layer beneath the Japanese Islands and its relation to crustal earthquakes

*Junichi Nakajima[1]

1. Department of Earth and Planetary Sciences, Tokyo Institute of Technology

The thickness of the seismogenic layer is one of the fundamental parameters for earthquake hazard analysis. Large earthquakes often rupture the entire brittle seismogenic layer, and so the thickness of the seismogenic layer is a primary control on the size of earthquakes. Omuralieva et al. (2012) estimated the cut-off depth (D90) of crustal seismicity beneath Japan using a high-quality seismic catalogue of the Japan Meteorological Agency. D90 is defined as the depth above which 90% of the earthquakes occur. The obtained D90 shows a considerable lateral variation, ranging from ~5 km to ~40 km. The D90 is deep along the Pacific coast of eastern Japan, while it is locally shallow around volcanic areas. These lateral variations in D90 are inversely correlated to values of surface heat flow. In this talk, I summarize the recent result of D90 in Japan and discuss the relation among D90, thermal structure, and the size of crustal earthquakes.

Keywords: Earthquake, seismogenic layer

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Problems with active fault evaluation in nuclear safety regulation

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1. Nagoya University

There are various factors behind the underestimation of active faults during the safety review of nuclear power plants. I have disclosed this problem in my books (“Nuclear Power Plants and Active Faults” published by Iwanami-Shoten in 2013, and “Active Faults and Nuclear Regulation in Japan”, in-edit). In the past, safety review was conducted in two stages—site review and seismic review, and active fault survey was conducted only in the latter. Therefore, we could not use active fault information for site determination. Moreover, the safety regulation rules (Regulatory Guide for Reviewing Seismic Design) were bylaws of government authorities that did not possess external binding power. Furthermore, it allowed arbitrariness in interpreting the definition of active faults. In the above-mentioned case, although problems related to laws and ordinances have improved due to the establishment of New Regulatory Requirements after the formation of the Nuclear Regulation Authority (NRA), the problem of the NRA itself having no authority to investigate remains. In this presentation, I discuss issues of active fault evaluation in safety regulation.

Usually, the construction of nuclear plants should be conducted as follows: (1) determine if an active fault exists in the premises or in the vicinity, ② estimate earthquake ground motion and ground deformation by active faulting before designing, or ③ avoid. This flow is the basic policy of the NRA examination team that I was a part of, for the New Regulatory Requirements. ③ "Avoid" means moving the location or refraining from constructing at the site. However, there was no corresponding description in the earlier regulatory guide. The New Regulatory Requirements prohibit important facilities from being installed on the outcrop of "faults etc. that may possibly activate in the future". In addition, operating is not permitted unless it meets the requirements. While there have been objections to this, we can discuss again how to better understand "avoiding". However, revising New Regulatory Requirements should be based on social consensus. I will discuss here several scientific subjects regarding ① "active fault recognition" and ② "prediction of earthquake motion and displacement".

Keywords: Nuclear power Plant, Active fault, Nuclear Regulation

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The longer active fault is, is the larger ground motion generated? –Surface and buried rupture earthquakes-

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1. Tottori University Graduate School of Engineering

Ground motion characteristics from surface and buried rupture earthquakes are demonstrated. Magnitude of surface rupture earthquake is large and it causes heavy damages in wide area. However, it is considered that ground motions from buried rupture earthquake is larger than those from surface rupture earthquake assuming same magnitude for both types of earthquake.

In case of aseismic design for important facilities, fault rupture scenarios tend to be conservative such as setting a long active fault with large magnitude. The larger magnitude is, the longer predominant period of ground motion from the earthquake is. However, ground motion in short period range that really affects on the target facility does not grow so large. Short period ground motion is affected more by fault distance than magnitude. Unfortunately, it is possible that larger ground motions in short period range are generated from small buried earthquakes than from large surface earthquake. Furthermore, probability of small buried rupture earthquakes are larger than that of large characteristic surface rupture earthquake. It might be an important issue for important facilities located in specific regions.

Keywords: Active fault, Ground motion, Surface rupture earthquakes, Buried rupture earthquakes

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Seismic safety of nuclear power plants against inland crustal earthquakes and the "science vs. engineering problem"

*Katsuhiko Ishibashi[1]

1. Emeritus Professor, Kobe University

The seismic safety of nuclear power plants (NPPs) against inland crustal earthquakes has been a big problem in Japan since a nuclear reactor developed in the United Kingdom, an aseismic country, was introduced as the first commercial reactor in the 1950s (e.g., Ishibashi, 2015). However, even now, this problem has not been settled at all. In this presentation, first I review various problems of seismic safety of NPPs related to inland crustal earthquakes referring to the ongoing safety regulation. Then, I discuss the so-called "science vs. engineering problem" concerning NPPs' seismic safety.

The fundamental problem in the seismic safety of NPPs against inland crustal earthquakes is that the largest earthquakes which could affect each NPP severely by strong ground motion, or surface fault dislocation, or coseismic crustal deformation, or ground failures, or large tsunami, cannot be predicted precisely because of the intrinsic nature of earthquakes. Active faults don't indicate seismic fault planes of future earthquakes, and distribution of SMGAs (Strong Motion Generation Areas), stress drop values nor slip amounts on SMGAs cannot be known beforehand. Thickness of earthquake generation layers in the upper crust around each NPP is also obscure, though very important. In addition, prediction of occurrence and strong motion of slightly deep earthquakes in special tectonic environments such as the 2018 Hokkaido earthquake (M_J 6.7, H37km, maximum observed PGA 1796 Gal) is extremely difficult.

These essential difficulties bring underestimation of DBEGM (Design Basis Earthquake Ground Motion) or tsunami, and missing of possible crustal movement, which have actually occurred in several NPPs. Successive large aftershocks which may cause severe effects to a NPP damaged by the main shock is also a serious problem, but is not taken into account in NPPs' earthquake countermeasures. Next NPP accident in Japan may be brought about by this kind of phenomena.

Keywords: Nuclear power plants, Seismic safety, Inland crustal earthquakes, Evaluation of largest earthquake, Successive large aftershock, Science vs. engineering problem

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Challenges to Seismic Safety of Nuclear Power Plants

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1. The University of Tokyo

Risk of nuclear power plants under threat of earthquake is not only a function of seismic hazard but also a function of a complex socio-technology system related to nuclear power plants.

Characteristics of seismic hazard can be summarized as follows:

- Strong ground motion is a phenomenon which is spatially distributed and affects simultaneously in space

- We cannot identify a worst-case ground motion because of inherent variability of earthquake (aleatory uncertainty),

- Uncertainty due to our limitation of knowledge is another source of reason why we cannot identify worst-case ground motion (epistemic uncertainty),

- There exists large uncertainty in prediction of rare (usually large) earthquake because of large epistemic uncertainty. Large epistemic uncertainty can be observed as different judgements among experts on the same issue.

A complex socio-technology system related to nuclear power plants is composed both of physical subsystems and of human and organizational subsystems. This means that not only the capacity of physical systems but also organizational resourcefulness and framework to prepare for and deal with such events should be carefully examined, when we discuss the capacity of nuclear power plants under extreme earthquake.

When organizational resourcefulness and framework is discussed, a sensitivity and adaptation to social preferences is important. For example, safety requirements to nuclear power plants shifted and will shift over time.

What is equally important is that recognition that uncertainty related to seismic hazards are shared among stakeholders and framework to deal with it should be prepared. One of good practices is considered to be an introduction of a process like SSHAC process [1], where representing the center, body and range of technically defensible interpretation is an aim. It is also important to recognize that scientific knowledge on natural hazards like earthquake also grows and sometimes shifts over time. Integrated decision making

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process on nuclear safety issues which helps to ensure consistent and transparent decision should be a key to deal with these issues.

Refenrence
[1] USNRC: Updated Implementation Guidelines for SSHAC Hazard Studies (NUREG-2213), 2018.

Keywords: Seismic safety, Nuclear Power Plants

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Strong motion at Ooi nuclear power plant

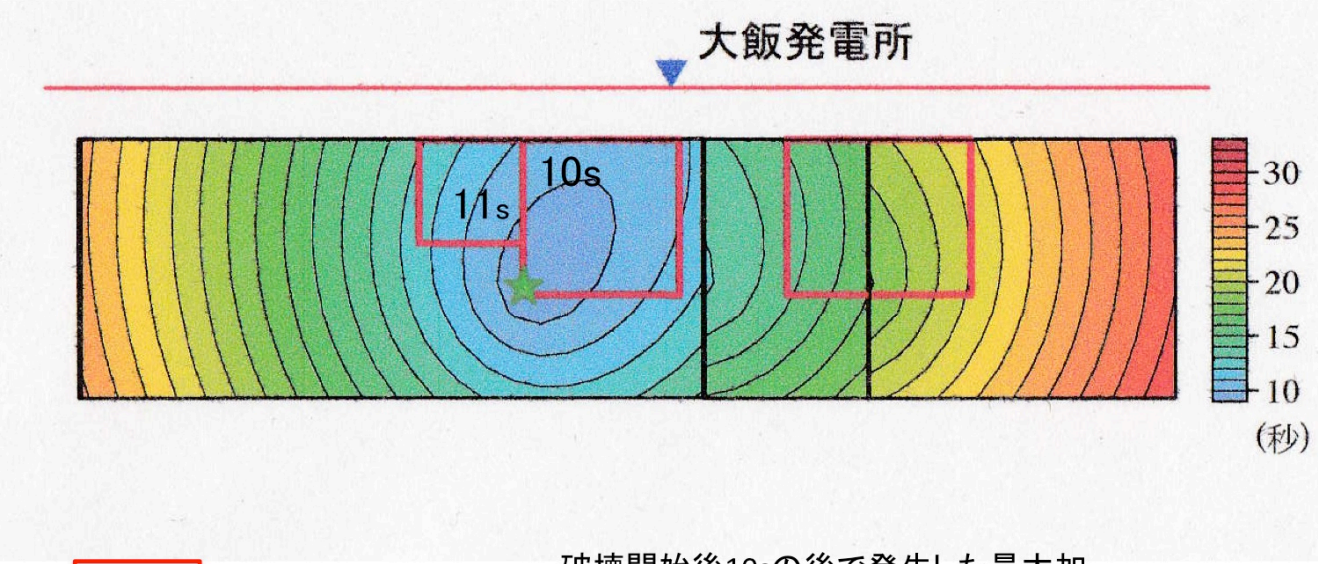
*Kunihiko Shimazaki[1]

1. University of Tokyo

The design basis seismic acceleration at Ooi Nuclear Power Plant is estimated as 856gal by using Irikura and Miyake (2001)'s 'recipe' and consideration on uncertainty in short-period spectral level. It appears to be smaller than so-called cliff edge acceleration estimated as 1260gal. However, more realistic acceleration would be greater than this cliff edge level.

Keywords: Ooi nuclear power plant, design basis ground motion, stress test

破壊開始点3・大飯発電所のアイソクロン



強震動生成域

破壊開始後10sの後で発生した最大加速度は、破壊が強震動生成域の端に達して発生したことがわかる。

原子力規制庁審査資料に加筆

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[J] Oral | H (Human Geosciences)：H-CG Complex & General

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | 105 1F

[H-CG32] Interdisciplinary approach to earth surface processes related to deposition, erosion and sediment transport

convener:Koji Seike(Geological Survey of Japan, AIST), Naofumi Yamaguchi(Center for Water Environment Studies, Ibaraki University), Hajime Naruse(Department of Geology and Mineralogy, Graduate School of Science, Kyoto University), Hideko Takayanagi(Institute of Geology and Paleontology, Graduate School of Science, Tohoku University), Chairperson:Koji Seike

To understand landscape evolution and dynamics of erosion, transport and sedimentation of earth-surface materials, the latest results of multiple research fields including engineering and earth sciences will be presented. As well as any researches of sedimentology and sedimentary petrology, interaction between fluid, sediments and geomorphology is focused. Interdisciplinary discussions of science, disaster prevention and resource exploration will be expected.

1:45 PM - 1:50 PM JST | 4:45 AM - 4:50 AM UTC

Introduction

1:50 PM - 2:20 PM JST | 4:50 AM - 5:20 AM UTC

[HCG32-01] Long-term beach observation and future shoreline prediction

★Invited Papers

*Masayuki Banno[1] (1.Port and Airport Research Institute)

2:20 PM - 2:35 PM JST | 5:20 AM - 5:35 AM UTC

[HCG32-02] Migration of sand waves observed in Okinose area of Osaka Bay

*Kojima Hibiki[1], Tetsuo Matsuno[2,3], Mamoru Sano[2], Nobukazu Seama[3,2], Noritaka Endo[4], Ken'ichi Ohkushi[1], Atsushi Tani[1] (1.Graduate School of Human Development and Environment, Kobe University, 2.Kobe Ocean Bottom Exploration Center(KOBEC), Kobe University, 3.Graduate School of Science / Faculty of Science, Kobe University, 4.School of Geoscience and Civil Engineering College of Science and Engineering, Kanazawa University)

2:35 PM - 2:50 PM JST | 5:35 AM - 5:50 AM UTC

[HCG32-03] Inverse analysis of lobe/gully on Mars: examination by 2D Voellmy fluid model

Kyohei Noumura[1], *Hajime Naruse[1] (1.Department of Geology and Mineralogy, Graduate School of Science, Kyoto University)

2:50 PM - 3:05 PM JST | 5:50 AM - 6:05 AM UTC

[HCG32-04] Development of provenance study using quartz shapes and surface microtextures

*Hiromi Itamiya[1], Ritsuko Sugita[1], Toshihiko Sugai[2] (1.National Research Institute of Police Science, 2.The University of Tokyo)

3:05 PM - 3:15 PM JST | 6:05 AM - 6:15 AM UTC

Discussion

Long-term beach observation and future shoreline prediction

*Masayuki Banno[1]

1. Port and Airport Research Institute

Port and Airport Research Institute (PARI) has measured daily beach profiles since 1986 at the Hasaki coast of Japan. This long-term and high-time-resolution beach profile data is used to understand the nearshore processes and predict the future beach morphological change. The talk will be about the long-term beach observation data and the future projection of the shoreline change in response to SLR and wave climate change under global climate change. Long-term beach observation data available at the other beaches will also be introduced.

Keywords: Shoreline change, Beach morphology

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Migration of sand waves observed in Okinose area of Osaka Bay

*Kojima Hibiki[1], Tetsuo Matsuno[2,3], Mamoru Sano[2], Nobukazu Seama[3,2], Noritaka Endo[4], Ken'ichi Ohkushi[1], Atsushi Tani[1]

1. Graduate School of Human Development and Environment, Kobe University, 2. Kobe Ocean Bottom Exploration Center(KOBEC), Kobe University, 3. Graduate School of Science / Faculty of Science, Kobe University, 4. School of Geoscience and Civil Engineering College of Science and Engineering, Kanazawa University

A micro-topography formed on unconsolidated sand particles by water flow with wavelengths from a few meters to several hundreds of meters is called sand waves. On the seabed (water depth between 30-45 m) in Okinose, eastern margin of Awaji Island in Osaka Bay, Japan, sand waves of a range of wavelengths between 10-100 m are observed. In this area, there is a constant flow called Okinose Return Current. Although it is important to elucidate the detailed characteristics, formation mechanism, and migration mechanism of the sand waves in Okinose due to the viewpoint of protection of marine resources and ocean navigation security, they have not been well studied (Yashima, 1992). Therefore, we investigated sand waves on the seabed in Okinose six times in about a year to reveal which direction and how long the sand waves migrate in this period.

We investigated the bathymetry of Okinose using the Multi-Narrow Beam Echo Sounder (MBES) mounted on FUKAE MARU (Kobe University, Graduate School of Maritime Sciences). In addition, seabed samples were obtained using a grab type mud sampler. Dates of the observation were September 27 and November 12 in 2017, and March 24, August 31, September 26, and October 13 in 2018. Survey area was south-north 2 km and east-west 1 km.

Analysis of the bathymetry revealed the sand waves with different wavelengths in southeast Okinose. Following the criteria given by Perillo and Ludwick (1984), sand waves were classified into three types by the wavelengths and the wave heights; large sand waves (wavelengths more than 50 m, wave heights more than 2 m), small sand waves (wavelengths between 10-50 m, wave heights between 0.6-2 m), and megaripples (wavelengths less than 10 m, wave heights less than 0.6 m). In these observations, large sand waves did not move, whereas small sand waves migrated 5 m to the north and megaripples would change every day. Since sand waves usually migrate to the direction of the residual current (Nemeth et al., 2002), our observation of the small sand waves is consistent. In addition, despite three natural disasters of the Osaka Northern Earthquake on June 18, 2018 and two typhoons No.20 on August 23 and No.21 on September 4 both in 2018, large sand waves were not changed obviously.

The structured sand waves have been reported (e.g. Osumi Strait in southern Kyushu, Japan (Ikehara, 1998) and Cadiz Bay in Spain (Nemeth et al., 2007)). Our investigation revealed that the sand waves in Okinose were also structured and classified into three types. Generally, wavelengths and wave heights of sand waves are determined by water depth, particle size of the sediment, and sea flow above the seabed. Therefore, it is important to evaluate the sea flow over the sand waves to understand their formation and migration mechanisms. In the next step, we have a plan to simulate the flow above the seabed of Okinose to approach the formation and migration mechanisms of Okinose sand waves.

Keywords: sand wave, Osaka Bay, migration

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Inverse analysis of lobe/gully on Mars: examination by 2D Voellmy fluid model

Kyohei Noumura[1], *Hajime Naruse[1]

1. Department of Geology and Mineralogy, Graduate School of Science, Kyoto University

It has been known lobate deposits accompanied with small gullies distribute on the surface of Mars, but their origin has not been clarified yet. Topographic features of lobate deposits on Mars resemble deposits of debris flow on Earth, which is a flow composed of high-concentration and fluid (water). Therefore, lobate deposits have been focused as proxies of fluid phase of water on Martian surface environments. However, several studies suggested that lobate landform can also be formed by other processes such as rock avalanches, and thus water in fluid phase may not be required for producing such deposits. Thus, the controversy on existence of fluid water has not been settled. To this end, this study aims to distinguish the formation process of lobes on Mars by inverse analysis of rheological properties of the flow. Two dimensional Voellmy fluid model was employed as the forward model, which has been proved to be capable of reproducing behavior of debris flows or snow avalanches on Earth. Istok Crater that locates in mid latitudes of the southern Hemisphere of Mars was chosen as the study area. Geomorphology of a lobate deposit on the northern fringe of the crater was measured from DEM, and the rheological parameters of the flow was reconstructed by parametric optimization of the forward model to fit the calculation results to actual geomorphology. As a result, the inverse analysis suggested that the rheological property of the formative process of the lobate deposit was quite different from terrestrial debris flows estimated on Earth. Also, the reconstructed parameters largely deviated from other known processes such as rock or snow avalanches. This may imply that the unknown processes such as avalanches of CO2 frost that does not exist on Earth should be supposed as the formation process of lobes.

Keywords: Mars, debris flow, gully

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Development of provenance study using quartz shapes and surface microtextures

*Hiromi Itamiya[1], Ritsuko Sugita[1], Toshihiko Sugai[2]

1. National Research Institute of Police Science, 2. The University of Tokyo

[Introduction]
Quartz is highly resistant to weathering and various surface microtextures are formed and preserved on grains. The microtexture of a quartz surface (MQS) reflects the sedimentary history of the grain, including its parent rock, transportation process, and depositional environment. The relationship between MQS and sedimentary history has been investigated by using scanning electron microscopy (SEM) (Krinsley et al. 1973; Mahaney, 2002). The types and frequency of microtexture may be different from previous studies in foreign countries because MQS relates to the geological and geomorphological settings at sampling sites. However, surface textural analysis has primarily been used to estimate fault activity, and the variation in MQS have not been studied aiming to the provenance study in Japan. In this study, we observed the quartz grains of Japan to reveal the relationship between quartz morphological features and sedimentary history. In addition to the SEM observation, the image analysis and statistics analysis were applied.

[Sampling and methods]
Nineteen fluvial sediments and nineteen coastal sands were collected in Japan. Carbonates, iron oxides and organic matters were removed from samples by chemicals and quartz grains (0.1 to 1 mm) were randomly handpicked under a stereomicroscope. After coating with a layer of platinum, twenty quartz grains for each sample were observed by SEM. Quartz shape was estimated by roundness (Takashimizu et al. 2016) and fractal dimension (Suzuki et al. 2013) using SEM images and ImageJ. A total of fifteen MQS was observed with reference to the previous study (Vos et al. 2014). The number of grains possessing each microstructure was counted in every sample. Their frequency distributions were applied to the principal component analysis (PCA) using statistical software.

[Result and Discussion]
Fluvial grains showed angular outline, high relief and large number of conchoidal fractures, which were probably produced by a powerful impact or pressure on the grain surface (Vos et al. 2014). Small hole of less than 10 μm can be observed on some samples. It derived from small inclusions, and its frequency may show the differences of parent rocks of samples.
Most of the quartz in seacoast are characterized by rounded outline and medium to low relief. On the surface, there are many v-shaped percussion cracks, which are produced by grain-to-grain collision in subaqueous environment (Krinsley et al. 1973). Some coastal samples had angular outline and many conchoidal fractures like fluvial sediments, but v-shaped percussion cracks are scarcely observed. It may be because grains of these coastal areas were supplied by steep rivers near sampling site. It means quartz shapes and surface microtextures of beach sands relate to the sediment supply.
Frequency distribution of MQS was applied to the PCA, and samples collected from the same area could be grouped in PCA scores plot. The first principal component (PC1) was explained by chemically formed microtextures and the second principal component (PC2) was explained by mechanically ones. PCA is effective method to grouping the samples under similar sedimentary history.
It is revealed that the morphological diversity of quartz grains can be observed, even in areas with complex geological and geomorphological settings such as Japan. The types of MQS were similar to the

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previous studies in foreign lands, but some types were sparsely observed compared to the previous report. MQS reflect parent rock, transportation systems and depositional environment, so it is important to comprehensively discuss the result of quartz analysis referring to the natural environment of sampling area.

(Krinsley et al, Cambridge University Press, 1973: Mahaney, Oxford University Press, 2002: Takashimizu et al. Prog. Earth Planet Sci., 2016, 3:2: Suzuki et al, J. Geol. Soc. Japan, 2013, 119(3), 205-216: Vos et al. Earth-Science Reviews, 128(0), 93-104)

Keywords: Quartz, SEM, Image analysis, Surface microtexture, Fractal dimension

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[J] Oral | H (Human Geosciences)：H-CG Complex & General

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | 105 1F

[H-CG32] Interdisciplinary approach to earth surface processes related to deposition, erosion and sediment transport

convener:Koji Seike(Geological Survey of Japan, AIST), Naofumi Yamaguchi(Center for Water Environment Studies, Ibaraki University), Hajime Naruse(Department of Geology and Mineralogy, Graduate School of Science, Kyoto University), Hideko Takayanagi(Institute of Geology and Paleontology, Graduate School of Science, Tohoku University), Chairperson:Hideko Takayanagi(Tohoku University), Koji Seike

To understand landscape evolution and dynamics of erosion, transport and sedimentation of earth-surface materials, the latest results of multiple research fields including engineering and earth sciences will be presented. As well as any researches of sedimentology and sedimentary petrology, interaction between fluid, sediments and geomorphology is focused. Interdisciplinary discussions of science, disaster prevention and resource exploration will be expected.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[HCG32-05] Detrital heavy mineral record and Nd-Sr isotopic signature in Bengal Fan

*Kohki Yoshida[1], Cruz Jarrett[2], Manoj M.C.[3], Nozomi Hatano[5], Christian France-Lanord[4], Takeshi Kuritani[6] (1.Department of Geology, Faculty of Science, Shinshu University, 2.Florida State University, 3.Birbal Sahni Institute of Palaeosciences, 4.CNRS- Universite de Lorraine, 5.Graduate School of Science and Technology, Shinshu University, 6.Hokkaido University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[HCG32-06] Evaluation of plant-fragment concentration mechanism in the turbiditic sediments in the Bouma Sequence by biomarker analysis in the Kawabata Formation, Yubari area, central Hokkaido, Japan.

*Hiroyasu Asahi[1], Satoshi Furota[2], Ken Sawada[3] (1.Graduate School of Science, Hokkaido University, 2.Japan Agency for Marine-Earth Science and Technology, 3.Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[HCG32-07] Tectonic behavior of a forearc basin reconstructed using turbidites: an example from the Plio-Pleistocene Kakegawa Group, central Japan

*Sone Haruki[1] (1.Graduate school of Shimane University, Natural Science and Technology, Major in Science of Environmental systems, Geoscience corse)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[HCG32-08] Most benthos floats up in liquefied sandy substrates: quantitative evaluation by measuring living-organism density

*Koji Seike[1], Shinji Sasa[2], Kotaro Shirai[3], Kaoru Kubota[4] (1.Geological Survey of Japan, AIST, 2.Port and Airport Research Institute, 3.AORI, The University of Tokyo, 4.Kochi Institute for Core Sample Research, JAMSTEC)

4:30 PM - 5:00 PM JST | 7:30 AM - 8:00 AM UTC

Discussion

Detrital heavy mineral record and Nd-Sr isotopic signature in Bengal Fan

*Kohki Yoshida[1], Cruz Jarrett[2], Manoj M.C.[3], Nozomi Hatano[5], Christian France-Lanord[4], Takeshi Kuritani[6]

1. Department of Geology, Faculty of Science, Shinshu University, 2. Florida State University, 3. Birbal Sahni Institute of Palaeosciences, 4. CNRS- Universite de Lorraine, 5. Graduate School of Science and Technology, Shinshu University, 6. Hokkaido University

The Bengal fan was formed by detritus shed by the Ganges and Brahmaputra rivers, reflecting India-Asia plate collision. The “IODP Expedition 354: Bengal Fan” recovered sediments recording the tectonic and climatic history related to the Himalayan orogeny (Fance-Lanord et al., 2016). We examined the heavy mineral assemblage, chemical composition of specific minerals and Nd-Sr isotope in the sediments deposited from the Miocene to present in the deepest hole (U1451A and B) in this expedition to clarify the detailed denudation history of the Himalayas. In addition, the heavy minerals in modern river sediments, taken from the Ganges and the Brahmaputra River in eastern India, are examined to compare with the Bengal Fan sediments.

The basal horizon of the Bengal Fan sediments, which consists of the latest Oligocene to earliest Miocene, was supplied by high-grade metamorphic terrene, correlatable to the High Himalaya Crystalline (HHC). Also, mafic metamorphic detritus, such as blue-green amphibole, were supplied suddenly from 14-13 Ma. Rare chromian spinels and Na-amphiboles were found in several horizons. These mafic detritus were actively provided after 7 Ma. These detritus were probably provided from the Yarlung-Tsangpo Suture Zone (YTSZ). After 6 Ma, olivine-pyroxene rich horizons are frequently intercalated in the Quaternary series. Tentative dominance of specific metamorphic minerals suggests episodic sediment production around HHC and YTSZ. The predominance of mafic minerals after 6 Ma indicates the contribution of the Brahmaputra River was increased. It is reported that the bed load sediments in the upper stream of the Brahmaputra River are characterized by the predominance of olivine, pyroxene, and ilmenite with a minor amount of spinels (Garzanti et al., 2004).

The depth profile of Sr-Nd isotopic signatures in the Bengal Fan sediments shows significant temporal variations. The range in 87Sr/86Sr and εNd indicate the dominance of Himalayan source. These signatures are bracketed by sediments from the Ganges, Brahmaputra River sands overlap with a data of the Lower Meghna (Pierson-Wickmann et al., 2001) indicating that the sediments in Bengal Fan are mixed products supplied from these two big rivers. Also, the Sr-Nd isotope depth profiles show a change in isotopic compositions around the lower part of the Middle Miocene.

These mineralogical and isotopic signatures indicate a relatively reduced supply of sediments from Brahmaputra river during the early Miocene time. The Sr-Nd isotopic signatures, the occurrence of mafic minerals and rare chromite grains also show significant variations indicating changes in the relative proportion of sediments originated from two big rivers. Especially in Pliocene and Quaternary sequences, the heavy mineral assemblage and Sr-Nd isotope signatures display a rapid and frequent change in the relative portion of sediments from both revivers. This is possibly related to the historical change of Brahmaputra river discharge refracting river capturing in eastern Himalayan syntaxis.

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Keywords: Himalaya, collision mountains, Miocene

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Evaluation of plant-fragment concentration mechanism in the turbiditic sediments in the Bouma Sequence by biomarker analysis in the Kawabata Formation, Yubari area, central Hokkaido, Japan.

*Hiroyasu Asahi[1], Satoshi Furota[2], Ken Sawada[3]

1. Graduate School of Science, Hokkaido University, 2. Japan Agency for Marine-Earth Science and Technology, 3. Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University

Kawabata Formation distributed in Yubari area, central Hokkaido, is formed by basin-filled and slope-apron turbidite systems, and sandstone and mudstone are mainly predominated as turbiditic sequence. Distinctive plant-fragment concentrated sandstones were found in the Kawabata Formation, and their sedimentological and biomarker analyses suggested that these sediments were deposited by hyperpycnal flow (Furota et al., 2014). However, such thin layer concentrated plant fragments are also formed in the typical turbidite characterized as the Bouma sequence. In the present study, we conducted biomarker analysis of sandstone and mudstone characterized as the Bouma sequence from the Kawabata Formation to evaluate sedimentological processes and to compare plant-fragment concentrated sandstones in hyperpycnite.

The sandstones and mudstones analyzed were collected from the route of the Soumokumai-zawa River, Yubari, central Hokkaido, during 2017. For the biomarker analysis, lipids were extracted with dichloromethane/methanol, and separated to aliphatic, aromatic and polar fractions. These lipids were identified and quantified by GC-MS and GC-FID.

The turbiditic sequence analyzed is about 15cm thick, and corresponds to the Bouma sequence, but no containing Td unit. Sedimentary layer equivalent to Ta units consists of medium-fine sands with tiny black plant-fragments. Tb unit consists of fine sands with parallel laminations containing the concentrated plant fragments. Tc unit also consists of fine sands about 1-2cm thick without cross laminations, and the concentrated plant fragments are observed as many black bands in this unit. Te unit is massive sediment that consists of very fine sands to silty muds without plant fragments.

Concentrations of *n*-alkane in the turbiditic sequence are the minimal values in the Ta units. The concetrations increase in Tb and Tc, and then decrease in Te units. This trend is also shown in variations in the concentrations of plant-derived terpenoids. Pristane/Phytane ratios are the highest value (ca. 5) in Tb and Tc units, indicating much higher contribution of terrestrial plant-derived particles in these sedimentary phases. The ratios of C27/C29 sterane, which are indicators of marine / terrigenous material ratios as source of organic matter, tend to decrease from Ta to Tc units, and are especially about 0 at Tc unit. On the other hand, the C27/C29 sterane ratio of the Te unit shows the highest value in the turbiditic sequence. These results imply that terrigenous components were separated and concentrated in specific layers by turbidity flow, which differs from continuous transport of terrigenous organic matter by hyperpycnal flow. Triterpenoids and diterpenoids are useful as angiosperm and gymnosperm (conifer) biomarkers, respectively. The diterpenoid compositions and HPP, which is an indicator of coniferous vegetation, are hardly changed throughout Ta to Te units. Triterpenoid compositions are also almost constant within the turbiditic sequence. These results suggest that the terrigenous materials were homogenized in sediments during transporting and reworking by turbidity current. In addition, A-ring degraded triterpenoid (des-A triterpenoids) were detected as major components in all sediment units. The

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des-A triterpenoids are thought to be generated by microbial degradation during early diagenesis. The des-A triterpenoid compositions are also nearly constant as the results of diterpenoids and non-degraded triterpenoids. However, the ratios of des-A triterpenoid/pentacyclic (non-degraded) triterpenoid are higher throughout the turbiditic sequence, especially Tb and Tc units. Furota et al. (2014) reported that the des-A/pentacyclic triterpenoid ratios in sandstone units were clearly lower than mudstone units in the hyperpycnite, suggesting that more fresh terrigenous organic matter is rapidly transported by the hyperpycnal flow. On the other hand, our results imply that terrigenous matter is not rapidly deposited and reworked by turbidity current forming a typical Bouma sequence, and might be diagenetically altered in these processes. Thus, it is suggested that organic geochemical features are clearly different between the hyperpycnal and typical turbidity flows, and the hyperpycnal flow system occurs the effective transport and deposition of fresh terrigenous organic matter compared to those by turbidity current.

Keywords: Turbidite, Biomarker, Hokkaido

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Tectonic behavior of a forearc basin reconstructed using turbidites: an example from the Plio-Pleistocene Kakegawa Group, central Japan

*Sone Haruki[1]

1. Graduate school of Shimane University, Natural Science and Technology, Major in Science of Environmental systems, Geoscience corse

The present study reconstructed the tectonic behavior of a forearc basin using the characteristics of turbidites. Topographic obstacles within a basin affects on the pathway of a turbidity current, causing the flow reflection or deflection within the basin. Turbidites recording flow reflections by outer rim of a forearc basin have been reported from the middle part of the Plio-Pleistocene Kakegawa Group, distributed in western Shizuoka, central Japan. Previous studies reconstructed basin geometry using reflected turbidites using the following concepts: (1) a turbidite sand bed tends to be thicker at the foot of slope where turbidity currents are locally stagnated. Thus the lateral thickness variation of a turbidite sand bed provides the location of foot of slope(s) within the basin. (2) A mud bed covering a turbidite bed becomes thickest at the basin center. The basin geometry reconstructions in the several horizons in the middle Kakegawa Group revealed the shift of the basin center and basin width through time. This methodology needs to be applied for the lower Kakegawa Group in order to understand the tectonic evolution of the basin. The present study described the turbidite beds in the lower part of the group and measured paleoflow and paleoslope directions from the ripple cross-lamination and inclined axis of small slump folds in order to reconstruct the behavior of the early phase of the Kakegawa Forearc Basin.

The lower Kakeagwa Group consists of alternations of sand and mud beds. The turbidite beds in the middle group are made up of fine-grained to very-fine-grained sand and show the characteristics of reflected turbidite without distinct massive division. The turbidites in the lower part, however, show the characteristics different from those in the middle part: they have a massive division with a coarse-grained to very-coarse-grained basal part, and thinner parallel and cross laminated divisions, showing the features of proximal turbidite. Some turbidites host wavy lamination, showing convex-up geometry, which is interpreted as the internal structure of antidunes. The top of the underlying mud beds are locally missing, where the overlying sand bed decomes thicker, and there are local mud clasts beds within the mud bed in some locations: these characteristics are interpreted as having been associated with a small-scale submarine slide. The dominant flow directions range from the east to the south, indicating offshore-ward flows. The division deposited from a reflected current is thinner than that in the middle part, and is not found in some turbidites: the turbidite beds in the lower part are thus interpreted as having been deposited mostly from obverse turbidity currents and having deposited on a slope environment dipping toward the offshore. The studied part of the lower group was resulted from the progradation of sediments from the north, and the basin center appears to have been located further offshore than that in the middle part of the group. Our turbidite observation resulted that there is a minor changes in frequency of reflected turbidites in the measured successions. For knowing the reason for such changes, we need more description of the turbidites in the distal area. As one of the possible reasons, the variation in uplift rate of the outer rim of the basin could be considered.

Keywords: Kakegawa Group, turbidite, forearc basin

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Most benthos floats up in liquefied sandy substrates: quantitative evaluation by measuring living-organism density

*Koji Seike[1], Shinji Sasa[2], Kotaro Shirai[3], Kaoru Kubota[4]

1. Geological Survey of Japan, AIST, 2. Port and Airport Research Institute, 3. AORI, The University of Tokyo, 4. Kochi Institute for Core Sample Research, JAMSTEC

Seabed liquefaction substantially affects benthic ecosystems. To investigate exogenous-forced behavior of organisms in liquefied substrates, we measured the body density of benthic organisms including bivalves, gastropods, annelids, and echinoderms collected from some localities in Japan, and compared them with the liquefied substrate density. Density of most measured benthic species showed was less than that of the liquefied seafloor sediments, suggesting that these species would float upwards in liquefied substrates. In contrast, a few individuals of three species showed higher body densities than the density of the liquefied sediments. These heavier benthic species would be expected to move downward during liquefaction of the substrate. These findings indicate that body density may determine the response of each benthic species to seabed liquefaction, forcing them to move upward or downward depending on their body density.

Keywords: liquefaction, sediment, earthquake, benthos

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[J] Oral | H (Human Geosciences)：H-CG Complex & General

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | 202 2F

[H-CG33] Useful life-support systems in closed bio-ecosystems

convener:Kaori Tomita-Yokotani(Faculty of Life and Environmental Sciences University of Tsukuba), Masanori Shinohara(Teikyo University of Science), Shunta Kimura(Graduate School of Life and Environmental Sciences, University of Tsukuba), Chairperson:Shunta Kimura

In this session, since 2011, we and invited researchers have been introducing and discussing about practical and useful life-support systems in closed bio-ecosystems for inhabitation on extraterrestrial environments. Not only biological studies but also engineering ones including broad research fields are our target. And also, we assume that it is indispensable to discuss about these interdisciplinary fields beyond the generation for inheriting to our next generation and for developing our field. Theme from old and basic to current and applicative from senior to youth including undergraduate are welcomed.

3:30 PM - 3:32 PM JST | 6:30 AM - 6:32 AM UTC

Introduction

3:32 PM - 3:47 PM JST | 6:32 AM - 6:47 AM UTC

[HCG33-01] Closed bio-ecosystems in extraterrestrial environments-Research in closed bio-ecosystems

*Kaori Tomita-Yokotani[1] (1.Faculty of Life and Environmental Sciences University of Tsukuba)

3:47 PM - 4:07 PM JST | 6:47 AM - 7:07 AM UTC

[HCG33-02] Concept and Studies of Aquaculture in Space -In the Past and Future-

★Invited Papers

*Masato Endo[1] (1.Tokyo University of Marine Science and Technology)

4:07 PM - 4:27 PM JST | 7:07 AM - 7:27 AM UTC

[HCG33-03] Protection effects of gasotransmitters against oxidation damager in vascular endothelial cells

★Invited Papers

*Shigeki Yoshida[1] (1.University of Tsukuba)

4:27 PM - 4:42 PM JST | 7:27 AM - 7:42 AM UTC

[HCG33-04] Study on nutrition intake and food selection to maintain health for habitation in space

*Yasuko Kimura[1], Shunta Kimura[2,3], Hiroshi Katoh[4], Kaori Tomita-Yokotani[2] (1.Jumonji University, 2.University of Tsukuba, 3.The University of Tokyo, 4.Mie University)

4:42 PM - 4:57 PM JST | 7:42 AM - 7:57 AM UTC

[HCG33-05] Limit of "rational optimism", Earth as CELSS, and sustainability of human-being

*Masanori Shinohara[1] (1.Teikyo University of Science)

4:57 PM - 5:00 PM JST | 7:57 AM - 8:00 AM UTC

Discussion

Closed bio-ecosystems in extraterrestrial environments-Research in closed bio-ecosystems

*Kaori Tomita-Yokotani[1]

1. Faculty of Life and Environmental Sciences University of Tsukuba

Researchers in this session have been studying useful life-support systems in closed bio-ecosystems since 2011. The final goal of our studies is to inhabit in extraterrestrial environments. There are various field of research related to biological and technical systems in closed systems. We have to have discussions with the researchers from a wide range of ages because our results will be inherited by the next generation. Here, I will introduce our session’ s outline and the contents of individual presentation. This year, we will focus on food for humans. The results of our discussions will contribute to our goal.

Keywords: closed bio-ecosystems, extraterrestrial environments, food

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Concept and Studies of Aquaculture in Space -In the Past and Future-

*Masato Endo[1]

1. Tokyo University of Marine Science and Technology

Aquaculture as a food production subsystem of closed ecological human habitat in space was advocated to provide animal protein especially, various examinations related with it have been proceeded by our studies for 20 years. In actual, the scientific knowledge of response in aquatic animals under gravity changing in space environment and fish production with material circulation has been accumulated. These results show the possibility of aquaculture in space, that will be the necessary basic data to realize a human life under space environment in the future. The concept and the studies of aquaculture in space have been focused on the production technology so far. Regarding improvement of the productivity, the introduction of automatic fish rearing and plankton culture system that has been developed at the ground level will be required. Apart from that, the consideration of material flow in the whole space habitat, and post-harvest technology will be needed. The comprehensive deliberations including other subsystem about the material and energy flows will be required, the study will be needed to conduct the various simulations with mathematical models made from the accumulated basic data of modules and subsystems constituting human space habitat. The preservation of products will be also required as the buffer of material circulation, therefore the applications of freezer storage, canned food and retort food production are necessary. Diversity of food consumption and artificial ecosystem considering the demands and limitations should be eventually investigated for good human life of space habitation. Various requirements and limitations occur to the construction of material flows in the artificial ecosystem, chose of produced species, and selection of the cooking methods. The preparation of their options is essential in consideration of the requirements and limitations for the whole facility of human space habitat.

Keywords: Aquaculture, Food production, Controlled ecological life support system

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Protection effects of gasotransmitters against oxidation damager in vascular endothelial cells

*Shigeki Yoshida[1]

1. University of Tsukuba

Reactive oxygen species (ROS) are chemical species which cause cellular damage. In this presentation, I introduce protection effects of gasotransmitters against oxidation damager, and functional food components with promotion effects of gasotransmitter production.

Keywords: oxidative stress, functional food components

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Study on nutrition intake and food selection to maintain health for habitation in space

*Yasuko Kimura[1], Shunta Kimura[2,3], Hiroshi Katoh[4], Kaori Tomita-Yokotani[2]

1. Jumonji University, 2. University of Tsukuba, 3. The University of Tokyo, 4. Mie University

It is an important to proper nutrient intake in order to maintain health for habitation in space such as Mars. The intake of proper nutrients for people to maintain health depends on age, sex, physique, physical activity situation. Furthermore, there are racial differences, and each country has established nutritional requirements for health.
Here, we will consider the proper nutrient intake in the space environment based on nutritional requirements on the ground. Then we will show combinations of several species as candidates of space food material for effective nutrient intake and propose cooking recipes used their species.

Keywords: habitation in space, health, Nutritional Requirements, Nutrients, food materials

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Limit of "rational optimism", Earth as CELSS, and sustainability of human-being

*Masanori Shinohara[1]

1. Teikyo University of Science

Today, we have two conflictive forecasts for our future. One is rational optimistic prosperity (e.g. Matt Ridley) and the other is anxiety about sustainable development mainly from many meteorological observations. In this presentation, reviewing advanced life support systems from various aspects, and comparing the Earth ecosystem with them, the possible progress of our sustainable humanosphere will be discussed.

Keywords: Closed Ecology, Sustainability, Rational Optimism

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | Convention Hall A 2F

[S-SS13] Strong Ground Motion and Earthquake Disaster

convener:Masayuki Kuriyama(Central Research Institute of Electric Power Industry), Kazuhiro Somei(Geo-Research Institute), Chairperson:Yoshinari Hayashi(Faculty of Safety Science, Kansai University), Dianshu Ju(Ohsaki Research Institute, Inc.)

Strong ground motion has social impacts as it induces earthquake disasters. We solicit contribution on any seismological topics related to strong ground motion that includes, but are not limited to, source processes, wave propagation, and site effects. We also welcome contribution on earthquake related disaster mitigation.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SSS13-01] Investigation of the effect of jog deviations on Riedel fractures by three-dimensional elasto-plastic analysis

*Tomohiro Toyoda[1], Toshihiro Noda[2], Shotaro Yamada[1], Akira Asaoka[3] (1.Nagoya University, Graduate School of Engineering, 2.Nagoya University, Disaster Mitigation Research Center, 3.Association for the development of earthquake prediction)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SSS13-02] A survey on earthquake prediction and public warning in seismological community

*Yoshinari Hayashi[1] (1.Faculty of Societal Safety Sciences, Kansai University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SSS13-03] Long-period strong ground motion of the Tokyo Bay area during the events occurred in the plate triple junction area

*Tomiichi Uetake[1] (1.R&D Department, TEPCO research Institute, Tokyo Electric Power Company)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SSS13-04] **Time-frequency and engineering characteristics on offshore ground motion**

*CHEN Su[1], FU Lei[1], LI Xiaojun[1] (1.Institute of Geophysics, China Earthquake Administration)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SSS13-05] **Long-period Ground Motion from Hypothetical Megathrust Earthquakes along the Nankai Through using the Ambient Seismic Field**

*Loic Viens[1], Tomotaka Iwata[1] (1.Disaster Prevention Research Institute, Kyoto University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SSS13-06] Fault model and strong ground motion evaluation for the Nankai megathrust earthquake

*Dianshu Ju[1], Hiroyuki Fujiwara[2], Nobuyuki Morikawa[2] (1.Ohsaki Research Institute, Inc., 2.National Research Institute for Earth Science and Disaster Resilience)

Investigation of the effect of jog deviations on Riedel fractures by three-dimensional elasto-plastic analysis

*Tomohiro Toyoda[1], Toshihiro Noda[2], Shotaro Yamada[1], Akira Asaoka[3]

1. Nagoya University, Graduate School of Engineering, 2. Nagoya University, Disaster Mitigation Research Center, 3. Association for the development of earthquake prediction

The Riedel fracturing process is strongly affected by the presence of jogs. For example, Fig. 1 describes left strike-slip fault with discontinuity of fault zone. The jog on the far side will be expanded with an accumulation of fault displacement and it causes depression of the ground surface as shown in Fig. 2(a), whereas the jog on the front side will be compressed and it causes bulge of the ground surface in Fig. 2(b). These transtensional/transpressional deformation fields called pull-apart/push-up are under the pure shear on which the tension/compression is superposed due to the presence of jogs. Authors have conducted three-dimensional elasto-plastic finite deformation analysis considering jogs of pull-apart and push-up as boundary conditions to numerically obtain the Riedel fracturing process. The abstract especially reports numerical investigations on the effects of the jog deviation on the angle of Riedel shears with principal stress rotation.

Simulations are implemented with the dynamic/static soil-water coupled elasto-plastic finite deformation analysis code ***GEOASIA***. Although the analysis code can accommodate two-phase analysis, only the one-phase analysis is carried out in the abstract. Finite element mesh with consideration of bending fault zone is shown in Fig. 3. Material parameters for SYS Cam-clay model are conformed to the preceding study[2)]. We prepared three models whose length is equal/doubled/tripled to the model in the *y*-direction (α=1, 2, 3). The analysis is conducted parametrically changing the jog deviation *d*=5, 10, 15mm. Figure 4 indicates shear strain distributions at the end of the simulations. The right diagonal Riedel shear band are obtained as a result of shear strain localization.

As for the results of *d*=15mm, the duplexing fracture patterns are obtained on the push-up side (α=1) whilst the P-shears are obtained on the pull-apart side (α=2, 3). However these fracturing patterns could no longer be detected in the cases of *d*=10, 5 mm. Especially in the case of *d*=5mm, only the independent single shears appear on the surface. The result suggests the significance of the installation of jogs to simulate these secondary fractures.

Focusing on the angle of Riedel shears on the tripled scale model α=3, there' s no difference in terms of fracture angles between the push-up and the pull-apart sides. However, the increase of a jog deviation makes Riedel shear angle lower/higher against the strike-slip running direction on the push-up/pull-apart side. It can actually be understood by the change of the principal stress direction. Figure 5 indicates the direction of maximum principal stress on the Riedel fractures above the regions A and B shown in Fig. 3 at the end of calculations, where the clockwise angle against running direction is positive. Because the direction of maximum principal stress in a pure sheared zone (straight fault zones without jogs) should be 45° in general, the angle deviation from 45° can be regarded as a result of jog installation. The figure indicates that the angle of the maximum principal stress become larger/smaller than 45° on the push-up/pull-apart side under transpressional/transtensional stress distribution. However, these transpressional/transtensional stress distribution gradually turn into pure shear with the decrease of a jog deviation. Therefore, the small difference of fracture angle between the push-up and the pull-apart sides with small jog deviation can be understood as a consequence of the increased percentage of pure shear in transpression/transtension.

(Acknowledgement) Numerical simulations in this paper are conducted by utilizing a supercomputer

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system in Kyoto University, Japan. And we received Grant-in-Aid for Scientific Research (Grant-in-Aid for Scientific Research (A): No. 17H01289).

1) Fossen, H. (2016): Structural Geology, Cambridge University Press, pp.377-400, 2nd edition.
2) Noda, T., et al. (2008): Soil-water coupled finite deformation analysis based on a rate-type equation of motion incorporating SYS Cam-clay model, S&F, Vol.48, No.6, pp.771-790.
3) Toyoda et al. (2018): Simulation of Riedel shear bands considering strong non-linearity of ground and geometrical barrier on strike-slip fault, JpGU2018, SCG66-05.

Keywords: strike-slip fault, Riedel shear, jog, elasto-plasticity, numerical analysis, fracture

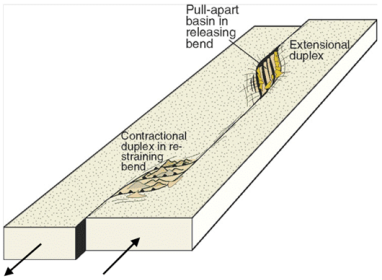


Fig. 1 Jog on strike-slip fault[1)]

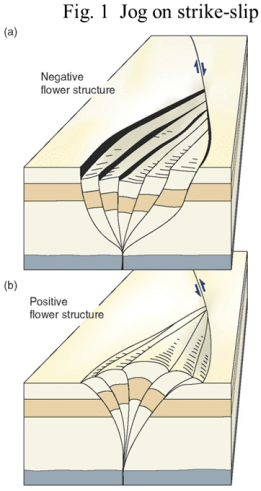


Fig. 2 Flower structures[1)]

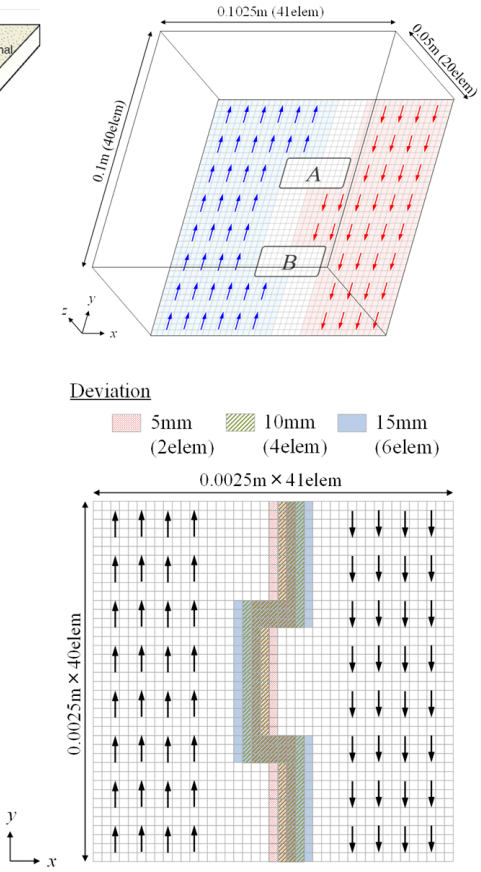


Fig. 3 Finite element mesh and boundary conditions

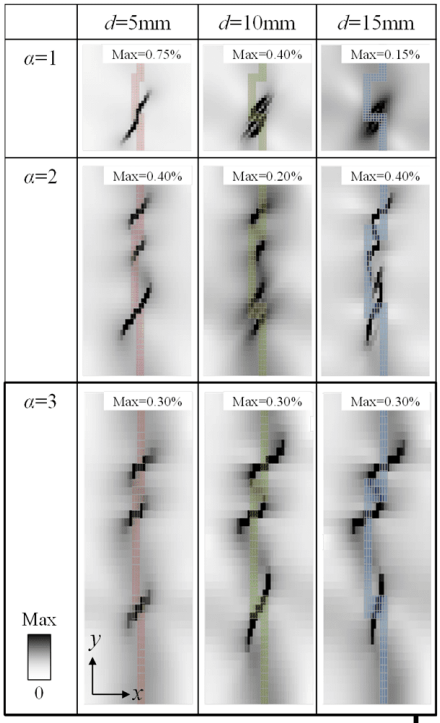


Fig. 4 Shear strain distributions at the surface

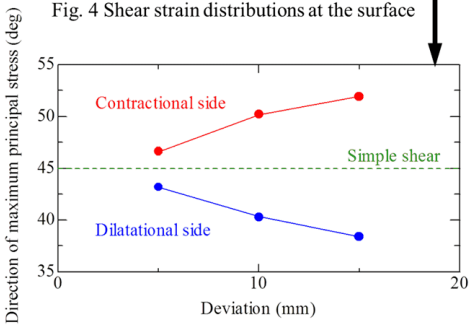


Fig. 5 rotation of the direction of principle stress

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A survey on earthquake prediction and public warning in seismological community

*Yoshinari Hayashi[1]

1. Faculty of Societal Safety Sciences, Kansai University

We conducted a questionnaire survey to clarify the comprehensive understanding of earthquake researchers about pre-earthquake prediction information. We divided the process up to the earthquake prediction information in following four stages, (1) the presence or absence of a phenomenon preceding a big earthquake, (2) the observability of the phenomenon, (3) the possibility of judging the observed data as abnormal, (4) possibility of public announcement of predicted earthquake information. We asked each researcher to respond with a numerical value of 10% from 0% to 100%. In addition, we asked for the probability of the success rate that the earthquake will occur in several days to one week.

A total of 129 researchers covered the delegates of the Japan Seismology Society, and 90 % respondents got responses. As delegates from the seismological society are elected by election by members, it can be thought that researchers who have certain insight in the field are selected. Responding to the questionnaire was basically based on requesting face-to-face at the meeting of the Fall Meeting in 2018, and asked for a reply by e-mail to those who could not do so.

In the tentative counting result, there is a wide range of responses from 0% to 100% in any of the four stages until public announcement success of the earthquake prediction information, and among seismologists it is obvious that there are various recognition in earthquake prediction. The average value of each stage is (1) "presence / absence of phenomenon" 47%, (2) "availability of observation" 47%, (3) "judgeability of the observed data as abnormal " 28%, (4) " public announcement possibility of predicted information" 41%. When we multiplied all respondents' answers of all four stages, the average value was only 6%. This is lower than the value expected by citizens and administration. In order to master information with low probability and low announcement frequency, it is necessary to consider reasonable countermeasures on the premise of a longer warning period with extremely low prediction rate and hit rate in comparison with civic perception.

Keywords: earthquake prediction, Nansai trough earthquake, Survey

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Long-period strong ground motion of the Tokyo Bay area during the events occurred in the plate triple junction area

*Tomiichi Uetake[1]

1. R&D Department, TEPCO research Institute, Tokyo Electric Power Company

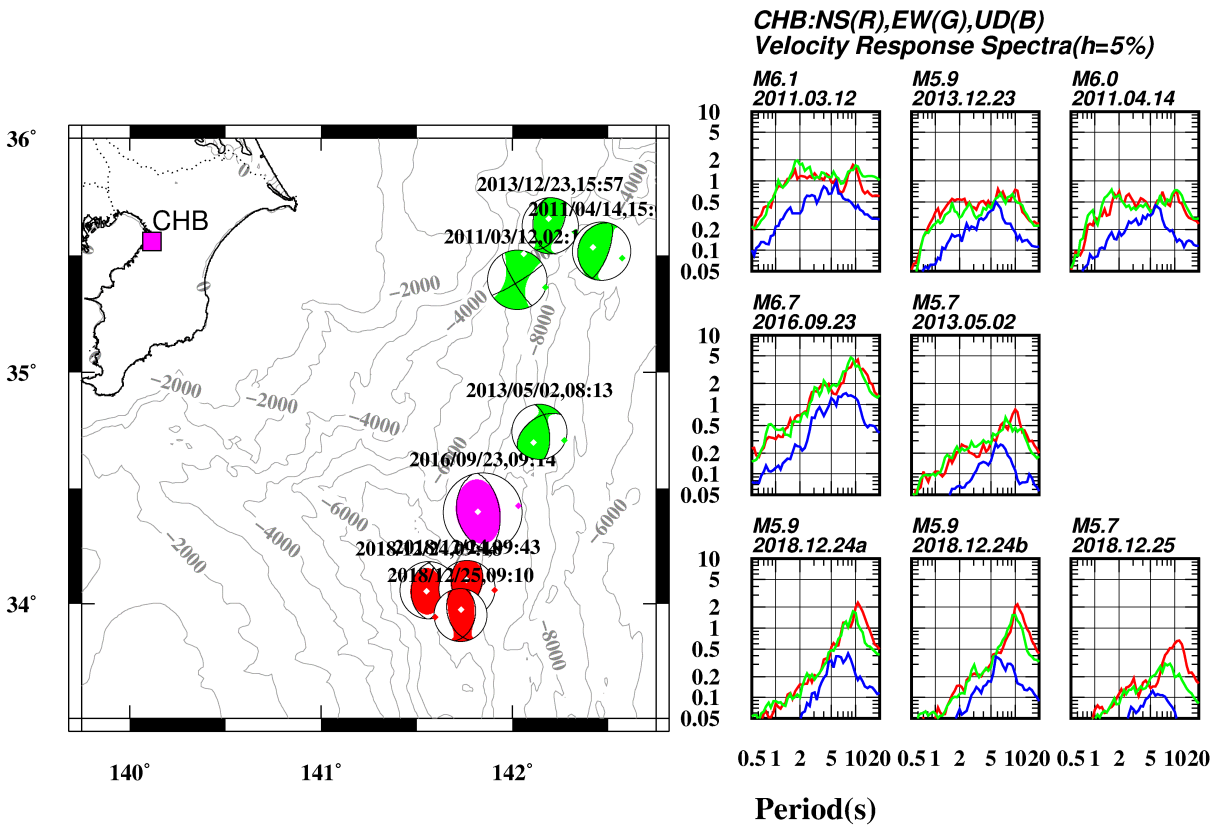
Uetake (2018) analyzed the velocity records of the Tokyo Bay area during the M6.7 earthquake of September 23, 2016 occurred in the north side of the plate triple junction. The velocity spectra of these data showed that the short period component was small and the component with the period of 10 seconds was large comparing with the records observed during the same magnitude events and at almost same distance. After that, in the south side of the triple junction area, two M5.9 earthquakes occurred on December 24, 2018, and one M5.7 earthquake occurred on December 25, so we have compared these earthquake records with those of the 2016 event. Furthermore, we tried to compare to the records of the north side events along the Japan Trench.

First, we analyzed the characteristics of the records from the M5.9 earthquake occurred at 9:18 on December 24, 2018. We used the records obtained by the broadband velocity type strong-motion seismograph installed in the thermal power plants on the Tokyo Bay shore. Four observation stations exist on the east coast of the Tokyo Bay and eight observation stations exist on the west coast. The epicentral distance is from 210 to 230 km for the observation points on the east coast and Yokosuka. The epicentral distance is from 230 to 240 km for the observation points on the west coast except for Yokosuka. Long-period ground motion continued for a long time in the velocity traces at any observation point, and the significant wave packets are recognized especially at observation stations in the northeastern coast of Tokyo Bay. The velocity response spectrum with damping of 5% were calculated from observed data, there is a peak at around 10 seconds in period at any observation station, and the short period side is small. The amplitude of the spectra at period of 1 to 2 seconds is under one-fifth of amplitude at period of 10 seconds. A clear group dispersion was recognized in the waveform of the northeastern coast of the Tokyo bay by the multi-pass filter analysis, this means that the surface wave component was dominant. These features are similar to the M6.7 event in 2016. A similar tendency can also be confirmed with the M 5.9 event at 9:43 on December 24, 2018 and the M5.7 event on 25 December 2019.

Next, we compared the ground motions of the 2018 events with those of the events occurred in the north side of the plate triple junction along the Japan Trench. The events with M 5.7 or more occurred in the south area from 35.5 degrees north latitude in 2008 to 2018 were selected. There are few occurrences of large earthquakes in this area, and the next 4 events were selected. M 5.5 on May 2, 2013, M 6.1 on March 12, 2011, M 6.0 on April 14, 2011 and M 5.9 on 23 December 2013 in order from the south. Examining the characteristics of the velocity response spectrum with damping of 5% of these events, the velocity response spectra of the event on May 2, 2013 shows a similar shape to the events in the vicinity of the triple junction, but those of the other three events show different shape. The velocity response spectra of these three events are large in the short period side and almost the same amplitude in the period range from around 2 seconds to 10 seconds as shown in figure. This suggests that there is a regionality in the seismic source characteristics of the earthquake along the Japan Trench.

Keywords: Long-period strong ground motion, Surface waves, Source characteristics

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Time-frequency and engineering characteristics on offshore ground motion

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1. Institute of Geophysics, China Earthquake Administration

Based on the offshore ground motions collected from California, U.S and Sagami trough zone, Japan, the time-frequency distribution feature of offshore ground motions was analyzed by Hilbert-Huang transform method. The corresponding spectral accelerations and dynamic amplification factor spectrum were compared with the design spectra in relevant seismic design standards. The research results indicate that, the offshore ground motions contain a wealth of long period component, the long period and ultra-long period component were dominant in frequency range. The energy distribution of the normalized marginal spectrum was correlated with epicenter distance. The horizontal offshore ground motion’ s energy was much larger than that of the vertical ground motion. Moreover, the further finds show that the dynamic amplification factor β-values of most offshore ground motions are greater than the current platform value of seismic design standards used, i.e., their long-period components are comment larger than that the seismic design standards given, so it is risky to carry out offshore facilities seismic design by land seismic design standards. In view of that there are lots of actual engineering structure, such as long-span bridges, oil and gas platform, etc., the long period components of offshore ground motions should be paid more attention in offshore engineering structure seismic design.

Keywords: Offshore ground motion, Seismic design, Hilbert-Huang transform method

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Long-period Ground Motion from Hypothetical Megathrust Earthquakes along the Nankai Through using the Ambient Seismic Field

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1. Disaster Prevention Research Institute, Kyoto University

Long-period ground motions from megathrust earthquakes are a real threat for large-scale human-made structures. The Nankai subduction zone, Japan, is expected to host a major megathrust earthquake in the near future and has therefore been instrumented with offshore and onshore permanent seismic networks. To simulate the long-period ground motions that could be generated by such earthquakes, we take advantage of the continuous data recorded offshore (DONET1 and DONET2 seismic stations) and onshore (Hi-net stations). We compute offshore-onshore impulse response functions from the continuous records using seismic interferometry by deconvolution. After amplitude calibration, we show that the impulse response functions reproduce well the long-period ground motions of moderate (M_w ~5) earthquakes. We construct realistic source models of several M_w 8+ earthquake scenarios that we use together with the computed impulse response functions to predict the long-period ground motions in the surrounding region. We finally calculate the velocity spectral response of our simulated waveforms and compare them to those obtained with ground motion prediction equations. This study suggests that the ambient seismic field recorded by the ever-increasing number of ocean bottom seismometers can be used to simulate the long-period ground motions from megathrust earthquakes.

Keywords: Long-period ground motion, Seismic noise, Green's function

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Fault model and strong ground motion evaluation for the Nankai megathrust earthquake

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In this study, based on the estimated seismic source area and tsunami source area for the Nankai megathrust earthquake by the Cabinet Office (2012), we figured out the fault parameters for the seismic source, by the procedure of Ju *et al.* (2016) for the subduction plate-boundary earthquakes whose ruptures reach the ground surface (sea bottom). Then, we evaluated the strong ground motions at 10 locations in and around Aichi prefecture and Osaka prefecture, using the empirical Green's function method. As the results of the Nankai megathrust earthquake model, the velocity response spectra of ground motion results of NGY station were about 250cm/s at the peak period 3s, and those of OSK005 were about 100cm/s to 200cm at the period 3s to 4s.

Keywords: Subduction plate-boundary earthquakes, Surface fault breaking, Strong ground motion evaluation, Nankai megathrust earthquake, Asperity model, Empirical Green’s function method

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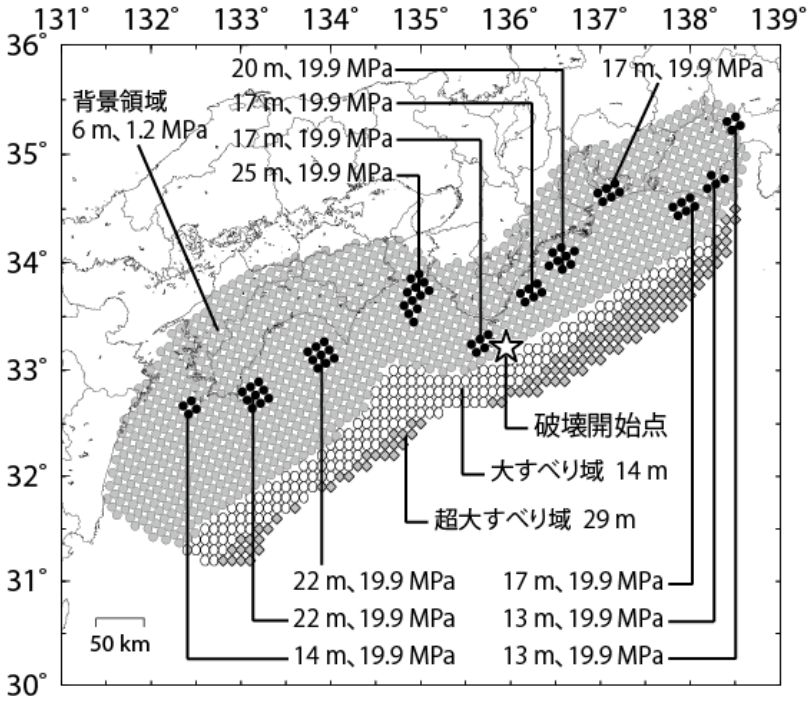


図 1　南海トラフ巨大地震の断層モデル

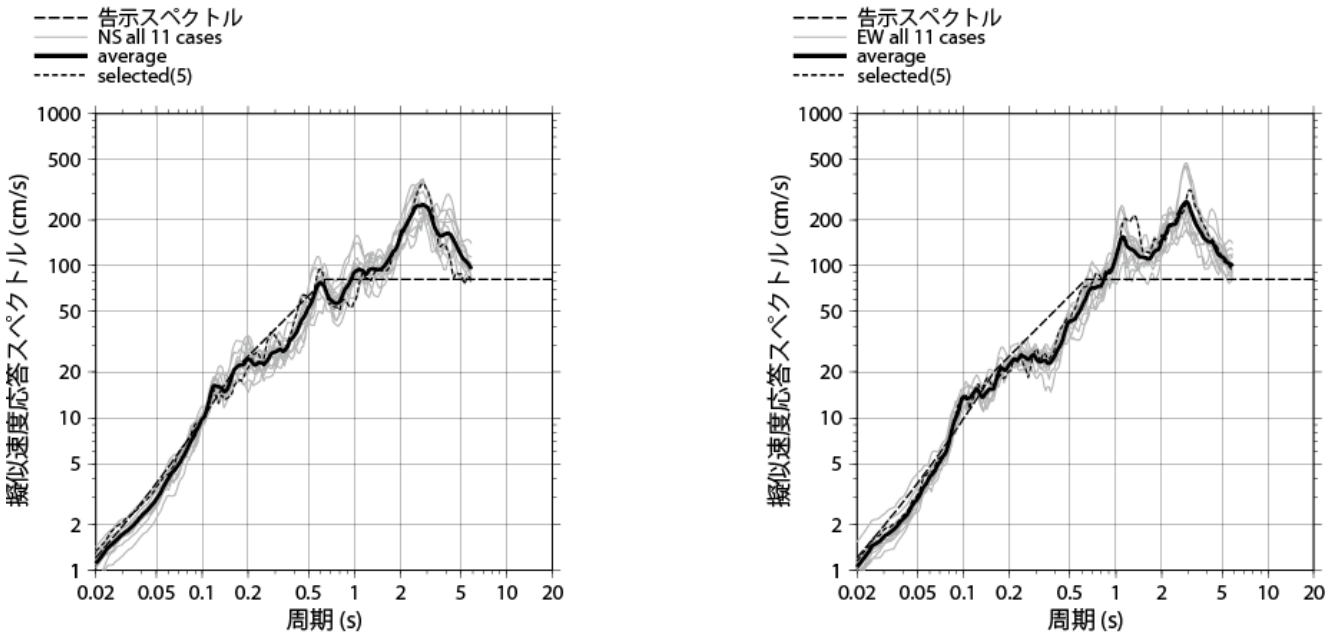
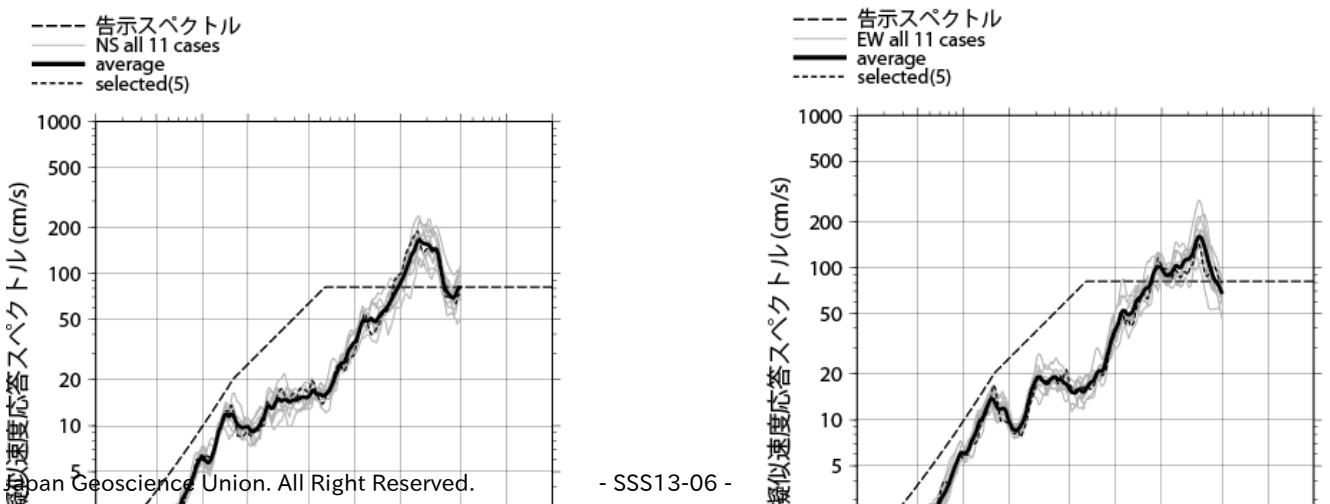


図 2　名古屋の三の丸 (NGY 観測点) における地震動評価結果（減衰定数 5%）



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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | Convention Hall A 2F

[S-SS13] Strong Ground Motion and Earthquake Disaster

convener:Masayuki Kuriyama(Central Research Institute of Electric Power Industry), Kazuhiro Somei(Geo-Research Institute), Chairperson:Susumu Kurahashi(Aichi Institute of Technology), Masahiro Korenaga(Railway Technical Research Institute)

Strong ground motion has social impacts as it induces earthquake disasters. We solicit contribution on any seismological topics related to strong ground motion that includes, but are not limited to, source processes, wave propagation, and site effects. We also welcome contribution on earthquake related disaster mitigation.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SSS13-07] One cause of the strong ground motion characteristics in Mukawa town during the 2018 Hokkaido eastern Iburi earthquake

*Nobuo TAKAI[1], Michiko Shigefuji[2], Takahiro Maeda[3], Masayoshi Ichiyanagi[1], Hiroaki Takahashi[1] (1.Hokkaido University, 2.Kyushu University, 3.NIED)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SSS13-08] Estimation of SMGA source model during the 2018 Hokkaido Eastern Iburi (Mw6.6) earthquake

*Susumu Kurahashi[1], Kojiro Irikura[1] (1.Aichi Institute of Technology)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SSS13-09] Strong ground motion prediction for the source fault model of Futagawa and Hinagu active fault zones (1) -Construction of the basin velocity structure model-

*Kimiyuki Asano[1], Tomotaka Iwata[1], Masayuki Yoshimi[2], Hiroe Miyake[3], Haruko Sekiguchi[1], Shinichi Matsushima[1], Hiroshi Kawase[1], Fumiaki Nagashima[1], Hiroaki Yamanaka[4], Kosuke Chimoto[4], Nobuyuki Yamada[5], Tatsuo Kanno[6], Michiko Shigefuji[6], Shigeki Senna[7], Takahiro Maeda[7], Atsushi Wakai[7], Asako Iwaki[7], Kaoru Jin[9], Hidetaka Saomoto[2], Seiji Tsuno[8], Masahiro Korenaga[8], Takeshi Sugiyama, Haruhiko Suzuki[9], Hisanori Matsuyama[9], Shunpei Manabe[9], Atsushi Yatagai[9], Shigeru Okamoto[10], Masaki Suehiro[10] (1.Disaster Prevention Research Institute, Kyoto University, 2.Geological Survey of Japan, AIST, 3.University of Tokyo, 4.Tokyo Institute of Technology, 5.Kochi University, 6.Kyushu University, 7.National Research Institute for Earth Science and Disaster Resilience, 8.Railway Technical Research Institute, 9.OYO Corporation, 10.Hanshin Consultants Co., Ltd.)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SSS13-10] Strong ground motion prediction for the source fault model of Futagawa and Hinagu active fault zones (2)-Strong ground motion prediction -

*Tomotaka Iwata[1], Kimiyuki Asano[1], Masayuki Yoshimi[2], Hiroe Miyake[3], Haruko Sekiguchi[1], Shinichi Matsushima[1], Hiroshi Kawase[1], Fumiaki Nagashima[1], Hiroaki Yamanaka[4], Kosuke Chimoto[4], Nobuyuki Yamada[5], Tatsuo Kanno[6], Michiko Shigefuji[6], Shigeki Senna[7], Takahiro Maeda[7], Asako Iwaki[7], Kaoru Jin[7], Hidetaka Saomoto[2], Seiji Tsuno[8], Masahiro Korenaga[8], Syunpei Manabe[9], Haruhiko Suzuki[9], Hisanori Matsuyama[9], Yatagai Atsushi[9] (1.Disaster Prevention Research Institute, Kyoto University, 2.Geological Survey of Japan, AIST, 3.University of Tokyo, 4.Tokyo Institute of Technology, 5.Kochi University, 6.Kyushu University, 7.National Research Institute for Earth Science and Disaster Resilience, 8.Railway Technical Research Institute, 9.OYO Corporation)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SSS13-11] Near-surface geophysical survey and hearing survey of housing damages at Yasunaga district, Mashiki Town stricken by the 2016 Kumamoto Earthquakes

*Tomio INAZAKI[1], Takanori Ogahara[1], Hiroshi Kisanuki[2] (1.Public Works Research Institute, Tsukuba Central Institute, 2.PWRI (Present Address: OYO Corporation))

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SSS13-12] Evaluation on Influence of Shallow Subsurface Structures to Earthquake Ground Motions in the Kumamoto Plain, Using the Borehole Seismic Data

*Masahiro Korenaga[1], Seiji Tsuno[1], Hiroaki Yamanaka[2], Kosuke Chimoto[2] (1.Railway Technical Research Institute, 2.Tokyo Institute of Technology)

One cause of the strong ground motion characteristics in Mukawa town during the 2018 Hokkaido eastern Iburi earthquake

*Nobuo TAKAI[1], Michiko Shigefuji[2], Takahiro Maeda[3], Masayoshi Ichiyanagi[1], Hiroaki Takahashi[1]

1. Hokkaido University, 2. Kyushu University, 3. NIED

The Hidaka mountain range, central Hokkaido, Japan, formed by the Hidaka arc-arc collision zone, with the Ishikari eastern fault zone on the west side and the Tokachi plain fault zone on the east side. The 2018 Hokkaido eastern Iburi earthquake (Mw 6.6) occurred on September 6, 03:08 JST at this arc-arc collision zone. The Japan Meteorological Agency (JMA) magnitude (Mj) was 6.7 and hypocentral depth was 37 km. The maximum seismic intensity (JMA-scale) 7 was observed in Atsuma town. During this earthquake, 41 people died mainly by a widespread large landslide in Atsuma town. The many building damages by strong ground motion were concentrated around HKD126 site. At K-NET HKD126 and JMA Atsuma Shikanuma stations, strong motion records had strong power to destroy the timber frame buildings. It is an important examination to know the cause of the generation of this destructive strong motion in spite of a low magnitude and deep focus.

We have conducted observations (2018 September 10- December 16) of earthquake ground motion due to aftershocks of this earthquake at near hillside station (MKW01). The target stations' underground shear wave velocity structures were estimated by microtremor array observation and multichannel analysis of surface waves method (Shigefuji et al 2019 Jpgu). We calculated theoretical amplification factor of the SH wave with the estimated shear wave velocity structure. The amplification factor of HKD126 is 5 times larger than the one of the MKW01 at a frequency around 1 Hz. Cause of this tendency are affected by low shear wave velocity in shallow part in HKD126; the engineering bedrock of HKD126 is deeper than the MKW01. We carried out the strong ground motion high-density line array observation (2018 December 01-16) along the line of HKD126 to MKW01 in Mukawa town, to know the changing of the ground motion amplitude by underground structures. We choose the earthquake records which were not affected by the nonlinear effect of soft soil. In these observed spectra, we can also understand the different amplitude as same as the theoretical ones. However, the predominant periods during mainshock is longer than this predominant period of theoretical and weak motion records. Generally, the strong ground motions are affected by the nonlinear response of surface soft soil. The strong motion record of HKD126 was examined the nonlinear effects by the DNL (degree of nonlinear effect) methods. The DNL value is 14.7; this value means large nonlinearity occurred (Noguchi et al. 2013) and the predominant period of the 1-2 s might be moved from the short-period side by this large nonlinearity. The strong ground motion power of 1-2 s during the main shock at HKD126 site was mainly amplified by this shallow underground velocity structure and this predominant range was conceivable changed for long periods side with nonlinear effect moreover.

A further step for studying this earthquake, we will examine the nonlinear effect for HKD126 in detail and we will spread the target area to examine the strong ground motion spatial distribution and discuss the 3-D underground structure.

A part of this study was supported by the Grant-in-Aid for Scientific Research No. 18K19952 and 17H06215 from MEXT of Japan, and MEXT of Japan’ s Earthquake and Volcano Hazards Observation and Research Program.

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Keywords: the 2018 Hokkaido eastern Iburi earthquake, Shear wave velocity, Site amplification

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Estimation of SMGA source model during the 2018 Hokkaido Eastern Iburi (Mw6.6) earthquake

*Susumu Kurahashi[1], Kojiro Irikura[1]

1. Aichi Institute of Technology

1. Introduction

The 2018 Hokkaido Eastern Iburi earthquake (Mw6.6, depth: 37km) occurred in the western Iburi region of Hokkaido, Japan, on September 6, 2018. The maximum seismic intensity with 7 was observed at Atsuma-cho. PGA of 1796 gal is observed at the HKD127(Oiwake) staion. Strong motions during this earthquake were widely observed, because the source depth was deep. We estimated the SMGA source model by comparing the synthetic and observed ground motions from the 2018 Hokkaido Eastern Iburi earthquake.
The observed records of this earthquake have some specific features. The observed ground motion at HKD126 station located in south of hypocenter has pulse-wave with maximum velocity of 158 cm/s. The observed record at HKD127 station located in north of hypocenter has three wave-packets. Observed ground motions at other stations also show three-wacepackets. Then, we estimated the SMGA source model considering these features seen in the observed records.

2. Estimation of the SMGA source model using empirical Green’ s function method

We constructed a characterized source model with SMGAs based on the slip distribution model inverted by Japan Meteorological Agency (2018). The source model of JMA. (2018) consists of one segment fault plane.
The EGF events whose records are used as the EGFs are selected to have hypocenters close to the SMGAs with almost the same radiation characteristics as the target events. We selected the records of an aftershock (Mw 4.3) as the empirical Green’ s functions based on the above conditions.
We calculated the spectral ratios between the mainshock and the EGF events to estimate the corner frequency of the EGF events. The source area and stress parameter of the event were estimated as 3.3km2 and 1.5MPa, respectively, from the seismic moment and the corner frequency using Brune’ s (1970, 1971) formula.
A SMGA area is divided into N x N subfaults, the area of which is taken to be equal to the fault area of each EGF event. Target frequency range is 0.5 - 10Hz. The best-fit characterized source model to simulate ground motions from the mainshock using the EGF method was determined, choosing the starting point, rupture velocity, and slip duration by comparing the observed and synthetic waveforms. The criterion of the best-fit model is to minimize the residuals between the observed and synthetic waveforms. The residual is defined as the sum of the squared residuals of displacement waveforms and acceleration envelopes at KiK-net stations. On the other hands, at K-NET stations, the residual is defined as the sum of the squared residuals of displacement and velocity waveforms to avoid non-lenear site effects on acceleration motions.
The best fitting SMGA source model has three SMGAs. The locations of the SMGAs are the northerm part, southern part and shallow part of the hypocenter. The areas and stress parameters of the SMGAs were estimated to be 136 km^2 and 20-25MPa, respectively. The area of combined SMGAs is agreement in comparison with the scaling relationship of combined asperity area versus seismic moment from Irikura and Miyake (2001).

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We are analyzing the detailed SMGA source model assuming with multi-segments with defferent strike and dip for each SMGA.

Keywords: the 2018 Hokkaido Eastern Iburi earthquake, strong motion generation area

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Strong ground motion prediction for the source fault model of Futagawa and Hinagu active fault zones (1) -Construction of the basin velocity structure model-

*Kimiyuki Asano[1], Tomotaka Iwata[1], Masayuki Yoshimi[2], Hiroe Miyake[3], Haruko Sekiguchi[1], Shinichi Matsushima[1], Hiroshi Kawase[1], Fumiaki Nagashima[1], Hiroaki Yamanaka[4], Kosuke Chimoto[4], Nobuyuki Yamada[5], Tatsuo Kanno[6], Michiko Shigefuji[6], Shigeki Senna[7], Takahiro Maeda[7], Atsushi Wakai[7], Asako Iwaki[7], Kaoru Jin[9], Hidetaka Saomoto[2], Seiji Tsuno[8], Masahiro Korenaga[8], Takeshi Sugiyama, Haruhiko Suzuki[9], Hisanori Matsuyama[9], Shunpei Manabe[9], Atsushi Yatagai[9], Shigeru Okamoto[10], Masaki Suehiro[10]

1. Disaster Prevention Research Institute, Kyoto University, 2. Geological Survey of Japan, AIST, 3. University of Tokyo, 4. Tokyo Institute of Technology, 5. Kochi University, 6. Kyushu University, 7. National Research Institute for Earth Science and Disaster Resilience, 8. Railway Technical Research Institute, 9. OYO Corporation, 10. Hanshin Consultants Co., Ltd.

The sub-theme #3 of the Comprehensive Research Project for the Major Active Faults Related to the 2016 Kumamoto Earthquake by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) developed a three-dimensional underground seismic velocity structure model in the Yatsushiro plain and other areas for improving strong motion prediction for future earthquakes along the Futagawa and Hinagu fault zones because there are still un-ruptured segments remained on these two fault zones.
In the Yatsushiro plain, which is located along the Hinagu fault, seismic reflection surveys using a P-wave vibrator were conducted along two lines in 2017 (Uki line and Yatsushiro line) to investigate the underground structure down to the seismic bedrock. Temporary strong motions stations were installed at 37 sites covering the whole area of the Yatsushiro plain. Small-size microtremor array survey was also conducted at these temporary stations. Large-size microtremor array surveys were carried out at 29 sites with a maximum array radius of 500-600 m in the whole area of the plain. Miniature and irregular array microtremor observations were conducted to survey shallow subsurface structure at 32 sites in the southern part of the Yatsushiro plain. Single-station microtremor H/V observations were carried out at 31 sites in the boundary area between the Yatsushiro and the Kumamoto plains.
Microtremor array measurements were also conducted at most of strong motion stations in the Amakusa Islands, the Minamata-Ashikita area, the Hitoyoshi basin, the Izumi plain, the Tamana plain, the Kikuka basin, Aso area, and the southern part of the Shimabara peninsula, which consists of 23 Large-size arrays and 76 small-size arrays. Single-station microtremor H/V observations were conducted at 47 sites in the Izumi plain and 44 sites the Tamana plain to investigate the spatial variation in the bedrock depth. Miniature and irregular array microtremor observations were also conducted at 48 sites in the Hitoyoshi basin. Hot-springs boring well-logs were collected in the Yatsushiro plain, the Mianamata-Ashikita area and the Hitoyoshi basin.
We modeled the 3D velocity structure above the seismic bedrock using these survey data and existing information. For the Yatsushiro plain, the Rayleigh wave phase velocity and H/V spectra from the microtremor observations were jointly analyzed to obtain the S-wave velocity profile at each measurement site. When we analyzed microtremor data, we referred to seismic reflection profiles and boring log as constraint information for bedrock depth. The sedimentary layers were modeled by two layers with S-wave velocities of 0.6 and 0.9 km/s. Shallow low-velocity layers were also considered above the layer of 0.6 km/s, and we assumed a layer of Vs 2.7 km/s at the top of the seismic bedrock (Vs 3.1 km/s). The top depth of Vs 2.7 km/s is well correlated with the bedrock depth from the reflection surveys, and its depth

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ranges from 0.3 to 0.6 km. The thickness of Vs 0.9 km/s is relatively large along the Yatsushiro line compared to the Uki line, which is consistent with interval velocities along these survey lines. Initial velocity model was constructed by the results of microtremor array analysis, and it was revised with H/V spectra at sites where phase-velocity dispersion curve was not available after checking consistency with gravity anomaly and boring well data.
Deep sedimentary velocity structure models were also constructed in the Hitoyoshi basin, the Amakusa Islands, Izumi plain and others using microtremor array surveys. The sedimentary layers were modeled by three layers with Vs 0.6, 0.9 and 1.6 km/s. Hot-spring borehole logs were also used in the Hitoyoshi basin. The seismic bedrock depth (Vs 3.1 km/s) is relatively deep in the eastern part of the Hitoyoshi basin (1.0~1.5 km). The top depth of Vs 1.6 km/s is relatively shallow around Amakusa Kamishima Island, which is consistent with high Bouguer anomaly in this area. The bedrock in the Izumi plain deepens toward the coast.
The final product of the 3D deep sedimentary velocity structure model and its validation by ground motion simulations will be presented in this presentation.

Acknowledgements: This work was conducted as a part of the Comprehensive Research Project for the Major Active Faults Related to the 2016 Kumamoto Earthquake of MEXT. The undergraduate and graduate students from Kyushu University, Tokyo Institute of Technology and Kyoto University participated in the field observations. We also sincerely appreciate local governments and residents in the area for helping our field works.

Keywords: deep sedimentary velocity structure model, strong motion prediction, Hinagu fault zone, Futagawa fault zone

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Strong ground motion prediction for the source fault model of Futagawa and Hinagu active fault zones (2) -Strong ground motion prediction -

*Tomotaka Iwata[1], Kimiyuki Asano[1], Masayuki Yoshimi[2], Hiroe Miyake[3], Haruko Sekiguchi[1], Shinichi Matsushima[1], Hiroshi Kawase[1], Fumiaki Nagashima[1], Hiroaki Yamanaka[4], Kosuke Chimoto[4], Nobuyuki Yamada[5], Tatsuo Kanno[6], Michiko Shigefuji[6], Shigeki Senna[7], Takahiro Maeda[7], Asako Iwaki[7], Kaoru Jin[7], Hidetaka Saomoto[2], Seiji Tsuno[8], Masahiro Korenaga[8], Syunpei Manabe[9], Haruhiko Suzuki[9], Hisanori Matsuyama[9], Yatagai Atsushi[9]

1. Disaster Prevention Research Institute, Kyoto University, 2. Geological Survey of Japan, AIST, 3. University of Tokyo, 4. Tokyo Institute of Technology, 5. Kochi University, 6. Kyushu University, 7. National Research Institute for Earth Science and Disaster Resilience, 8. Railway Technical Research Institute, 9. OYO Corporation

The research group for the Comprehensive Research Project for the Major Active Faults Related to the 2016 Kumamoto Earthquake supported by MEXT (PI: Prof. Hiroshi Shimizu, Kyushu Univ.) has conducted an integrated research on long-term evaluation of earthquake occurrence of active faults (Sub-theme 1), seismic activity and crustal structure (Sub-theme 2), strong ground motion prediction (Sub-theme 3) and outreach (Sub-theme 4). The research group of Sub-theme 3 developed a three-dimensional underground seismic velocity structure model in and around the source area and strong ground motion prediction for future earthquakes along the Futagawa fault zone and the Hinagu fault zone as there are still un-ruptured segments remained on these two fault zones after the 2016 Kumamoto earthquake. In this paper, we present the strong ground motion predictions.

Asano et al. (2019) explained how to develop the three-dimensional velocity structure model up to the engineering bedrock. We developed a subsurface velocity structure model down to the engineering bedrock, using boring database and miniature-size microtremor array measurement (e.g. Senna et al., 2018). We constructed source fault models for the Futagawa fault zone (Uto and Uto-hanto-hokugan segments) and for the Hinagu fault zone (Takano-Shirahata, Northern Hinagu, Southern Hinagu, Northern Yatsushiro Sea, and Southern Yatsushiro Sea segments). The location of the modeled source fault of the Uto segment is set to about 1km north from the present one (HERP, 2013). The active fault traces of the Hinagu fault segments are slightly modified from the research results by Sub-theme 1. We assumed two kinds of models for the dip angle setting of the source fault of the Southern Hinagu segment, 90deg. and 50deg. The latter is assumed referring to the microearthquake distribution by Sub-theme 2. The rake angle for each source fault was determined from the stress conditions of the source fault area by the stress inversion result (Sub-theme 2). The earthquake moment magnitude of the future Futagawa and Hinagu fault zones are 7.0 and 7.3-7.4, respectively.

We used “The Recipe” (Strong ground motion prediction for earthquakes with specified source model) (HERP, 2016) for strong ground motion prediction. The rupture starting points were assumed from the implication of the rupture starting point of the 2016 Kumamoto mainshock on the crustal resistivity distribution (Sub-theme 2). The hybrid (FDM and stochastic Green’s function method) method with the cross-over period of 1 sec was used for simulating ground motions on the engineering bedrock. Seismic equivalent linear analysis was applied to the area of the subsurface velocity model to get the time history of the ground motions at the surface and JMA seismic intensity was calculated using the simulated waveform data. Additionally, we estimated a JMA seismic intensity distribution in Kumamoto prefecture using PGV values of the engineering bedrock and JMA seismic intensity increments by the micro-topography classification and Vs30 values.

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Keywords: 2018 Kumamoto earthquake, Strong ground motion prediction, Futagawa fault zone, Hinagu fault zone

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Near-surface geophysical survey and hearing survey of housing damages at Yasunaga district, Mashiki Town stricken by the 2016 Kumamoto Earthquakes

*Tomio INAZAKI[1], Takanori Ogahara[1], Hiroshi Kisanuki[2]

1. Public Works Research Institute, Tsukuba Central Institute, 2. PWRI (Present Address: OYO Corporation)

We conducted a detailed geophysical survey to the near surfaces and hearing survey of housing damages at Yasunaga District, Mashiki Town stricken by the 2016 Kumamoto Earthquakes. The geophysical survey was carried out in March 2017 along a 350 m long short survey line set on a road between Route 28 and Akitsu River. Hearing survey was also conducted along the survey line. We directly interviewed with residents in May 2018, or indirectly inspected housing sites. A total of 31 dwellings were surveyed supported by board members of the Yasunaga District community association. We could have quite valuable information on the earthquake related evidences as exemplified as follows; 1) ground water sprang out from an open crack under the floor and the housing was divided into two segments. 2) Dry wells revived just after the earthquake and were still pouring ground water. 3) Bulges were generated along a street or the boundaries between roads and dwellings. Different types were reported on the mode of occurrence of ground deformation between the northern and the southern part of the surveyed district. No specific deformed structure or faulting structure was identified in the near surfaces along the survey line set in the Yasunaga District. In contrast, a thick soft layer characterized as low resistivity and low Vs occupied the surfaces up to 20 m deep at the southern half of the line, or Akitsu lowland area. The above evidences strongly suggest that surface deformed structure observed in the Yasunaga District was originated by non-tectonic forces influenced by local artificial topography and the existence of the soft layer instead of active faulting. Our survey results also demonstrate the importance of high-resolution near-surface geophysical surveying and direct interviewing to the residents for the detailed undestanding of local earthquake disasters.

Keywords: 2016 Kumamoto Earthquakes, Mashiki Town, Yasunaga District, near surface geophysics, housing damage survey

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Evaluation on Influence of Shallow Subsurface Structures to Earthquake Ground Motions in the Kumamoto Plain, Using the Borehole Seismic Data

*Masahiro Korenaga[1], Seiji Tsuno[1], Hiroaki Yamanaka[2], Kosuke Chimoto[2]

1. Railway Technical Research Institute, 2. Tokyo Institute of Technology

The Kumamoto Plain, located in the Northern part of Kumamoto prefecture, Kyushu island, is consist of diluvial plateau in the west slope of Mt. Aso and alluvial lowland formed by Shirakawa and Midorikawa. It is suggested that the earthquake ground motions are amplified largely and intricately, due to the complex and soft soil sediments.

To investigate characteristics of earthquake ground motions in the Kumamoto Plain, we installed temporary seismic stations along the north-south line in Kumamoto Plain, immediately after the 2016 Kumamoto earthquake. We obtained seismic data of the main shock (Mj 7.3, occurred on 4/16 2016) at 2 sites near Mt. Hanaoka, in the northern edge of the Kumamoto Plain. We showed that the strong ground motions observed at the 2 sites during the main shock, were affected by the non-linearity and the polarization to direction of north-south.

To clarify the cause of these distinctive trends of the ground motions, we conducted detailed observations and surveys the site where the main shock was recorded. We installed seismometers simultaneously on the ground and on the engineering bedrock at a depths of 40m, with a sample rate of 1000 Hz. We calculated the Fourier spectral ratio of the seimic data on the ground to the data on the engineering bedrock. As a result, we confirmed that the characteristics of the NS and EW component of the spectral ratio are clearly different around 1-4 Hz. It is suggested that complex shallow subsurface structure affects the polarization to direction of north-south.

In addition, we performed P-S logging to understand shear wave velocity of the alluvial soils to the engineering bedrock at this site. We compared site amplification factors estimated from weak ground motion data to those calculated from P-S logging data and S-wave velocity structures estimated by array microtremor observations. Finally, we discussed the influence of shallow subsurface structure to the earthquake ground motions in complex and soft soil sediments.

Keywords: 2016 Kumamoto earthquake, borehole seismometer, shallow subsurface structures

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | Convention Hall A 2F

[S-SS13] Strong Ground Motion and Earthquake Disaster

convener:Masayuki Kuriyama(Central Research Institute of Electric Power Industry), Kazuhiro Somei(Geo-Research Institute), Chairperson:Kentaro Kasamatsu(Kajima Corporation), Kazuhito Hikima(Tokyo Electric Power Company Holdings, Inc.)

Strong ground motion has social impacts as it induces earthquake disasters. We solicit contribution on any seismological topics related to strong ground motion that includes, but are not limited to, source processes, wave propagation, and site effects. We also welcome contribution on earthquake related disaster mitigation.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SSS13-13] Factors of large amplitude ground motions excited by small to moderate earthquakes
- Examination of KiK-net Kuriyama-nishi of the 2013 Tochigi-ken Hokubu Earthquake (Mj6.3) -

*Kentaro Kasamatsu[1], Kenichi Kato[2], Tetsushi Watanabe[2], Tetsuo Shiota[3] (1.Kajima Corporation, 2.Kobori Research complex inc., 3.Shikoku Electric Power CO.,Inc.)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SSS13-14] Source modeling and strong ground motion simulation in the Tokyo metropolitan area of the 1923 Kanto earthquake based on seismic intensity inversion analysis

*Fumino Suzuki[1], Kenichi Kato[1], Katsuhisa Kanda[1], Takashi Ikeda[1] (1.KOBORI RESEARCH COMPLEX INC.)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SSS13-15] A Simple Fault Model to Calculate Strong Ground Motions Including Fling Steps for the Main Shock of the 2016 Kumamoto Earthquake

*Atsushi Nozu[1], Yosuke Nagasaka[1], Shuanglan Wu[1] (1.Port and Airport Research Institute)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SSS13-16] **Fling-steps displacements by the discrete wavenumber method**

*SHUANGLAN WU[1], Atsushi Nozu[1], Yosuke Nagasaka[1] (1.PORT AND AIRPORT RESEARCH INSTITUTE)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SSS13-17] Extension of characterized source model for long-period strong motions near surface-rupture-earthquakes

*Kojiro Irikura[1], Susumu Kurahashi[1], Yasuhiro Matsumoto[2] (1.Aichi Institute of Technology, 2.KOZO_KEIKAKU Engineering, Inc.)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SSS13-18] A Study for the cause of earthquake damages by the 2014 Nakagano-ken Hokubu earthquake (M_J6.7) – consideration using the strong motion simulation –

*Kazuhito Hikima[1], Ryoichi Nakamura[2], Tomiichi Uetake[1] (1.Tokyo Electric Power Company Holdings, Inc., 2.Earthquake Research Institute, Univ. of Tokyo)

Factors of large amplitude ground motions excited by small to moderate earthquakes
- Examination of KiK-net Kuriyama-nishi of the 2013 Tochigi-ken Hokubu Earthquake (Mj6.3) -

*Kentaro Kasamatsu[1], Kenichi Kato[2], Tetsushi Watanabe[2], Tetsuo Shiota[3]

1. Kajima Corporation, 2. Kobori Research complex inc., 3. Shikoku Electric Power CO.,Inc.

In KiK-net Kuriyama-nishi (TCGH07), a large amplitude ground motion with peak acceleration of about 1.2G was observed in the 2013 Tochigi-ken Hokubu Earthquake (Mj6.3). Both borehole and surface records are characterized as being predominant about 6Hz. Hikima (2015) divided small to moderated earthquakes into five group based on the focal region, and examined the difference in site amplifications of TCGH07 using spectral inversion method. Predominant frequency around 6Hz are limited characteristics found only in earthquakes that occurred in the west and vicinity of TCGH07. He guessed that the cause was the influence of site amplification factor and path characteristics.

In this study, in order to investigate the factor of large amplitude earthquake ground motion of TCGH07 from another point of view, we estimated attenuation relationship of the peak acceleration of 5-8Hz ground motion using observation records of small to moderate earthquakes, and evaluated the amplification factor of TCGH07. Futhermore, we investigated the spatial distribution of the residuals for the attenuation relationship in TCGH07, and compared with slip distribution of the main shock.

The attenuation relationship was estimated using borehole records of 17 KiK-net observatories around TCGH07 for inland crustal earthquakes that occurred in the focal region of the main shock. The database used for this study consists of the 1147 records of 178 earthquakes in the range of the hypocentral distance about 3 to 100 km, the focal depth within about 11 km and Mj 2 to 5.2. Maximum acceleration amplitude of the larger of the two horizontal components was used. The attenuation relationship was estimated in a model obtained by adding the term of the site amplification factors to the regression model by Si and Midorikawa (1999). The coefficients for the hypocentral distance representing the viscous damping were given 0.002 with reference to Si and Midorikawa (1999). For the constraint of the solution, KiK-net Fujiwara-2 (TCGH17) with the highest S-wave velocity was taken as the reference of the site amplification factors.

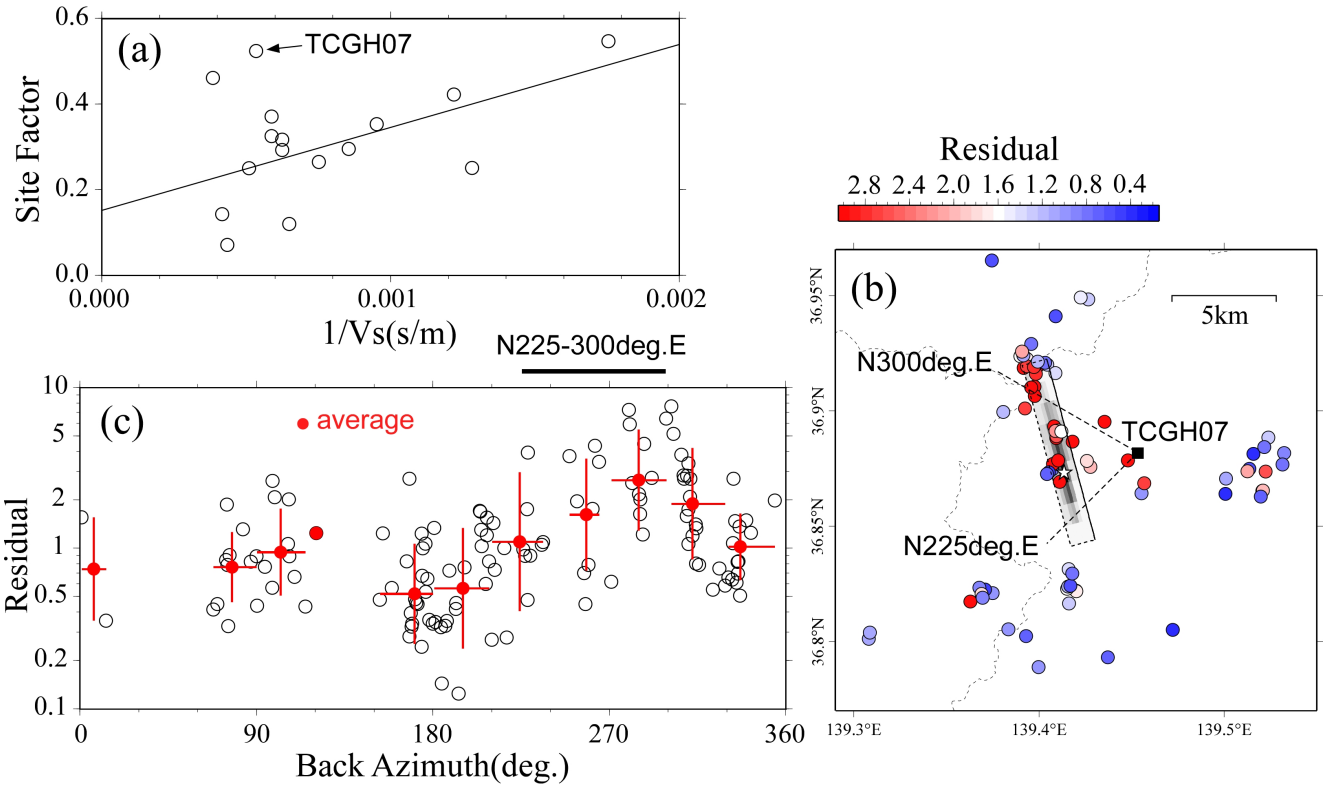
Fig.(a) shows the site amplification factor evaluated at each observatory as the distribution for the S-wave velocity of the observation depth. It tends to be proportional to the reciprocal of S-wave velocity. If the relationship between them is approximated by a linear equation, the amplification factor evaluated in TCGH07 greatly exceeds this average relation. It can be said that TCGH07 is easy to shake at frequency 5-8Hz compared with surrounding observatories. The residual of the maximum acceleration amplitude (observation / attenuation relationship) was evaluated for each earthquake in TCGH07. Fig.(b) shows their spatial distribution. In this figure, the center of the color contour is adjusted to be the average value of the residuals. The gray contour denotes the slip distribution of the main shock by the Hikima (2014). Regional characteristics are found in the distribution of residuals, such as small in the earthquakes that occurred in the south and east, and large in the earthquakes that occurred in the west. Regions where the residuals are large roughly correspond to the slip region of the main shock. Fig.(c) shows the dependence of the residual on the back azimuth. Although there was a bias in the number of earthquakes, the average and

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standard deviation calculated by grouping at 30 degree intervals were shown in red circles and lines respectively. Obvious orientation dependence was found. The residual is large in the case of the earthquake occurring in the direction of N225-300deg.E corresponding to the slip region of the main shock. In addition to the shakeability of TCGH07 around 6Hz, the amplitude of the earthquake ground motion is further increased in the case of the earthquake occurred around the slip region of the main shock.

At the time of the main shock, as one of the reasons why the large amplitude ground motion was observed in TCGH07, it can be considered that the site amplification factor is large around 6Hz as pointed by Hikima (2015). However, the regional characteristics of the residuals of the small to moderate earthquakes shown in this study may indicate differences in the excitation characteristics of earthquakes. In that case, even at the time of the main shock, short-period ground motion strongly excited in the region where the residuals were large further increased the amplitude of TCGH07. We are investigating the stress drop of small to moderate earthquakes that occurred in the focal region of main shock.

Keywords: 2013 Tochigi-ken Hokubu Earthquake, KiK-net Kuriyama-nishi, Large Amplitude, Attenuation Relationship



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Source modeling and strong ground motion simulation in the Tokyo metropolitan area of the 1923 Kanto earthquake based on seismic intensity inversion analysis

*Fumino Suzuki[1], Kenichi Kato[1], Katsuhisa Kanda[1], Takashi Ikeda[1]

1. KOBORI RESEARCH COMPLEX INC.

1. Introduction

The 1923 Kanto earthquake had serious damage to the Tokyo metropolitan area. It is concerned that similar large earthquake will occur repeatedly in the future. So, it is important to evaluate characteristics of the source and strong ground motions of this event. The short-period strong ground motions were not recorded during this event. Therefore, the seismic intensity data are effective for the source modeling used to the short-period strong motion simulation. Kanda and Kato (2018) evaluated the short-period spectral level of the acceleration source spectrum A, and number of strong motion generation area (SMGA) by the inversion analysis using seismic intensity data investigated by Moroi and Takemura (2002). In this study, the short-period spectral level A_i of six SMGA by Kanda and Kato (2018) are evaluated, and the strong ground motions of two sites in the Tokyo metropolitan area are simulated using the stochastic Green's function method.

2. Seismic source modeling

A_i's are evaluated referring to A, seismic moment of each SMGA M_{0ai}, and area S_{ai} by Kanda and Kato (2018). Assuming that omega-square model, Brune's model (Brune, 1970, 1971) and circular crack model (Eshelby, 1957) are applicable to modeling of each SMGA, A_i is proportional to M_{0ai}/S_{ai}.

The whole fault A is 4.66×10^{19}Nm/s^2 by Kanda and Kato (2018), and each SMGA A_i is 1.4 to 2.2 $\times10^{19}$ Nm/s^2. The whole fault A by Kato et al. (2013) is 2.46×10^{19}Nm/s^2, and maximum A_i has the almost same level as this. Kato et al. (2013) constructed the source model based on the slip distribution evaluated by Sato et al. (2005) using seismic waveform and geodetic data of The 1923 Kanto earthquake. Therefore this model reflects relatively long period ground motion. This study’ s model based on seismic intensity reflects relatively short period ground motion. Note that the difference.

Each SMGA is converted into a rectangular model holding the area. Strike and dip angle are set along the subducting the Philippine Sea plate. Background area is not considered. Other parameters (density, S wave velocity, rupture velocity (Vr), fmax and radiation pattern coefficient) are the same as those of Kato et al. (2013). Rise time of each SMGA is set from the relationship of $\tau_i=0.5S_i^{1/2}/Vr$. Rupture starting point of the whole fault is set on the SMGA located in the western Kanagawa, and rupture type of each SMGA is multi-hypocenter. The Q value is $100f^{0.7}$ (f is frequency) with reference to Central Disaster Management Council (2004).

3. Strong ground motion simulation

In order to the effect of the source model based on seismic intensity inversion to strong motions in the Tokyo metropolitan area, the strong motions at Asakawa and Etchujima evaluated by the stochastic

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Green's function method. Soil structural models follow Kato et al. (2013).
The results of the strong motions evaluation are investigated about differences of 2 sites, contributions of each SMGA and differences from strong motions using the source model of Kato et al. (2013).

Keywords: the 1923 Kanto earthquake, seismic intensity, short-period spectral level, strong motion generation area, strong ground motion simulation

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A Simple Fault Model to Calculate Strong Ground Motions Including Fling Steps for the Main Shock of the 2016 Kumamoto Earthquake

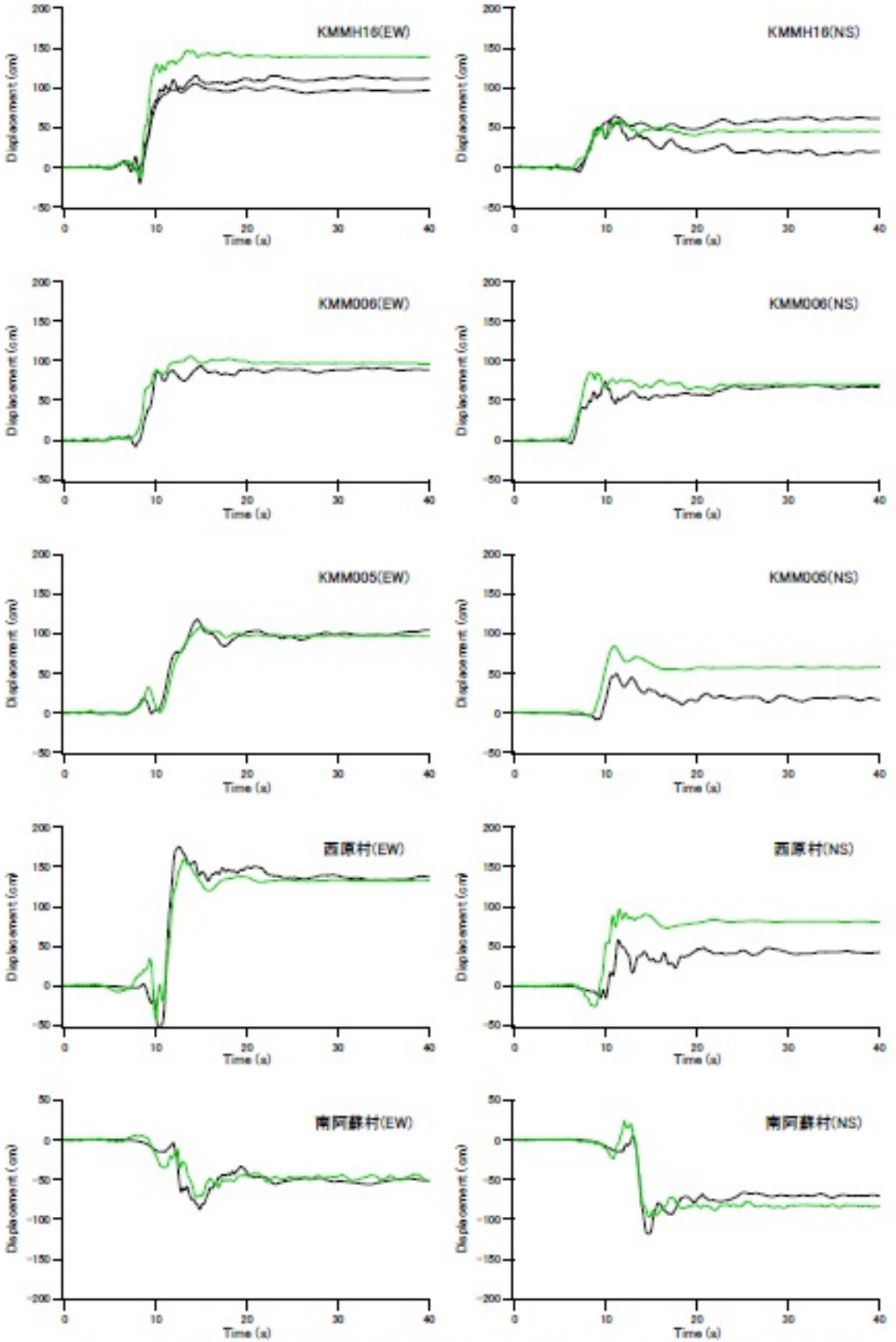
*Atsushi Nozu[1], Yosuke Nagasaka[1], Shuanglan Wu[1]

1. Port and Airport Research Institute

A composite source model was developed to simulate strong ground motions during the main shock of the 2016 Kumamoto earthquakes which can consider both fling steps due to slips near the site and pulses from deeper asperities. The authors' intention was to develop a simple source model which can be easily handled by engineers. To this end, a simple geodetic fault model by the Geospatial Information Authority of Japan (GSI), comprising of three faults with uniform slip, was used as a starting point and parameters related to the temporal evolution of the slip were added. The added parameters included the rupture starting point, rupture propagation pattern, rupture velocity and rise time. The resultant model was used as a background region, which was combined with asperities to form a composite source model. The ground motions from the background region were calculated by the discrete wavenumber method (Bouchon, 1981). The ground motions from the asperities were calculated by what we call "the corrected empirical Green's function method" (Kowada et al., 1998; Nozu et al., 2009). The simulation results showed that the composite model can well reproduce near-source displacement and velocity waveforms including fling steps at KMMH16, KMM006, KMM005, Komori and Kawayo, although the model was relatively simple in a sense that the slip-velocity function and the rise time were uniform throughout the background region. A closer look at the results showed that the fling steps were slightly overestimated or underestimated depending on the site. It was obvious that if we had introduced more complicated slip models, the results would have been closer to the observations. However, from an engineering point of view, it was a meaningful result that such a simple source model could explain ground displacements with fling steps without significant discrepancy because, in a prediction problem, it is difficult to assign a detailed slip distribution. On the other hand, to represent pulses with approximate periods of 1 s, it was definitely necessary to consider asperities.

Keywords: crustal deformation, fling step, the 2016 Kumamoto earthquakes

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背景領域＋アスペリティを考慮した変位波形の計算結果（黒が観測，緑が計算）（原点は気象庁の発震時刻）

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Fling-steps displacements by the discrete wavenumber method

*SHUANGLAN WU[1], Atsushi Nozu[1], Yosuke Nagasaka[1]

1. PORT AND AIRPORT RESEARCH INSTITUTE

The discrete wavenumber method introduced by Bouchon (1977, 1981, 2003), provides a way to accurately calculate the complete Green’ s functions for many problems with a minimum amount of mathematics, and it is appropriate to represent the seismic waves by the summation of plane waves in the wavenumber domain for each frequency. However, there are still some problems to be solved by adoption of this approach in several specific cases. For example, the effects of imaginary part of complex frequency and the truncation of wavenumbers on near-fault fling-steps displacements.
For the first one, it advantages that a complex frequency with a small positive imaginary part is introduced in Bouchon (Bouchon, 1979) to solve the problem of integrand becomes zero when obtaining the near-fault ground motions. The determination and effects of the imaginary part of the complex frequency as defined by $\omega_c=\omega-\lambda i$, the values of λ in the range of $\lambda=[\pi/2T\omega,\ \pi/T\omega]$ recommended by Bouchon (2003) is still not clear. Therefore, in order to obtain more accuracy displacement waveforms, trail and errors have been conducted on near-fault fling-steps displacements under various point source models and it resulted that, $\lambda=2\pi/T\omega$ rather than $\lambda=\pi/T\omega$ can be recommended, (the displacement waveforms of dip-slip case under various could be obtained in Figure 1 below).
In terms of the second parameter, since for the near-fault displacements, in which seismic source and stations are located at a nearly same depth or at very low frequency range, the convergence of integration or summation over wavenumbers becomes very slow, the truncation of wavenumbers in such a case should be determined carefully. The use of $k_{max}=4k_{\alpha}$ was recommended (Bouchon and Aki, 1977), where $k_{\alpha}=\omega/\alpha$ and α stands for the P wave velocity. And the pioneering work of Honda and Yomogida (2003) addressed the issue of appropriately setting this parameter for the simulation of fling-step displacements by testing the accuracy of the fling-step displacements calculated through the DWN method by comparing the results with the analytical solutions for the static displacements (Okada, 1985) and proposed to use $k_{max}=4\ km^{-1}$ in the low frequency range. However, their study was focused on cases where a large amount of seismic moment is released at several kilometers under the surface. In this research, aimed at establishing a criteria for the k_{max} value applicable even for the shallow slip cases, based on the solutions in complete elastic wavefield, the truncation wavenumber was deduced related to the source depth dependent theoretically. And $k_{max}=5\pi/Z_s$ was recommended, where Zs is the depth of the source. The criteria for k_{max} was fully verified in the various point source model and the resultant displacements showed good agreements with analytical solutions (Okada (1985), which are illustrated in the following Figure 2).

Keywords: fling-steps displacements, discrete wavenumber method, complex frequency, point source depth dependent truncate number of the wavenumber integration, point source models

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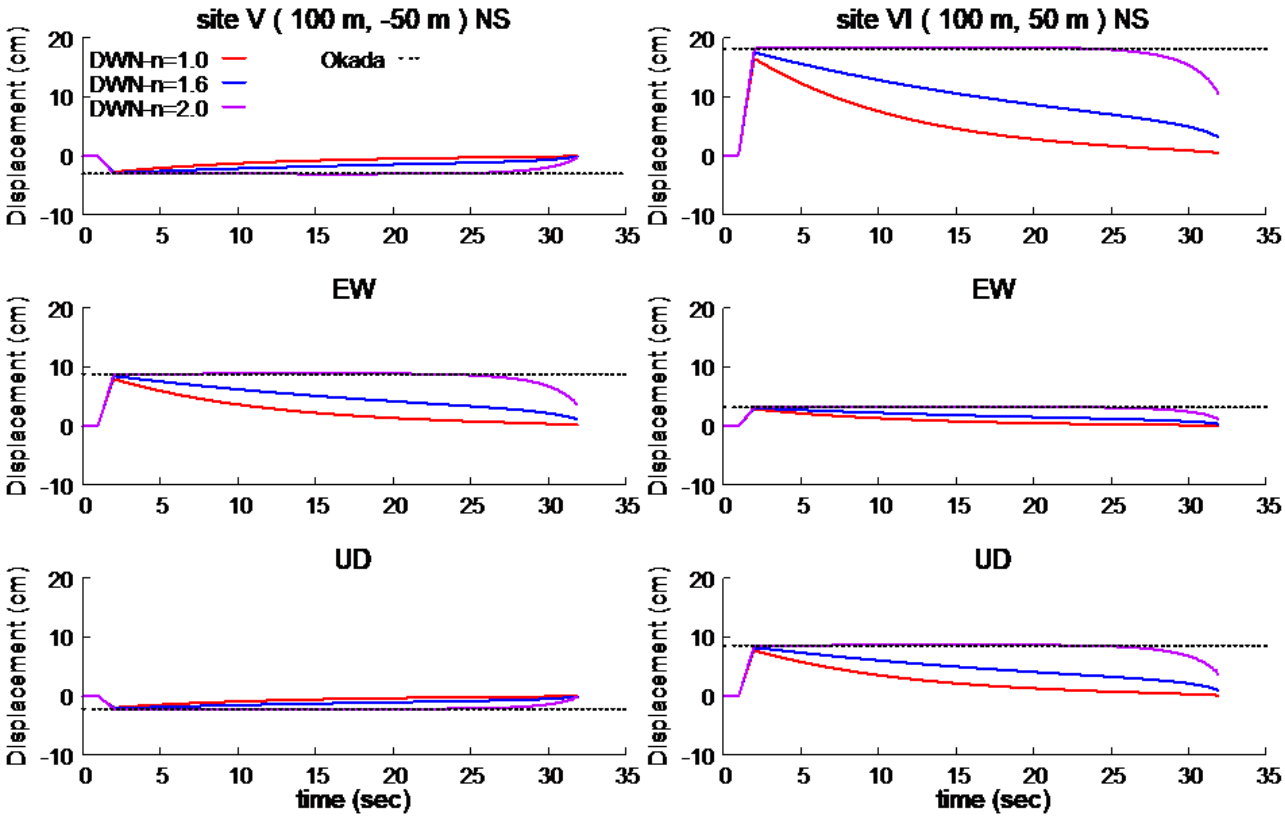


Figure 1 Dip-slip (dip45°): effects of complex frequency (i.e., n-value) on the near-fault fling-steps displacement

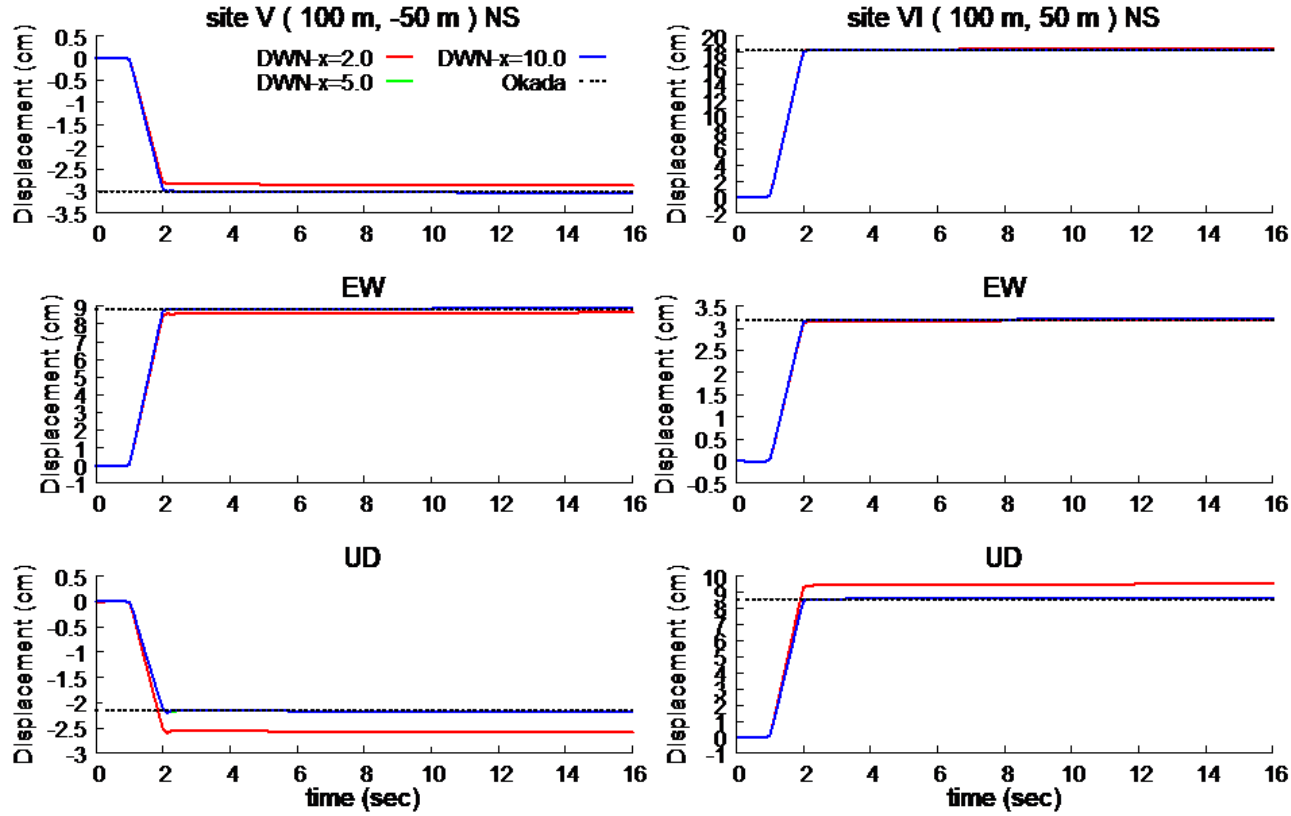


Figure 2 Dip-slip (dip45°): effects of point source depth dependent truncate wavenumber (i.e., x-value) on fling-steps displacements

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Extension of characterized source model for long-period strong motions near surface-rupture-earthquakes

*Kojiro Irikura[1], Susumu Kurahashi[1], Yasuhiro Matsumoto[2]

1. Aichi Institute of Technology, 2. KOZO_KEIKAKU Engineering, Inc.

Introduction: Strong ground motions from the 2016 Kumamoto earthquake (Japan) were well simulated based on the characterized source model consisting of strong-motion-generation-areas (SMGAs) with high stress drop and a background area with low stress drop except very-near fault stations (Irikura et al., 2017). Strong ground motions observed at very-near-fault stations less than 3 km away from the surface traces along the Futagawa fault zone have specific long-period motions including maximum permanent displacements beyond 2 m. To reproduce long-period ground motions at those very-near-fault stations, we need not only to put SMGAs but also to add long-period motion generation areas (LMGAs) in surface layers from fault surface to a certain depth above the seismogenic zone. During the 2010 Mw7.1 Darfield earthquake (New Zealand), surface breaks caused by the mainshock were found associated with active faults by field surveys. Strong ground motions from the 2010 Darfield earthquake were also simulated well using the conventional characterized source model except ground motions at very-near fault stations. Reproduction of very-near-fault motions with permanent components for the 2010 Darfield earthquake are also needed to take into account LMGAs in surface layers. The same phenomena have been observed in the 2011 Nagano-ken Hokubu earthquake (Mw 6.2), the 1999 Chi-Chi earthquake (Mw 7.6), and other surface-rupture earthquakes as long-period motions and permanent displacements seen in the 2016 Kumamoto and 2010 Darfield earthquakes Then, we propose the extension of the characterized source model adding long-period motion generation areas (LMGAs) from fault surface to a certain depth above the seismogenic zone. The parameters for SMGAs are given following the recipe by Irikura and Miyake (2010). The parameters of LMGAs are discussed in relation to scaling relationships of surface-rupture earthquakes.

Extension of characterized source model: Long-period motions with permanent displacements at the very-near-fault stations during the 2016 Kumamoto earthquake are not well simulated based on the conventional characterized source model. SMGAs in the conventional characterized model were determined inside the seismogenic zone deeper than 3 km. To generate long-period motions near the fault traces, long-period motion generation areas (LMGAs) are deployed in surface layers from fault traces down to a certain depth. Similar studies have been made by several authors (e.g. Ikutama et al. 2017; Tanaka et al., 2018; Satoh, 2018; Iwaki et al., 2018). Ground motions more than 2 s observed at very-near-fault-distance stations such as 93048 (Nishihara Village Hall), 93051 (Mashiki Town Hall), KMMH16 (Mashiki-KiK-net station) in the 2016 Kumamoto earthquake are well reproduced adding long-period motion generation areas (LMGAs). During the 2010 Mw7.1 Darfield (New Zealand), surface breaks caused by the mainshock were found associated with active faults by field surveys. Strong ground motions from the 2010 Darfield earthquake were also simulated well using the conventional characterized source model except ground motions at very-near fault stations. Reproduction of very-near-fault motions with permanent components for the 2010 Darfield earthquake are also needed to take into account LMGAs in surface layers. To determine the extended characterized source model for strong motion prediction of target earthquakes, first the procedures for estimating the outer and inner fault parameters are preserved for the SMGAs. Next, to set LMGAs for the target earthquake, L_b (Length of LMGA), W_b (Width of LMGA), D_b (Maximum slip of LMGA), T_b (rise time of slip velocity time, function) are systematically given, following scaling relationships for surface-rupture earthquakes.

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Keywords: strong ground motions, characterized source model, strong-motion generation area, long-period motion generation area

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A Study for the cause of earthquake damages by the 2014 Nakagano-ken Hokubu earthquake (M_J 6.7) –consideration using the strong motion simulation –

*Kazuhito Hikima[1], Ryoichi Nakamura[2], Tomiichi Uetake[1]

1. Tokyo Electric Power Company Holdings, Inc., 2. Earthquake Research Institute, Univ. of Tokyo

- INTRODUCTION -

During the 2014 Nagano-ken Hokubu earthquake, distinct surface ruptures were observed along the known Kamishiro fault, so it suggests that fault slip was occurred near the shallow parts on the fault plane. However, the damage caused by strong motion was not so heavy near Shiojima district, where the most distinct surface rupture was observed, and the fatal damage befall around Horinouchi district, where locate at 7 to 8 km south from Shiojima. To study the reason of the discrepancy among these damages and the fault slip is important for understanding the cause of strong motions.
In previous study (Hikima *et al.*, 2015: SSJ, 2018:JpGU), we carried out source process inversion using strong ground motion records. In this study, we performed the strong motion simulation using the derived source model and the 3D structure model and discussed the cause of the strong ground motions and the damages.

- SOURCE MODEL -

The outline of the source model by Hikima *et al.* (2018) is as follows.
Basically, the waveforms of KiK-net borehole stations (by NIED) within about 50 km from the source area were used for the analysis. The acceleration waveforms were filtered between 0.03 and 0.8 Hz, and were integrated to velocity waveforms for the inversion analysis. In addition, two displacement waveforms at K-NET Hakuba (NGN005) and KiK-net Hakuba (NGNH36), which were adequately integrated from acceleration waveforms (Nakamura *et al.*, 2015:SSJ), were also incorporated to the analysis.
The source process was inverted by the multi time window analysis (Yoshida *et al.*, 1996, Hikima, 2012). We calculated the Green's functions by 3D finite difference method using a 3D velocity structure model. The 3D velocity structure was taken from the model constructed for the long period ground motion prediction map by the HERP.
The parameters of the hypocenter were taken from Sakai *et al.* (2015). Although the strike of the fault plane was set as 25 degree in Hikima *et al.* (2018), we also consider other strike angles in this study. The dip angle was varied according to depth, and the values were 60 and 50 degree for deep and shallow part, respectively. The fault size was 19 km for length and 15 km for width. The subfault size was 1.0km. Some large slip areas were estimated on the fault plane. One was slightly deeper from the hypocenter and the other one was on the shallow and small part of the fault plane. Although the amount of final slip was similar on these area, the time functions on shallow part were broader than those on deeper part, so it suggests that the strong motions from the shallow portion relatively lack high frequency components than those from deeper parts. Furthermore, large slip was not estimated on the fault plane near Horinouchi district.

- STRONG MOTION SIMULATION -

The strong motion simulation was performed by 3D finite difference method using the inverted source model and the 3D velocity structure. We used finer grid spacing than the calculation for the Green's function to consider higher frequency.

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Although large PGV values were calculated near the region where the surface rupture was emerged, almost same level strong motions were estimated also near the Horinouchi. To survey the reason of these strong motions, we checked the snap shots and found that the directivity effect from the large slip which lies on the shallow part of the fault. Furthermore, when the amplification by the surface geology was also considered, the amplitude around Horinouchi became larger than the region near Shiojima and so on. It seems that the results correspond to the observed damage distribution in the source region. From these results, we think that the causes of the strong ground motion around Horinouchi are the source process (directivity effect) and the amplification by the surface geology.

Keywords: 2014 Nagano-ken Hokubu earthquake, Strong motion simulation, Source process, Near fault ground motion

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | Convention Hall A 2F

[S-SS13] Strong Ground Motion and Earthquake Disaster

convener:Masayuki Kuriyama(Central Research Institute of Electric Power Industry), Kazuhiro Somei(Geo-Research Institute), Chairperson:Yosuke Nagasaka(Port and Airport Research Institute), Masumi Yamada(Disaster Prevention Research Institute, Kyoto University)

Strong ground motion has social impacts as it induces earthquake disasters. We solicit contribution on any seismological topics related to strong ground motion that includes, but are not limited to, source processes, wave propagation, and site effects. We also welcome contribution on earthquake related disaster mitigation.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SSS13-19] Strong ground motion simulation of the Northern Osaka earthquake of June 18, 2018

*Yosuke Nagasaka[1], Atsushi Nozu[1] (1.Port and Airport Research Institute)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SSS13-20] **Strong Motion of the 2018 Mw 6.4 Hualien, Taiwan Earthquake and Its Impact on Seismic Design Code in Taiwan**

*Chun-Hsiang Kuo[1], Jyun-Yan Huang[1], Che-Min Lin[1], Kuo-Liang Wen[2] (1.NCREE National Center for Research on Earthquake Engineering of Taiwan, 2.NCU National Central University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SSS13-21] Simulation of Rupture Directivity Effect for the February 6, 2018 Hualien, Taiwan Earthquake

*Cheng-Feng Wu[1], Huey-Chu Huang[1] (1.Department of Earth and Environmental Sciences, National Chung Cheng University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SSS13-22] Strong motions and estimation of the sursurface soil structure for the 2018 Hualien earthquake in Taiwan

*Masumi Yamada[1], Ikuo Cho[2], Chun-Hsiang Kuo[3], Che-min Lin[3], Ken Miyakoshi[4], Yujia Guo[4], Takumi Hayashida[5], Yasuhiro Matsumoto[6], James Mori[1], Yin-Tung Yen[7], Keng-Chang Kuo[8] (1.Disaster Prevention Research Institute, Kyoto University, 2.National Institute of Advanced Industrial Science and Technology , 3.National Center for Research on Earthquake Engineering, 4.Geo-Research Institute, 5.Building Research Institute, 6.Kozo Keikaku Engineering, 7.Sinotech Engineering Consultants, 8.Kaohsiung university of Science and Technology)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SSS13-23] **Effect of Near Surface Geology on the Recorded Ground Motion of the Nepal Earthquake in Kumaon Himalaya**

*SOHAN LAL[1], Anand Joshi[1], M.L. Sharma[1] (1.Indian Institute of Technology Roorkee)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SSS13-24] Broadband Source Modeling for the Himalayan Collision Zone

*Hiroe Miyake[1], Babita Sharma[2], Kazuki Koketsu[1], Soma Nath Sapkota[3] (1.Earthquake Research Institute, University of Tokyo, 2.National Centre for Seismology, Ministry of Earth Sciences, India, 3.Department of Mine and Geology, Nepal)

Strong ground motion simulation of the Northern Osaka earthquake of June 18, 2018

*Yosuke Nagasaka[1], Atsushi Nozu[1]

1. Port and Airport Research Institute

Strong ground motion simulation with point source model is simpler than the model with rectangular asperities. On the other hand, if the point source model ignores spacio-temporal extension of the fault, this can cause discrepancy between observation and synthetics. We have examined the applicability of the pseudo point-source model (Nozu, 2012) for intraslab earthquakes and so on and the results showed good agreement with observation records. However, validation of the method for crustal earthquakes is not enough. In this study, we conducted strong ground motion simulation for the June 18, 2018 Northern Osaka earthquake (M_J6.0) as an example of crustal earthquake.

First we assumed two fault planes based on moment tensor solution and aftershock distribution. These two fault planes have the mechanism of reverse fault and right-lateral slip fault, respectively. Then we estimated slip distribution by general inversion technique using empirical Green's functions. The result was that the reverse fault first ruptured and the right-lateral fault ruptured after a while, larger slip was seen on the reverse fault.

We then conducted strong ground motion simulation with the pseudo point-source model. In the method, we regard one asperity as one point source that follows omega-square model. We get the synthetic waveforms by combining the omega-square model with path spectrum, empirical site amplification factor, and site phase characteristics for each target station. We assumed only one point source in the first case. We put the point source on the hypocenter, and determined seismic moment (1.7×10^{17} Nm) and corner frequency (0.65 Hz) so that the synthetic Fourier spectra explain observed spectra the best. For phase characteristics, we chose the earthquake of June 19, 2018 occurred at 4:53 (M_J3.9). This small earthquake has the mechanism of reverse-fault, which explained the observed phase characteristics better than the phase of right-lateral earthquake. The result with one point source showed good agreement with observations in terms of amplification and phase characteristics. However, the result underestimated at OSK002, the closest station from the epicenter.

In order to improve this problem, we then conducted the simulation with two point sources, which can better consider the effect of the rupture propagation than the case of one point source. The location of the second point source is about 0.3km above the first point source. The relative rupture time is 0.41s. We used the same small earthquake for phase characteristics for both point sources. The seismic moments and corner frequencies were determined in the same manner as the case of one point source as M1=0.7×10^{17}Nm, fc1=0.6Hz, M2=1.1×10^{17}Nm, fc2=0.9Hz. As a result, the amplification at OSK002 was improved and the characteristics of the Fourier spectra were also improved compared to the one point source case.

Keywords: 2018 Northern Osaka earthquake, Strong ground motion simulation, point source model

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Strong Motion of the 2018 Mw 6.4 Hualien, Taiwan Earthquake and Its Impact on Seismic Design Code in Taiwan

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The maximum observed PGA and PGV at various stations during the 2018 Hualien, Taiwan earthquake were 594 Gal and 146 cm/s, respectively. Pulse-like velocities were observed at all stations within a distance of 4 km from the Milun fault. The horizontal spectral accelerations of the pulse-like records indicated two obvious amplifications at periods of roughly 1 s and 2 s. Natural frequencies of 0.8 to 1.5 Hz were observed in the region near the Milun fault using microtremor measurements. The spectral acceleration peak at periods of roughly 2 s is mostly seen in the east-west direction, indicating a typical fault-normal seismic radiation from the fault rupture. Consequently, we contend that the amplifications of spectral acceleration at approximately 1 and 2 s were caused by site amplification and the rupture front, respectively. The site amplification at the period of approximately 1 s may have been one reason for the collapse of medium-rise buildings during this earthquake. Evident soil nonlinearity resulted in smaller horizontal than vertical PGA at many stations in the near-fault region. Return period of the Milun Fault is believed to be about 67 years (1951 and 2018) and thus it is a 53% probability of being exceeded in a 50-yr mean recurrence interval. The demand of seismic design in the Hualien City will have to be increased especially in the long-period according to the observed ground motions during this earthquake.

Keywords: Near-Fault Ground Motion, PGV, Pulse-like Velocity

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Simulation of Rupture Directivity Effect for the February 6, 2018 Hualien, Taiwan Earthquake

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The Hualien earthquake (M_W 6.4) occurred off Taiwan’s eastern coast on February 6, 2018. This earthquake has struck the eastern Taiwan and also caused several houses collapsed and casualties. From the observed strong motion data at the disaster sites, an obvious directivity pulse appears in the velocity waveform and the peak ground velocity (PGV) exceeds 50 cm/s. In order to further investigate the strong ground motion characteristics of this earthquake, we perform the broadband (0.1-10 Hz) strong ground motion simulation using the stochastic Green's function method. About the source parameters, we adopt the empirical formulas. Besides, the slip distribution on the fault plane is calculated by using the hybrid k-squared slip model. By comparing the simulation results with the observed data, we get the best slip model from the hypothetical slip models. Moreover, we effectively simulate the directivity pulses at several stations at the south of the earthquake. The disaster areas are located near and above the asperity of the fault plane. According to simulation results of different velocity structures, the addition of the shallow velocity structure makes the synthetic waveforms more similar to the observed data at most stations. The amplifications of the PGVs are about a factor of 2.0 at the stations near the disaster areas. Therefore, the disasters of the Hualien earthquake could be caused by the forward-directivity and site amplification effects.

Keywords: Hualien earthquake, ground motion simulation, stochastic Green's function method, hybrid k-squared slip model

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Strong motions and estimation of the sursurface soil structure for the 2018 Hualien earthquake in Taiwan

*Masumi Yamada[1], Ikuo Cho[2], Chun-Hsiang Kuo[3], Che-min Lin[3], Ken Miyakoshi[4], Yujia Guo[4], Takumi Hayashida[5], Yasuhiro Matsumoto[6], James Mori[1], Yin-Tung Yen[7], Keng-Chang Kuo[8]

1. Disaster Prevention Research Institute, Kyoto University, 2. National Institute of Advanced Industrial Science and Technology , 3. National Center for Research on Earthquake Engineering, 4. Geo-Research Institute, 5. Building Research Institute, 6. Kozo Keikaku Engineering, 7. Sinotech Engineering Consultants, 8. Kaohsiung university of Science and Technology

The 2018 Hualien earthquake occurred around 23:50, February 6, 2018 (local time). The depth of the event was about 10 km and the moment magnitude was 6.4 (USGS). Crustal deformation in the Hualien basin was clearly observed in the InSAR image (e.g., GSI 2018, Hashimoto 2018). The rupture propagated along the Milun fault from north to south and the northern part of the Longitudinal Valley fault was also ruptured. Particularly, the discontinuity of the interference fringes at the Milun fault was clear on the InSAR image.

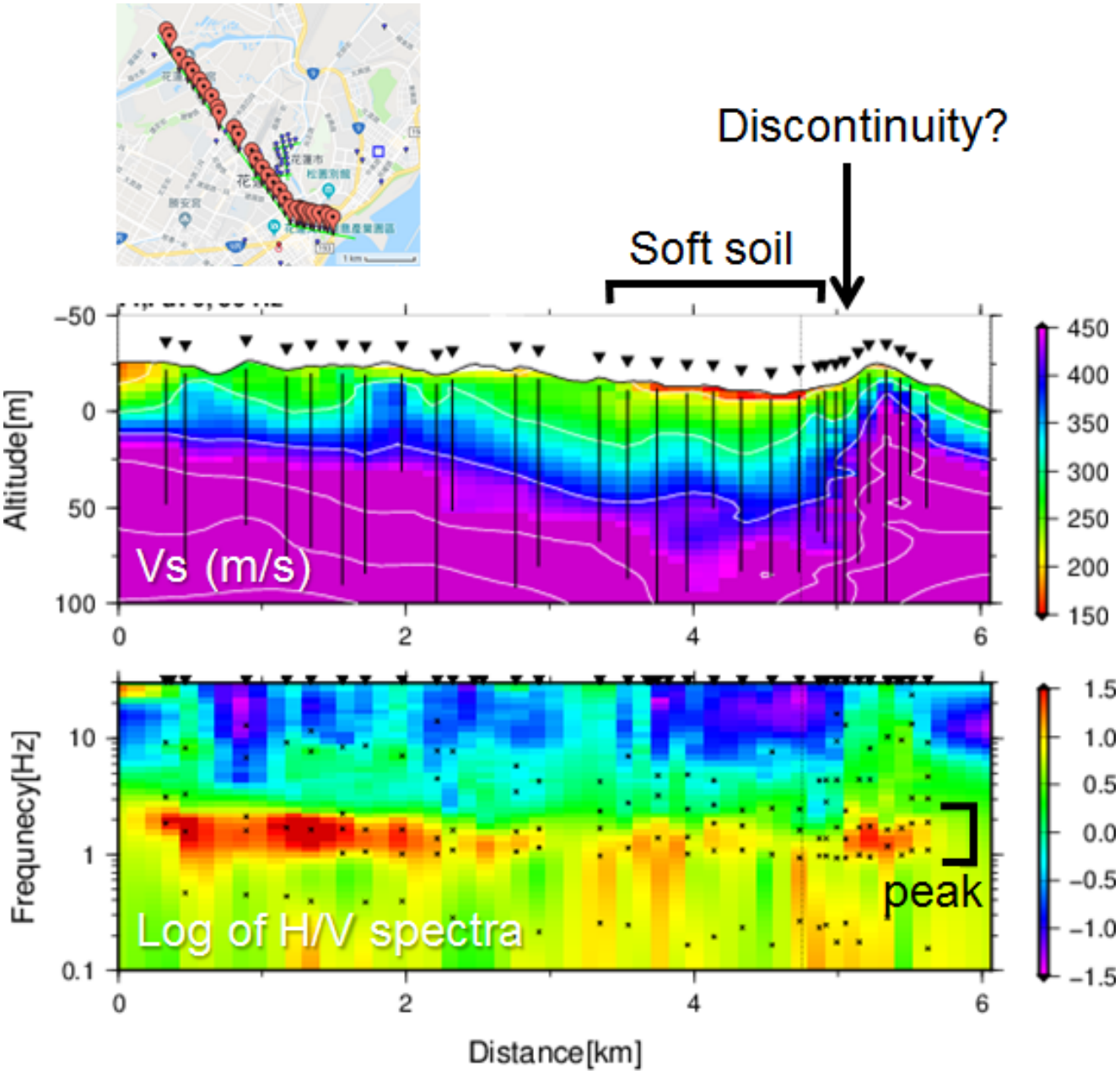
In Hualien city, the middle-rise four buildings collapsed during the earthquake, due to the collapse of the pillars at the first floor. They were located at the place where discontinuous fringes were observed in the InSAR images. There is a possibility that the discontinuous displacements or ground motions in the vicinity of the fault affect on the damage of the buildings (NARlabs 2018).

In order to understand the cause of building damage in Hualien city and the heterogeneous subsurface soil structure in the Hualien basin, we performed microtremor array measurement on October 20-26, 2018. We performed the measurement at every 100-200 m along the EW section of the basin. At each measurement point, we used 5 seismometers to obtain the phase-velocity dispersion curves at the shallow subsurface structure. In total, we measured microtremors at 64 observation points and obtained the phase-velocity dispersion curves and H/V spectra.

Our profile shows that the peak of the H/V spectra is about 1-2 Hz along the measurement line, which probably corresponds to the basement at the depth of 50-100m. The average Vs at the depth of 10-30m is about 200-400 m/s. There is a clear difference between the east and west side of the Milun fault: at the west side of the fault, there is a soft soil deposit on the shallow surface (10m) with the average Vs less than 200m/s. At the east side of the fault, the soft layer with the Vs<400m/s is very thin. Therefore, we estimated the engineering bedrock of the west side of the Milun fault is deeper than the east side. This difference of the basin thickness is consistent with the movement of the Milun fault during the 2018 Hualien earthquake estimated from the InSAR image.

Keywords: Hualien earthquake, Strong motion, Subsurface soil structure, Microtremor

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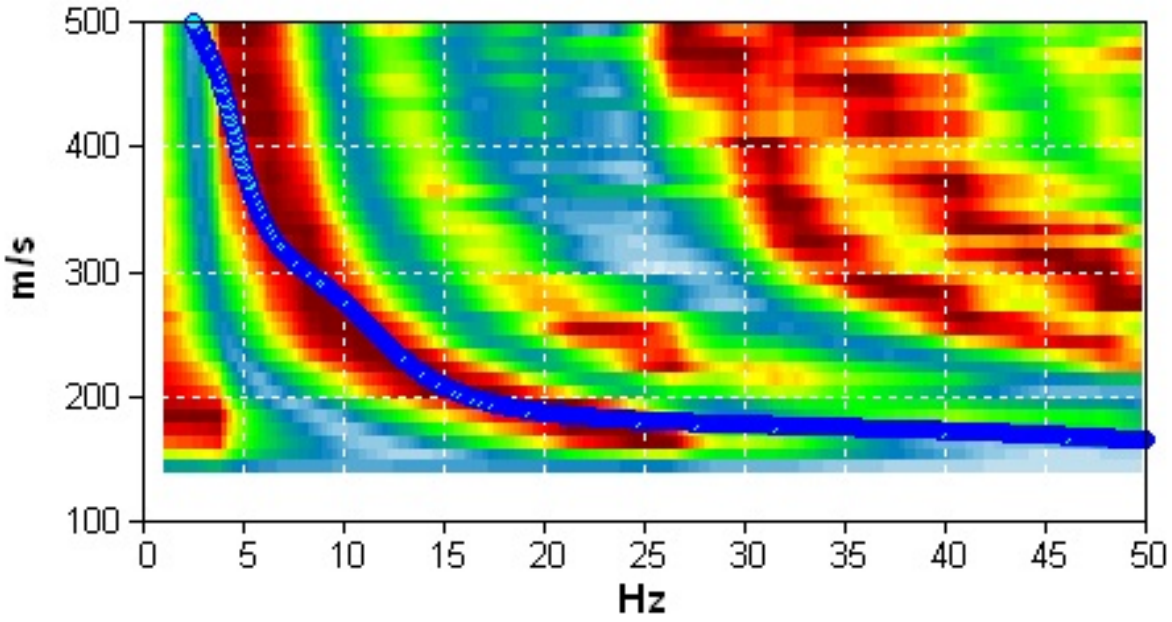
Effect of Near Surface Geology on the Recorded Ground Motion of the Nepal Earthquake in Kumaon Himalaya

*SOHAN LAL[1], Anand Joshi[1], M.L. Sharma[1]

1. Indian Institute of Technology Roorkee

An earthquake has been devastated the Nepal on 25 April 2015. The earthquake experienced the low frequency amplification. The subsurface structure alters the seismic wave through which they propagate and can amplify or de-amplify the amplitude of the coming wave from the source for the frequency ranges. The Nepal earthquake was been recorded at the Kumaon Himalaya region at the western side from the epicenter. The present paper highlights the effect of local geology on the recorded ground motion and calculation the shallow subsurface velocity model using the joint fit of the surface wave dispersion curve and HVSR ratio. The theoretical transfer function generated which satisfy both the dispersion curve and the HVSR ratio is directly convolve with the hard rock simulated time series to calculate the surface simulation. The simulation of the Nepal earthquake was done using the semi- empirical technique.

Keywords: Site effect, Strong ground motion, Simulation



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Broadband Source Modeling for the Himalayan Collision Zone

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The Himalayan collision zone is characterized by the significant tectonic setting. There are earthquakes with low-angle thrust faulting as well as continental outerrise earthquakes. Recently several historical earthquakes have been identified by active fault surveys [e.g., Sapkota et al., 2013]. We here investigate source scaling for the Himalayan collision zone as a fundamental factor to construct source models toward seismic hazard assessment. As for the source scaling for collision zones, Yen and Ma [2011] reported the subduction-zone source scaling in Taiwan, and pointed out the non-self-similar scaling due to the finite crustal thickness. On the other hand, current global analyses of stress drop do not show abnormal values for the continental collision zones [e.g., Allmann and Shearer, 2009]. Based on the compiled profiling of finite thickness of the curst and dip angle variations, we discuss whether the bending exists for the Himalayan source scaling and implications on stress drop that will control strong ground motions. Due to quite low-angle dip faulting, recent earthquakes in the Himalayan collision zone fit the upper bound of the current source scaling of rupture area vs. seismic moment (< Mw 8.0), and do not show significant bending of the source scaling. Toward broadband source modeling for ground motion prediction, we perform empirical Green’s function simulations for the 2009 Bhutan and 2015 Gorkha earthquake sequence to quantify both long- and short-period source spectral levels [e.g., Miyake et al., 2017; Sharma et al., 2018].

Recent Himalayan events showed the upper bound of the current source scaling of rupture area vs. seismic moment (< Mw 8.0), and current plots well match with Somerville et al. (1999) without bending. However, re-estimates of maximum fault width may change the source scaling. We also found that Himalayan events less than M6-class follow crustal earthquake scalings for short-period ground motion generation. If M7-class sources are modeled to follow crustal earthquake scalings, simulated ground motions tend to be larger than GMPEs on rock. Short-period ground motion saturation will be validated after broadband ground motion modeling for more events (e.g., Gorkha aftershocks).

Keywords: Himalayan collision zone, broadband source model, scaling, 2015 Gorkha earthquake

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[S-SS16] Crustal Deformation

convener:Mako Ohzono(Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido University), Tadafumi Ochi(Institute of Earthquake and Volcano Geology, Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Masayuki Kano(Graduate school of science, Tohoku University), Chairperson:Yoshiyuki Tanaka(Earth and Planetary Science, The University of Tokyo), Masayuki Kano(東北大学 大学院理学研究科 地球物理学専攻)

Study of crustal deformation plays an extremely important role in the investigation of wide scale earth dynamics those are earthquake and volcanic activity, plate motion and so on. In our session, we discuss the study related to crustal deformation, such as development of observation instrument, observed crustal deformation, analysis method, and simulation study.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SSS16-01] Development of New GEONET Analysis Strategy

*yasuaki kakiage[1], satoshi abe[1], kazuyuki ohashi[1], hideo hamazaki[1], kazuyuki tanaka[1], satoshi kawamoto[1], yuki hatanaka[1] (1.GSI of Japan)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SSS16-02] Relationship between deformation of the forearc wedge of Southwest Japan and the 1707 Hoei earthquake

*Yukinobu Okamura[1], Masanobu Shishikura[1] (1.Research Institute of Earthquake and Vocano Geology, National Institute of Advanced Industrial Science and Technology)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SSS16-03] A possible slow slip event beneath the Kii Peninsula inferred from historical tilt records in 1970's

*Masayuki Kano[1], Yasuyuki Kano[2] (1.Graduate school of science, Tohoku University, 2.Earthquake Research Institute, The University of Tokyo)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SSS16-04] The effect of the steady plate subduction in the case of southwest Japan

*Yuto Iwase[1], Takeo Ito[1] (1.Graduate School of Environmental Science, Nagoya University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SSS16-05] Development of Mechanical Coupling Model on Subducting Plate Interfaces

*Hiroshi Kimura[1], Takeo Ito[1], Keiichi Tadokoro[1], Ryohei Sasajima[2] (1.Department of Earth and Planetary Sciences, Nagoya University, 2.Research Center For Earthquake Prediction, Disaster Prevention Research Institute, Kyoto University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SSS16-06] Monitoring vertical deformation with optical lattice clock –an application of relativistic geodesy

*Yoshiyuki Tanaka[1], Yuichi Imanishi[2], Yoshiaki Tamura[3] (1.Earth and Planetary Science, The University of Tokyo, 2.Earthquake Research Institute, The University of Tokyo, 3.Mizusawa VLBI Observatory, National Astronomical Observatory of Japan)

Development of New GEONET Analysis Strategy

*yasuaki kakiage[1], satoshi abe[1], kazuyuki ohashi[1], hideo hamazaki[1], kazuyuki tanaka[1], satoshi kawamoto[1], yuki hatanaka[1]

1. GSI of Japan

Geospatial Information Authority of Japan (GSI) has been operating GEONET (GNSS Earth Observation Network System), which involves over 1,300 GNSS stations, since 1996. The daily coordinates for each station are estimated by Bernese GNSS software to monitor the crustal deformation in Japan. The analysis strategy was updated four times. Current version is the fourth generation (4G) analysis, which was developed in 2009. We are now developing a new strategy (5G) because the software, reference frame, and other physical models used in 4G analysis have been obsolete. Major features of 5G analysis are: 1. Update of reference frame, 2. GPS and GLONASS integration, 3. Improvement of the troposphere model, 4. More stable daily coordinates of the reference station (TSUKUBA-1) for analysis. GSI developed 5G prototype in 2017.
The 5G prototype firstly conducts “fix-point analysis” to estimate daily coordinates of TSUKUBA-1. Then all other stations are estimated using GPS and GLONASS data individually. Finally, the GPS and GLONASS solutions are integrated.
The daily coordinates of the TSUKUBA-1 is estimated by a global analysis using worldwide IGS stations under No-Net-Translation constraint. But, we analyzed the data from 1996 to 2004 constraining IGS stations coordinates(SINEX results) directly.
In case of all other GEONET analysis, there is limiting condition to solve combined solution. So we evaluate the combined solutions with respect to limiting condition.
We will show the in detail of fix point analysis and 5G analysis, especially combine solution.

Keywords: Geodesy

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Relationship between deformation of the forearc wedge of Southwest Japan and the 1707 Hoei earthquake

*Yukinobu Okamura[1], Masanobu Shishikura[1]

1. Research Institute of Earthquake and Vocano Geology, National Institute of Advanced Industrial Science and Technology

We propose a hypothesis that the deformation of the forearc wedge of Southwest Japan and wide varieties of plate boundary earthquakes along the Nankai Trough have been caused by oblique subduction of the undulating Philippine Sea Plate (PSP). Interseismic and coseismic deformations of the forearc wedge of Southwest Japan have been observed by geodetic measurements, however, these deformations have not been accumulating. In contrast, N-S trending uplift zones, namely the Akaishi and Kii mountains, have been growing during the Quaternary periods. The mountains correspond to the zones of PSP trending in NE-SW and the subsiding areas of the Kii strait and Ise Bay to Nobi plain are located above the NW-SE to E-W trending PSP. If the axes of undulations of the subducting slab have been fixed to the PSP, the depth of the PSP trending in NE-SW have been decreasing and that of the PSP trending in NW-SE to E-W have been increasing. The uplifting and subsiding zones correspond to the area of plate depth decrease and increase respectively, thus we infer that the vertical movements of the forearc wedge have been caused by the change of the plate depth. Relative sea level change shown by uplifted sessile assemblage have indicated that uplift during the 1707 Hoei earthquake has been accumulated while those of 1854, 1944 and 1946 plate-boundary earthquakes have not. This fact strongly suggests that there is a strong coupling zone lasting for several hundred years under the Kii Peninsula, and that the break of the coupling triggers the Hoei-type earthquake that ruptured the entire plate boundary. We also point out the possibility that there is another coupling zone under the Akaishi Mountains. The deformation of the forearc wedges of the Southwest Japan and differences of rupture patterns of the plate boundary along the Nankai Trough can be attributed to the change of the depth of the PSP.

Keywords: Nankai Trough, crustal movement, Philippine Sea Plate, 1707 Hoei earthquake

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A possible slow slip event beneath the Kii Peninsula inferred from historical tilt records in 1970’s

*Masayuki Kano[1], Yasuyuki Kano[2]

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Slow slip events (SSEs) have been often observed prior to large earthquakes such as the 2011 Tohoku-oki earthquake and the 2014 Iquique earthquake (e.g., Kato et al., 2012; Mavrommatis et al., 2014; Ruiz et al., 2014). In addition, numerical studies demonstrated that intervals of SSEs became shorter in the latter half of the interseismic period (e.g., Matsuzawa et al., 2010). Therefore, activities and variations of SSEs in time and space provide important clues to anticipated large earthquakes.

Many studies have investigated activities of SSEs based on dense geodetic observation networks established in the early 2000’s (e.g., Sekine et al. 2010; Nishimura et al. 2013). On the other hand, there are few reports before the establishment of such dense networks (Kimata et al., 2001; Kobayashi and Yamamoto, 2011). Here, we report a possible SSE beneath the Kii Peninsula based on historical tilt records in 1970’s.

We used tilt data recorded in Kishu observatory in the Mie Prefecture operated by Kyoto University. Horizontal-pendulum tiltmeters were installed in directions of N57W and N33E. The original tilt data was drawn on bromide (light-sensitive) papers, each of which consists of tilt records for about one week. We have digitized bromide records in 1970’s and connected to a single continuous record.

In the late November in 1973, there was a slow tilt change of >0.5 μrad down to the northeast that lasted for a few days. Assuming that this crustal deformation was due to an SSE along the plate boundary, we have constructed a possible model of SSE. Because it is difficult to constrain fault parameters from a single station record, we conducted a forward modeling assuming already known SSE models beneath the Kii Peninsula obtained by Nishimura et al. (2013). Among 42 template fault models from 1996 to 2012, 3 models were able to qualitatively explain the direction of tilt changes. The centroids of these fault models locate ~30-50 km western side of the observatory. However, the calculated tilt change was about one order smaller than the observed one. Therefore, it is possible that the amount of slip was greater than the template models or the location of SSE was closer to the observatory.

Around the source area, relatively large (magnitude 5.9) earthquake and the following magnitude 5.4 earthquake occurred near the plate boundary on November 25, just before the initiation of the tilt change. The seismicity in this area was usually low, and thus these earthquakes may relate to a possible SSE.

The Kishu observatory have recorded tilt changes since 1947, soon after the 1946 Nankai earthquake. Therefore, further detection of possible SSEs in the latter half of the 20th century will reveal how SSEs behave after large earthquakes.

Acknowledgments:

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We used tilt records at Kishu observatory operated and preserved by Disaster Prevention Research Institute, Kyoto University.

Keywords: Slow slip events, Tiltmeters, Kii Peninsula

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The effect of the steady plate subduction in the case of southwest Japan

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1. Graduate School of Environmental Science, Nagoya University

The deformation of the subduction zone expresses the superposition of the elastic coupling and the steady plate subduction. In the former, the elastic coupling on the plate interface corresponds to stress accumulation for the next earthquake. Thus, the earthquake releases the accumulated stress on the plate interface due to the elastic coupling. The accumulated stress due to elastic coupling is not accumulating over the earthquake cycle. In the latter, the steady plate subduction expresses the creeping on the plate interface. Hence, the shear stress on the plate interface does not accumulate within the earthquake cycle. However, the steady plate subduction effect the long-term deformation over the earthquake cycle. In order to understand the process of the subduction zone, the steady plate subduction is essential not only in seismology but also in geomorphology and geology.

In order to evaluate and understand the effect of steady plate subduction, we introduce a three-dimensional finite element (FE) method. Our target area is southwest Japan. We make a FE model that the size of a model region is 1460km×1400km×700km, where southwestern and northeastern corners of the FE model are corresponding to Amami Island and Tohoku region, respectively. The FE model considers the topography, the three-dimensional shape of the Philippine Sea plate and the complex underground structure that the Philippine Sea plate is subducting in the asthenosphere. The FE model consists of four blocks, such as the Philippine Sea plate, oceanic mantle, continental mantle, and crust. The material of mantle assumes a viscoelastic medium. The crust and the Philippine Sea plate assume an elastic medium. To realize the subducting Philippine sea plate, we set up the boundary condition. The kinematic expression of the Philippine Sea plate is the relative plate motion along the plate interfaces, which are both upper and bottom surfaces of the Philippine Sea plate. In this study, the relative plate motion at each point is expressed by the Euler pole.

As a result, the simulated long-term vertical deformation correlates with topography. The feature of large scale topography, such as the Seto Inland Sea, Kii mountain, Hyuganada and so on, are well reproduced. For the shear stress on the plate interface, The depth-dependent variation is available. There is small shear stress on the plate interface at deeper than Moho depth because of shear stress relaxed by a viscoelastic medium. At shallower than the Moho depth, although the shear stress is available, the direction of shear stress is different from the direction of the Philippine Sea plate because the three-dimensional shape of the Philippine sea plate produces the shear stress on the plate interface. For normal stress on the plate interface, the normal stress on the plate interface is more significant than shear stress. The normal stress produces long-term vertical deformation and tectonic stress distribution. Hence, the tectonic stress around subduction zone produced by dominantly normal stress. The normal stress on the plate interface does not relate with the curvature of the plate interface but is due to the curvature changing rate.

Keywords: steady plate subduction, southwest Japan, tectonic stress, three-dimensional finite element method (FEM)

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Development of Mechanical Coupling Model on Subducting Plate Interfaces

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1. Department of Earth and Planetary Sciences, Nagoya University, 2. Research Center For Earthquake Prediction, Disaster Prevention Research Institute, Kyoto University

Introduction

Interplate earthquakes occur at regions where the interplate strain has been accumulated by plate convergence. To evaluate the interplate seismic potential, many previous studies have tried to estimate the spatial distribution of interplate "coupling" [e.g., Loveless and Meade (2010); Yokota et al. (2016); Nishimura et al. (2018); Kimura et al. (in prep.)]. In their models, "coupling" is defined as the ratio between slip deficit rate and convergence rate, based on the kinematic concept. However, the actual situation of plate interface should be treated as mechanical "locking" (sometimes called as asperities) or "creeping". It is considered that the seismic ruptures at asperities can generate the strong-motion that gives constructions serious damages. Thus, it is essential to comprehend the spatial distribution of the mechanical "locking" region on the plate interface. We then introduce the two kinds of back-slips to develop the mechanical coupling model on the basis of the geodetic observation data. Using this model, we test several scenarios of mechanical coupling distributions along the Nankai Trough for forward simulation.

Modeling of Mechanical Coupling

The mechanical coupling model we developed in this study is similar to the "pinned asperities" model presented by Bürgmann et al. (2005). We consider two kinds of back-slip on the plate interface: active back-slip and passive back-slip. The first one is applied on the mechanical coupling region, that is the mechanically locked region to the plate interface between subducting and overriding plate. We calculate the active back-slip rate from the relative block motion rate based on the Euler vectors of each block. The second one is the slip around the mechanical coupling region generated to completely relieve the along-dip and along-strike shear strain due to the active back-slip. We model the relationship between shear strain concentration $\boldsymbol{\varepsilon}$ and passive back-slip rate $\boldsymbol{v}$ around the mechanical coupling region with a linear equation $\boldsymbol{\varepsilon} = G\boldsymbol{v}$, where G is the Green's function matrix. To estimate the passive back-slip, we first calculate the shear strain due to the given active back-slip on the mechanical coupling region. Then, we inverse the passive back-slip rate using the linear equation above. We repeat these two procedures until the shear strain concentration becomes zero. We call the region where the active or passive back-slip is observed as kinematic coupling region. The elastic component of crustal displacement at the surface can be calculated from the total back-slip on the kinematic coupling region.

Forward Simulation

We conduct the forward simulation using our mechanical coupling model for some scenarios of mechanical coupling distributions along the Nankai Trough. We divide the test region into 12 rigid blocks and calculate the active back-slip rate on mechanical coupling regions using the Euler vectors referring to Kimura et al. (in prep.). Figure 1 shows one example of (a) given mechanical coupling distribution and (b) spatial distribution of the simulated passive back-slip rate. Blue lines mean the edges of mechanical coupling regions. Because the relative block motion rate is about two times faster in the western region than that in the eastern region, the passive back-slip area is larger around the western mechanical coupling region, extending down to ~50 km in depths. In this presentation, we discuss for the other cases

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of mechanical distributions. In this study, we give the mechanical coupling distributions and Euler vectors for forward simulation. Because of this, the estimated passive back-slip rate depends on the given distribution, and we could not know other scenarios of mechanical coupling distributions. To resolve this problem, we will estimate the spatial distributions of mechanical coupling and Euler vectors simultaneously as a non-linear problem in future studies.

Keywords: Mechanical Coupling, Passive Back-slip, Strain Concentration, Crustal Deformation Observation Data, Plate Subduction Zone

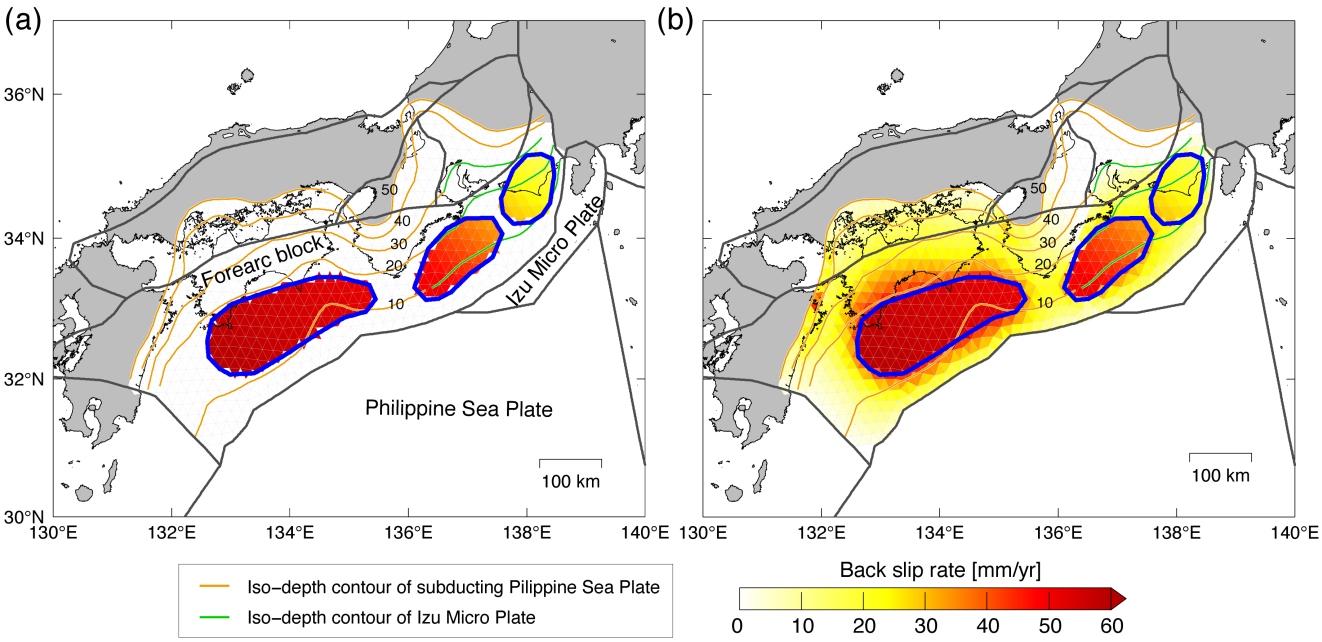


Figure 1: Map showing the spatial distribution of back-slip rate of (a) given active back-slip, and (b) calculated passive back-slip as well as given back-slip.

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Monitoring vertical deformation with optical lattice clock –an application of relativistic geodesy

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Crustal deformations due to earthquake and volcano activities have been detected by geodetic observation methods. The obtained deformations have been analyzed together with horizontal components and physical mechanisms (e.g., fault slip) to cause such deformations have been investigated. Representative methods to observe vertical deformation are leveling survey as a terrestrial method and the Global Navigation Satellite System (GNSS) as a space geodetic technique. The latter includes the Global Positioning System (GPS). Leveling has a long history (>100 years) and is still the most precise method to measure the height difference between relatively near two sites (e.g., <5 mm for 4 km). However, measurement errors increase with longer survey routes and it needs considerable time to complete the survey when the network is larger (about 2 km/day). GNSS, having a shorter history (<30 years), can measure the height difference over a long distance more precisely than levelling (plus-minus 1 cm for 24-hour average for \sim 100 km baseline). The spatial resolution is also better than levelling, thanks to the dense observation network such as GEONET in Japan. However, GNSS suffers from serious atmospheric noises. The precisions to detect vertical deformations in time scales shorter than 24 hours degrade (e.g., plus-minus 3 cm for 3-hour average) due to insufficient measurement time for canceling out the atmospheric noises. Seasonal time-scale crustal deformations are also hard to discriminate from the effects of atmospheric water vapor.Recently, precisions of atomic clocks have become better and better. In particular, optical lattice clock proposed in Japan (Katori 2002; 2017) achieved a relative precision of 5 x 10^-19 in three hours, which is approximately 3 orders of magnitude better than Cesium atomic clocks used to determine 1 second of International System of Units (SI). By the general relativity, the length of 1 second measured by an atomic clock changes according to the variation in the local gravitty potential (gravitational red shift). In general, the length of 1 second becomes shorter at higher altitude with smaller gravity potential energies. Fiber linked two optical lattice clocks can measure the relative potential difference between the two sites. The precision of 5 x 10^-19 corresponds to the height difference of 5 mm. Tectonic gravity potential changes in geodetic time scales are negligible in most cases since even an M-9 earthquake causes a geoid height change by only a few cm at maximum. This means that most part of the temporal variation in the measured gravity potential difference reflects the temporal change in height. The above-mentioned measurement precision and time by optical lattice clock is superior to GNSS, implying that optical lattice clock can replace GNSS as for monitoring of vertical deformation. Since November 2018, Japan Science and Technology (JST) has begun a new project regarding optical lattice clock, consisting of developers of optical lattice clock and geodesists. In this presentation, we will introduce this new project and the goal of the "relativistic geodesy" group. We discuss possible applications of optical lattice clock to crustal deformation monitoring.

Keywords: optical lattice clock, relativity theory, crustal deformation, gravity potential, atomic clock, relativistic geodesy

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[S-SS16] Crustal Deformation

convener:Mako Ohzono(Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido University), Tadafumi Ochi(Institute of Earthquake and Volcano Geology, Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Masayuki Kano(Graduate school of science, Tohoku University), Chairperson:Yuji Himematsu(Graduate School of Science, Hokkaido University), Atsushi Mukai(Faculty of Urban Management, Fukuyama City University)

Study of crustal deformation plays an extremely important role in the investigation of wide scale earth dynamics those are earthquake and volcanic activity, plate motion and so on. In our session, we discuss the study related to crustal deformation, such as development of observation instrument, observed crustal deformation, analysis method, and simulation study.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SSS16-07] Surface Deformation before and after the 2016 Kumamoto Earthquake Detected by SAR

*Manabu Hashimoto[1] (1.Disaster Prevention Research Institute, Kyoto University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SSS16-08] Co- and post-seismic crustal deformations associated with the 2016 Kumamoto earthquake sequence using ALOS-2/PALSAR-2 data

*Yuji Himematsu[1], Masato Furuya[1] (1.Graduate School of Science, Hokkaido University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SSS16-09] GNSS time series analysis of postseismic deformation induced by 2016 Kumamoto earthquake (M7.3)

*Satoshi Fuwa[1], Mako Ohzono[1] (1.Hokkaido University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SSS16-10] **The viscoelastic crustal response to the magma discharge/recharge in the upper crust: implications for the uplift of the Aira caldera before and after the 1914 eruption of the Sakurajima volcano**

*Tadashi Yamasaki[1], Freysteinn Sigmundsson[2], Masato Iguchi[3] (1.Geological Survey of Japan, AIST, 2.Nordic Volcanological Center, University of Iceland, 3.DPRI, Kyoto University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SSS16-11] Factors controlling annual changes in groundwater migration in the fault fracture zone of Manpukuji fault

*Atsushi Mukai[1], Shigeaki Otsuka[2], Yoichi Fukuda[3] (1.Faculty of Urban Management, Fukuyama City University, 2.Kobe Gakuin University, 3.Graduate School of Science, Kyoto Univ.)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

Discussion

Surface Deformation before and after the 2016 Kumamoto Earthquake Detected by SAR

*Manabu Hashimoto[1]

1. Disaster Prevention Research Institute, Kyoto University

We analyzed SAR images acquired by ALOS-1/2 and Sentinel-1 before after the Kumamoto earthquake in 2016 and detected preseismic and postseismic surface deformation.

We applied time series analysis to ALOS-1 images during 2007 - 2011 with StaMPS. However, we could not detect significant deformation around the Futagawa-Hinagu faults and in the Kumamoto plain.

For the purpose of study of postseismic deformation, we collected ALOS-2 and Sentinel-1 images that were acquired from both descending and ascending orbits till the end of 2018, and analyzed them with Gamma(R) software. We detect at least 6 spots of increase of Line of sight (LOS) in and around the active fault traces in ALOS-2 descending interferograms. Three of them are located close to surface traces of the Futagawa-Hinagu faults or their extension. The maximum LOS change exceeds 10 cm till August 2018. This deformation is much larger than postseismic ddisplacements observed with GNSS after other inland earthquakes in Japan. Converting LOS changes into quasi-EW and vertical components, we found that westward movement is dominant on the SE side of the Futagawa-Hinagu faults.

We also notice a zone of LOS increase of 6 cm or more that extends NW-ward in the Kumamoto city from the junction of Futagawa and Hinagu faults. We observed coseismic subsidence in the same area in coseismic interferograms and there are several reports of small surface ruptures. Considering the location and timing, this off-fault LOS increase may be related to stress release by this event. The fifth one is in northern part of the Aso caldera, which also exceeds 6 cm. The last is found in the Kikuchi city, more than 10 km north of the Futagawa fault. This zone is extended in the direction of WNW-ESE along a channel.

Sentinel-1 interferograms also show similar distribution of displacements in spite of low coherence.

Changes in LOS increase across the surface fault traces are so sharp and nonsymmetrical. It may be difficult to explain all these deformations with not only afterslip on a couple of faults. This area is covered with thick pyroclastic flow and marine or non-marine deposits. Because there may be a weak correlation between the distribution of these deposits and postseismic deformation, subsurface heterogeneous structure may affect spatial distribution of postseismic deformation.

Keywords: ALOS-1/2, Kumamoto Earthquake, postseismic deformation, SAR, Sentinel-1, Surface deformation

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Co- and post-seismic crustal deformations associated with the 2016 Kumamoto earthquake sequence using ALOS-2/PALSAR-2 data

*Yuji Himematsu[1], Masato Furuya[1]

1. Graduate School of Science, Hokkaido University

The 2016 Kumamoto earthquake sequence started to occur at 21:26 on 14 April 2016 (JST: Japan Standard Time) with Mw 6.2 earthquake at the southwestern part of the Beppu-Shimabara graben, one of the tectonic lines across the central Kyushu island. It was followed by moment magnitude (Mw) 7.0 mainshock on 16 April at 01:25. Japan Meteorological Agency catalog reported that the mainshock focal mechanism was dominated by strike-slip components with north-south extensional axis. Geodetic measurements by Global Navigation Satellite System (GNSS) and satellite synthetic aperture radar revealed not only right-lateral displacement as the focal mechanism showed, but also greater than 1 m of subsidence at the northwest side of the Futagawa fault. In particular, PALSAR-2 pixel tracking data depicted phase discontinuities across the northeast-southwest direction. Some urgent field surveys were also conducted, and reported the locations and dislocation amounts of surface ruptures due to the earthquakes (e.g., Shirahama et al., 2016). We compare displacements along the surface rupture that were derived from the PALSAR-2 pixel tracking data and the previous field surveys. Measuring displacements along the surface ruptures in detail is important for evaluating rupture processes and propagation features along the faults during the earthquake event.

We also report the post-seismic deformations following the 2016 Kumamoto earthquake using PALSAR-2 data, and discuss the difference of spatial characteristic in the co- and post-seismic deformations. Although some papers have also reported post-seismic deformations observed by GNSS measurements and Sentinel-1 InSAR data for estimating viscoelastic structures beneath the central Kyushu island, near-fault post-seismic deformations are still poorly understood. We employed the conventional InSAR stacking for extracting long-lasting small deformations and mitigating artificial noise. We also performed the 2.5-dimensional analysis for depicting quasi-eastwest and quasi-vertical displacements using the stacked interferograms. To identify the small deformation signals, two independent quasi-displacement fields are generated. Although multiple aperture interferometry (MAI) allow us to detect along-track horizontal movements, we could not identify actual post-seismic deformation signals due to strong ionospheric artifact noises in most of MAI data.

Keywords: Synthetic Aperture Radar, 2016 Kumamoto Earthquake Sequence, Crustal Deformation, Surface Ruptures, SAR Interferometry, ALOS-2/PALSAR-2

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GNSS time series analysis of postseismic deformation induced by 2016 Kumamoto earthquake (M7.3)

*Satoshi Fuwa[1], Mako Ohzono[1]

1. Hokkaido University

In order to investigate the afterslip and the viscoelastic relaxation mechanisms induced by the 2016 Kumamoto earthquake (M7.3), which occurred on 16 April 2016 in Kyushu Island, Japan, we conducted times series analysis of GNSS data. Although there are several models for this postseismic deformation, they treat early postseismic period with only velocity or displacement data. Several time series analysis for other large earthquakes is also proposed, but there has been little consideration about whether it reflects their mechanisms. We use 48 sites around the focal area of daily coordinates (F3 solutions) provided by the Geospatial Information of Japan (GSI) for two years from the earthquake. Because most of the afterslip is thought to be finished during the first 0.25 years in postseismic period, we fitted logarithmic decay function assuming the afterslip to 90-days postseismic time series data using weighted nonlinear least squares method and estimated their time constants. Then, we re-fitted both of logarithmic decay function and exponential decay function, which assuming viscoelastic relaxation, together to whole two years postseismic time series fixing the time constant of logarithmic decay function. As a result of this time series analysis, each afterslip and viscoelastic time evolution are estimated at each GNSS site. Using the cumulative deformation field of logarithmic decay function, afterslip distribution is estimated. The afterslip is located around the coseismic fault, and major slip area is assumed complementary to the coseismic slip area. Cumulative viscoelastic deformation signal is also used for rheological parameter estimation. We set stratified rheological structure, which composed of upper elastic layer and lower Maxwell viscoelastic layer, and searched appropriate thickness of elastic layer and viscosity of the viscoelastic layer. As a result, we found the elastic thickness with 20 km and viscosity of viscoelastic layer with 1×10^{19} Pa s. These estimated values roughly correspond to the results of previous studies. There are several remaining issues, such as the dependency of fitting period of the logarithmic time decay function, and application for the complicated fault geometry and rheological structure for modeling. However, this time series analysis and estimation of each mechanism using those results are effective to the interpretation for the postseismic deformation after this earthquake.

Keywords: 2016 Kumamoto earthquake, postseismic deformation, time series analysis

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The viscoelastic crustal response to the magma discharge/recharge in the upper crust: implications for the uplift of the Aira caldera before and after the 1914 eruption of the Sakurajima volcano

*Tadashi Yamasaki[1], Freysteinn Sigmundsson[2], Masato Iguchi[3]

1. Geological Survey of Japan, AIST, 2. Nordic Volcanological Center, University of Iceland, 3. DPRI, Kyoto University

Volcano deformation has often been analysed in terms of crustal elasticity, where the temporal volume change of the deformation source is required to explain any transient behaviour of ground displacement. However, the response of viscoelastic crust, both to magma discharge and eventual subsequent recharge, is not negligible because the effective crustal viscosity is expected to be lowered by higher geothermal gradient at volcanoes. The present study, using a 3-D finite element model with a linear elastic layer underlain by a linear Maxwell viscoelastic layer with spatially uniform viscosity, examines the viscoelastic crustal response to both magma discharge and recharge into the upper crust. The model considers a sill-like magma chamber emplaced at the bottom of the elastic layer inflating at a constant rate, during which the magma discharge due to an eruption occurs instantaneously all at once. Numerical experiments have revealed that the viscoelasticity in response to magma discharge promotes surface uplift. The uplift depends on how long the pre-eruptive magma charge lasted, that is, how much viscoelastic relaxation in response to the magma charge occurred in pre-eruption period. If the relaxation was significant, the uplift due to viscoelastic relaxation is greater than that due to magma recharge earlier in post-eruption period. On the contrary, at later times, the uplift due to magma recharge exceeds the relaxation-derived one. However, since the viscoelastic response to magma recharge detracts the uplift, the post-eruptive magma volume is recovered before the surface elevation is recovered. This viscoelastic model behaviour is then adopted for the geodetic data in the Aira caldera, southern Kyushu, Japan, giving important constraints on the model parameters. A model with constant magma supply rate explains the observed exponential-like recovery of the surface elevation after the 1914 eruption if the following conditions are satisfied: (1) the effective crustal viscosity is ~5x10^18 Pa s, and (2) magma emplacement at a depth of ~10-15 km is initiated ~50 years before the eruption, with a constant supply rate of at least ~0.01-0.02 km^3/yr. The constrained model predicts that the accumulated volume of magma during the first 50 years in the post-eruption period is lower than that estimated by elastic model, but is on the contrary larger thereafter. In addition, the surface uplift immediately before the 1914 eruption is predicted to be ~3 times lower than that supposed in previous studies. Our results suggest that geodetic signals observed before and after the magma discharge due to an eruption need to be revisited with respect to the crustal viscoelasticity.

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Factors controlling annual changes in groundwater migration in the fault fracture zone of Manpukuji fault

*Atsushi Mukai[1], Shigeaki Otsuka[2], Yoichi Fukuda[3]

1. Faculty of Urban Management, Fukuyama City University, 2. Kobe Gakuin University, 3. Graduate School of Science, Kyoto Univ.

Rokko-Takao station in the southern area of Hyogo prefecture crosses Manpukuji fault, and the groundwater discharge can be observed all the time about the fault fracture zone. The groundwater discharge and pore pressure observed at the station usually contain annual changes which have the minimum value in spring and the maximum one in autumn. However, the scale of the annual changes depends on year. In 2017, we could not see any definite annual changes in the groundwater discharge and pore pressure. In this study, we investigated some factors controlling the annual changes in groundwater migration and report about the effects of regional crustal movements, precipitation and seismic motions on them.

We have been performing the continuous observation of groundwater migration nearby the fault fracture zone with the groundwater discharge meter and the pore pressure meters, as well as crustal movements with strainmeters, extensometers and water-tube tiltmeters. We calculated the tidal amplitudes and phases in the groundwater discharge and pore pressure by applying the tidal analysis program ‘BAYTAP-G’ to the observational data, and compared them with the theoretical ones obtained by ‘GOTIC2’; the program for computation of oceanic tidal loading effect. The observed phases in major constituents O1 and M2 almost agreed with the theoretical ones for every observed groundwater migrations. This shows that the groundwater discharge and pore pressure changes at the station have similar response to tidal stress.

The groundwater discharge and pore pressure changes in 2017 showed just slight annual changes, the amplitudes of which were at least 10% of the annual averages, while the amplitudes of the annual changes were a few 10% or more of the annual averages in other years from 2015. When we investigated the observational data of groundwater discharge that started to be observed before 2000, the annual changes were diminished definitely in 2005 and 2012 as well. It was considered that the variations in the amplitudes of annual changes might be caused by regional crustal movements, precipitation, seismic motions and so on.

We calculated the dilatation changes as regional crustal movements by using GSI’s GEONET data. The dilatation showed significant annual changes even in 2005, 2012 and 2017, so that the diminished annual changes were considered not to be caused by the regional crustal movements. Second, we investigated the effect of annual precipitation. The annual precipitation were unusually small just before 2005, 2012 and 2017, so that it seems that small precipitation might cause decreasing of groundwater and small annual changes in groundwater migrations. However, this idea does not agree with the observed result that the pore pressure had kept to be high level all through 2017.
Permeability in the fracture zone of Manpukuji fault was observed to be reduced over one year after 2011 Tohoku Earthquake (Mukai and Otsuka, 2014). Similar permeability changes occurred just after 2016 Kumamoto Earthquake and 2016 Central Tottori Earthquake as well (Mukai et al., 2017). The diminishment of annual changes in groundwater migrations were observed just after such large earthquakes. This might suggest that temporal decrease of permeability due to the large earthquakes

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prevented groundwater migration and propagation of pore pressure, and resulted in the small annual changes.

Keywords: fault fracture zone, groundwater migration, annual change

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[S-SS16] Crustal Deformation

convener:Mako Ohzono(Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido University), Tadafumi Ochi(Institute of Earthquake and Volcano Geology, Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Masayuki Kano(Graduate school of science, Tohoku University), Chairperson:Takao Tabei(Department of Global Environment and Disaster Prevention, Faculty of Science and Technology, Kochi University), Takeo Ito

Study of crustal deformation plays an extremely important role in the investigation of wide scale earth dynamics those are earthquake and volcanic activity, plate motion and so on. In our session, we discuss the study related to crustal deformation, such as development of observation instrument, observed crustal deformation, analysis method, and simulation study.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SSS16-12] Rapid uplift in SW Taiwan caused by fold growth

*Yoshiki Takei[1], Youichiro Takada[2] (1.Department of Natural History Sciences, Graduate School of Science, Hokkaido University, 2.Hokkaido University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SSS16-13] Construction of GNSS monitoring system in Nepal for the earthquake potential evaluation in the Himalayan Frontal Zone

*Takao Tabei[1], Mako Ohzono[2], Kazuki Koketsu[3], Hiroe Miyake[3], Rajendra Bhandari[4], Janak B. Chand[4], Bishow R. Silwal[4], Soma N. Sapkota[4] (1.Department of Global Environment and Disaster Prevention, Faculty of Science and Technology, Kochi University, 2.Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido University, 3.Earthquake Researech Institute, University of Tokyo, 4.Department of Mines and Geology, Nepal)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SSS16-14] The kinematic model along the Sumatran fault using a new dense GNSS observation (AGNeSS+) in Banda Aceh

*Takeo Ito[1], Takao Tabei[2], Fumiaki Kimata[3], Makoto OKUBO[2], Tadashi Yamashina[2], Cecep Pratama[4], Didik Sugiyanto[5], Mukusin Umar[5], Nazli Ismail[5], Irwandi Nurdin[5] (1.Nagoya Univ, 2.Kochi Univ, 3.Tono Research Institute of Earthquake Science, 4.Gadjah Mada University, 5.Syiah Kuala University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SSS16-15] Mechanical modeling of interseismic deformation in the Central Andes: implications for back-arc shortening

*Shaoyang Li[1,2], Fuqiang Shi[3], Marcos Moreno[4], Jun'ichi Fukuda[1] (1.Earthquake Research Institute, University of Tokyo, Tokyo, Japan, 2.Department of Earth and Environmental Sciences, The University of Iowa, Iowa City, IA, USA, 3.Shaanxi Earthquake Agency, Xi’an, China, 4.Departamento de Geofísica, Facultad de Ciencias Físicas y Matemáticas, Universidad de Concepción, Concepción, Chile)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SSS16-16] Inferring regional stress field based on SAR analysis and dynamic simulation of the 2018 Palu earthquake

*Takafumi Yokota[1], Ryosuke Ando[1], Yosuke Aoki[2] (1.Graduate School of Science, University of Tokyo , 2.Earthquake Research Institute, University of Tokyo)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

Discussion

Rapid uplift in SW Taiwan caused by fold growth

*Yoshiki Takei[1], Youichiro Takada[2]

1. Department of Natural History Sciences, Graduate School of Science, Hokkaido University, 2. Hokkaido University

The Taiwan orogeny is result of the continental collision between the Luzon arc on the Philippine Sea plate and the Eurasian continental margin. GNSS velocity field indicates rapid and on-going east-west compression (e.g., Yu et al., 1997; Tsai et al., 2015). Due to such background compression, very rapid uplift up to 37 mm/yr has been aseismically proceeding in the southwestern part of Taiwan, which is detected by levelling and InSAR measurements (Ching et al., 2016; Tsukahara and Takada, 2018). Tsukahara and Takada (2018) showed that such rapid uplift cannot be explained solely by fault motion, and they concluded that a fold growth would contribute to the uplift motion as suggested by Ching et al. (2016). Actually, mud diapirs are widely distributed from South China Sea to the coastal area of Southwest Taiwan, and some of those are observed as mud volcanoes on land (e.g., Lin et al., 2009; Hsu et al., 2013; Doo et al., 2015). From physical point of view, mud diapirism can be regarded as a fold growth with buoyancy under strong horizontal compression. There is no previous study, however, that quantitatively estimates the possibility of fold growth in SW Taiwan. In this study, we quantitatively examined the fold growth rate in SW Taiwan on the basis of continuum mechanics. First, we modeled the earth’ s crust as non-linear viscous fluid following power-law creep. Next, considering that the background stress is much larger than the stress perturbation caused by the fold growth, we linearized the governing equations and analytically calculated the fold growth rate following the conventional method (Smith, 1977; Fletcher and Hallett, 1983). So far, this approach has been applied to foldings periodic in space, while the folds in SW Taiwan (on land) are not periodic but rather isolated. Following Bassi and Bonnin (1988) formulation, therefore, we assumed a Gaussian shaped fold at initial stage, and calculated its growth rate under various conditions. The medium consists of a substratum (mud) and a brittle surface layer. The power exponent is set as one for the substratum (Newtonian) and a thousand for the surface layer. In addition, we considered surface erosion and sedimentation that modify the effect of gravity as pointed out by Martinod and Molnar (1995).
The result of calculation shows that the Gaussian shaped perturbation can grow up for a certain combination of model parameters consistent with observations. Also, we found that surface erosion and sedimentation prompt the fold growth. The surface uplift and subsidence rates associated with the Gaussian shaped fold growth are roughly consistent with levelling and InSAR measurements. Among all, the subsidence pattern is well explained by the folding, which could not be explained by the elastic dislocation model (Okada, 1992). On the other hand, the largest uplift rate in the numerical simulation is about 10 mm/yr smaller than the ones given by InSAR and levelling surveys, which indicates that large displacement gradient in the observed result was not well reproduced by the simulation. The actual folding in SW Taiwan might associate brittle failures as well as viscous deformation. We will combine both fault motion and fold growth to explain the mechanisms of rapid aseismic deformation in SW Taiwan in the future.

Keywords: Aseismic crustal deformation, Fold growth, Taiwan

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Construction of GNSS monitoring system in Nepal for the earthquake potential evaluation in the Himalayan Frontal Zone

*Takao Tabei[1], Mako Ohzono[2], Kazuki Koketsu[3], Hiroe Miyake[3], Rajendra Bhandari[4], Janak B. Chand[4], Bishow R. Silwal[4], Soma N. Sapkota[4]

1. Department of Global Environment and Disaster Prevention, Faculty of Science and Technology, Kochi University, 2. Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido University, 3. Earthquake Researech Institute, University of Tokyo, 4. Department of Mines and Geology, Nepal

We have deployed 10 continuous GNSS stations in central Nepal since 2016 under the SATREPS project of “Integrated Research on Great Earthquakes and Disaster Mitigation in Nepal Himalaya (NERDiM)” (2016-2021). The main purpose of the GNSS observation is to monitor ongoing crustal deformation for estimating earthquake generation potential in the Indian-Eurasian plate boundary zone. We focus especially on the crustal activity of the “Central Seismic Gap” located just west of the source region of the 2015 Gorkha earthquake (Mw 7.8), where no destructive event has been recorded since 1505. Prior to our project there were about 50 continuous GPS stations distributed over the whole of Nepal, most of which were constructed and maintained by universities and institutions in USA and France. We determined station deployment so as to reinforce such pre-existing networks. One-second and 30-second interval data collected at each station are automatically transmitted on a semi-daily basis to a data server at Kathmandu via domestic cell phone network. In addition, we have already introduced a high-performance machine that has the ability of automated GNSS data processing and archiving. Soon we will start daily baseline processing using GNSS data from the SATREPS NERDiM stations and also from the pre-existing domestic and international networks.

In paralle to the station construction, we collect all available GNSS data in Nepal and process them using PPP-AR method of GIPSY/OASIS II ver.6.4. Total number of stations is less than 10 as of 2004 and gradually increased year by year. Since the 2015 Gorkha earthquake, many stations have been added in and around the Kathmandu Valley. However, the number of stations where stable data collection is still ongoing may be less than 30. The result shows that roughly N-S contraction of about 0.1 ppm/yr is significant over the whole of the country, implying that about half of the relative Indian-Eurasian plate motion (36-37 mm/yr) is taken up in crustal shortening of the Himalayan frontal zone due to strong coupling on the plate boundary. Occurrence of the 2015 Gorkha earthquake disturbs deformation field in the source region in central Nepal but does not seem to affect further west. It means that large amount of strain has remained unreleased in “Central Seismic Gap”. We need to cope with high potential of earthquake generation in this region in the near future. New SATREPS NERDiM GNSS stations will contribute to enhance spatio-temporal resolution of the deformation field in the region concerned.

Keywords: Nepal, Earthquake, GNSS

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The kinematic model along the Sumatran fault using a new dense GNSS observation (AGNeSS+) in Banda Aceh

*Takeo Ito[1], Takao Tabei[2], Fumiaki Kimata[3], Makoto OKUBO[2], Tadashi Yamashina[2], Cecep Pratama[4], Didik Sugiyanto[5], Mukusin Umar[5], Nazli Ismail[5], Irwandi Nurdin[5]

1. Nagoya Univ, 2. Kochi Univ, 3. Tono Research Institute of Earthquake Science, 4. Gadjah Mada University, 5. Syiah Kuala University

The 2004 Sumatra-Andaman earthquake (Mw 9.2) has occurred along the Sunda trench. In Banda Aceh district, evaluation of the earthquake generation potential along the Sumatran fault is highly urgent because of a large fault slip rate, the lack of major earthquakes for more than 100 years and recent Coulomb stress increase on the fault due to the 2004 event. After the 2004 event, we have deployed the Aceh GNSS Network for the Sumatran fault System (AGNeSS), which consists of 24 GNSS sites. AGNeSS have releveled the along-strike variations of elastic coupling and creeping along the Sumatran fault system (Ito et al.,2012). Recently, seismic activity is increasing around the Seulimeum fault. So, we try to evaluate the earthquake potential around the Seulimeum fault.

However, AGNeSS have already passed a decade since developed, and the site condition of GNSS sites is disintegrating. So, we extend AGNeSS, which consists of new dense 25 GNSS site (we call the AGNeSS+). We developed the new GNSS site in 2016. The AGNeSS+ aims to evaluate the seismic potential along the Seulimeum fault, where is close to urban of Banda Aceh province. The new dense GNSS site has two profiles crossing the Seulimeum fault. The length and the average interval of the profile are about 30km and about 3km, respectively. Also, an interval of GNSS site near the Seulimeum fault is shorter.

In this study, we show the first result of AGNeSS+, and a block motion model around the Banda Aceh area base on AGNeSS+. We developed the block motion model based on geological information. The Banda Aceh city locates between two fault segments, which is Aceh and Seulimeum segments. The block motion model considers these block boundary. In this presentation, we show the first results of slip deficit along Seulimeum segments and kinematic block motion.

Keywords: GNSS, Banda Aceh, Block motion model

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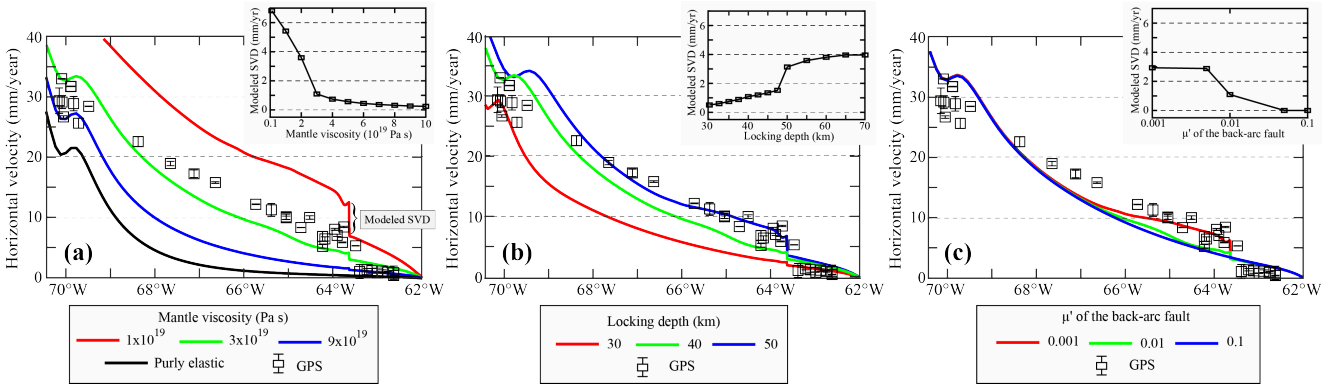
Mechanical modeling of interseismic deformation in the Central Andes: implications for back-arc shortening

*Shaoyang Li[1,2], Fuqiang Shi[3], Marcos Moreno[4], Jun'ichi Fukuda[1]

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Coupling in the plate interface is considered the primary mechanical process transferring tectonic forces into interseismic deformation at subduction zones. Given that interseismic deformation affects the whole volume of the margin, the spreading of the deformation field across the continental plate not only depends on the pure-plate coupling deformation but is also affected by the rheological properties and active continental faulting. Here, we use numerical mechanical models, including viscoelastic mantle wedge and frictional back-arc fault, to investigate the interseismic GPS-derived velocity field in both horizontal and vertical directions in the Central Andes. In this region, GPS observations show a slow decrease of velocities over a significantly far-reaching area from the trench, with a sharp localized shortening gradient across a major back-arc fault at the trench distance > 800 km. These signals cannot be explained only by modeling plate locking and back-arc shortening. We first implement a grid-searching method to test the contribution and interaction of subduction locking and viscous mantle flow in the velocity field. Our simulation results show that these two processes produce similar horizontal deformation patterns, while the vertical deformation is particularly sensitive to the locking depth. We further perform mechanical viscoelastic models with a frictional back-arc fault and examine the effects of subduction locking, viscous mantle flow, and frictional strength of the back-arc fault on the activation of the back-arc fault (attached Figure). We find that the back-arc fault should be remarkably weak and is active only under considerable viscous mantle flow to reproduce the observed sharp localized shortening across the back-arc fault. Our results, therefore, suggest that the preexisting weakness of the crust plays an important role on the distribution of interseismic deformation and shortening the continental crust, highlighting a generic feedback between long-term mantle structure and present-day deformation.

Keywords: Interseismic deformation, GPS velocities, Back-arc shortening, Viscoelastic mantle relaxation, Central Andes



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Inferring regional stress field based on SAR analysis and dynamic simulation of the 2018 Palu earthquake

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1. Graduate School of Science, University of Tokyo , 2. Earthquake Research Institute, University of Tokyo

The 2018 Palu, Indonesia, earthquake occurred along the Palu-Koro fault in the Sulawesi Island on 28th September. The Palu-Koro fault defines the boundary of the microplates, North Sula block and Makassar block. The information of the stress field around the Palu-Koro fault is necessary to understand the complicated tectonic system consisting of several micro-plates nearby Sulawesi Island as well as the basic mechanism underlying this earthquake event. Little, however, has been reported on the stress field probably due to relatively small seismic activity of this area. This study aims to estimate the stress field around the Palu-Koro fault based on the observed surface displacement and the fault slip pattern of 2018 Palu earthquake.

First, we compared SAR images taken before and after the earthquake by the pixel offset method to obtain the data of the surface displacement. The overall left-lateral displacement was observed with local variations in the geometry of the surface offsets. Then, we constructed the model of the Palu-Koro fault based on the surface displacement data and the previously-obtained geomorphological data. Finally, we simulate the surface displacement caused by dynamic rupture of the model of the Palu-Koro fault under given stressing conditions, and compare the result with the observation to infer the causative regional stress field.

The simulation is FDP-BIEM(fast domain partitioning - boundary integral equation method) [1]. The numerical cost of the original BIEM is in proportion to the cube of the total time steps. In contrast, that of FDP-BIEMis in proportion to the square of the total time steps. The simulation was performed on the physical assumption that one of the axes of principal stress is vertical, that the vertical principal stress equals to lithostatic pressure, and that the initial principal stress ratios are constant spatially. There are 3 free parameters. One is the azimuth of the axis of the maximum horizontal principal stress, and the others are the principal stress ratios.

This study constrains the azimuth of the axis of the maximum horizontal principal stress is within a certain range of about 25 degrees by considering the condition necessarily to explain the overall fault ruptures exhibiting left-laterally. If the azimuths of the horizontal principal stress axes are determined by independent observation such as the stress tensor inversions using focal mechanism solutions, this technique can also estimate principal stress ratios. More detailed modeling of the dynamic rupture process may also constrain the stress state around this fault zone.

[1]R. Ando, “On Applications of Fast Domain Partitioning Method to Earthquake Simulations with Spatiotemporal Boundary Integral Equation Method,” Mathematical Analysis of Continuum Mechanics and Industrial Applications II, Springer Nature Singapore Pte Ltd., 2018

Keywords: the 2018 Palu earthquake, dynamic rupture simulation, stress field

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[J] Oral | S (Solid Earth Sciences)：S-EM Earth's Electromagnetism

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[S-EM18] Geomagnetism, paleomagnetism and rock magnetism

convener:Hisayoshi Shimizu(Earthquake Research Institute, University of Tokyo), Masahiko Sato(Department of Earth and Planetary Science, The University of Tokyo), Chairperson:Masahiko Sato(Department of Earth and Planetary Science, University of Tokyo), Akira Baba(山梨県富士山科学研究所)

We are going to discuss the issues on the magnetic fields of the Earth and planets, paleomagnetism, rock-magnetism, and their applications. This session includes following topics: (1) observation and analysis of the magnetic fields of the Earth and planets, (2) paleomagnetic field variations obtained from natural and archaeological materials, (3) numerical simulations on the magnetic fields of the Earth and planets, (4) measurements and theories of magnetic properties of rocks, minerals, meteorites, and other materials, (5) climate changes and surface tectonics based on the paleomagnetic measurements of rocks and sediments, (6) observations of the magnetic anomalies and the crustal magnetization models of the Earth, planets, and satellites, and (7) developments of the measurement method and data analysis. The presentation and discussion will be made in Japanese or English in this session.
This session contributes toward development of the SEDI-Japan community.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SEM18-01] On the formation process of the Mt.Hoei, Fuji volcano. A scenario based on the emplacement temperature inferred from paleomagnetic method.

*Akira Baba[1], Hidetoshi Shibuya[2], Toshitsugu Fujii[1], Tatsuro Chiba[3] (1.Mount Fuji Research Institute, 2.Department of Earth and Environmental Sciences, Faculty of Advanced Science and Technology, Kumamoto University, 3.Asia Air Survey Co., Ltd.)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SEM18-02] Reconstruction of paleointensity during 5 to 9 th century from Mt. Fuji lavas

Hiromichi Komatsu[2], *Tadahiro Hatakeyama[1,4], Akira Baba[3] (1.Information Processing Center, Okayama University of Science, 2.Faculty of Biosphere-Geosphere Science, Okayama University of Science, 3.Mount Fuji Research Institute, Yamanashi Prefecture, 4.Graduate School of Biosphere-Geosphere Science, Okayama University of Science)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SEM18-03] Reconstruction of full-vector archaeomagnetic reference curve in East Asia from 200 CE to 1100 CE

*Yu Kitahara[1], Daiki Nishiyama[2], Masao Ohno[1], Yuhji Yamamoto[3], Tadahiro Hatakeyama[4] (1.Faculty of Social and Cultural Studies, Kyushu University, 2.Faculty of Science, Kochi University, 3.Center for Advanced Marine Core Research, Kochi University, 4.Information Processing Center, Okayama University of Science)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SEM18-04] A high resolution paleomagnetic record across and around the Matuyama-Brunhes polarity transition from the Chiba composite section

*Makoto Okada[1], Yuki Haneda[2], Yusuke Suganuma[3,4] (1.Department of Earth Sciences, Faculty of Science, Ibaraki University, 2.Graduate School of Scinece and Engineering, Ibaraki Univeristy, 3.National Institute of Polar Research, 4.Graduate University for Advanced Studies)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SEM18-05] Brunhes-Matuyama contact aureole surrounding the Kurobegawa Granite

*Koji Fukuma[1], Hisatoshi Ito[2], Mami Takehara[3], Ryuji Yamada[4], Takashi Kubo[5] (1.Department of Environmental System Science, Faculty of Science and Engineering, Doshisha University, 2.Central

Research Institute of Electric Power Industry, 3.National Institute of Polar Research, 4.National Research Institute for Earth Science and Disaster Prevention, 5.MAIBUNKAN)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SEM18-06] Paleomagnetic study of the IODP Site U1335 sediments in the eastern equatorial Pacific - relative paleointensity and inclination anomaly over the last 8 Myr

*Yuhji Yamamoto[1], Toshitsugu Yamazaki[2] (1.Center for Advanced Marine Core Research, Kochi University, 2.Atmosphere and Ocean Research Institute, University of Tokyo)

On the formation process of the Mt.Hoei, Fuji volcano. A scenario based on the emplacement temperature inferred from paleomagnetic method.

*Akira Baba[1], Hidetoshi Shibuya[2], Toshitsugu Fujii[1], Tatsuro Chiba[3]

1. Mount Fuji Research Institute, 2. Department of Earth and Environmental Sciences, Faculty of Advanced Science and Technology, Kumamoto University, 3. Asia Air Survey Co., Ltd.

Mt. Hoei (Hoei-san) is located at the southeastern flank of Fuji volcano, and composed mostly of angular rock-fragments which are quite different in petrographic features from the coeval basaltic ejecta of 1707 A.D (Tsuya,1955). It's edifice was formed by a single eruption, the Hoei eruption, according to historical literatures documenting the eruption (e.g. Miyaji and Koyama, 2007). Miyaji et al.,(2011) classified 17 units of the Hoei eruption into 3 stage on the basis of the patterns of the eruptive pulses, and proposed that Mt. Hoei was formed by lateral intrusion of degassed basaltic magma in stage 2. However, detailed geological study of the Mt. Hoei has not been made after Tsuya(1955). Here we report paleomagnetic results of volcanic ejecta of the Mt. Hoei.

Samples for paleomagnetic measurements were collected from 3 sites, the spatter cone in the 1st crater, the ridge of Mt. Hoei and the erosion valley of Gotenniwa. They were oriented by a sun compass to eliminate the influence of local magnetic anomalies. At each site, we collected 20 to 24 samples using an engine powered core picker. Samples were measured using a spinner magnetometer, and were subjected to progressive alternating field (AFD) and thermal demagnetization (ThD).

The mean magnetic directions of each sites show remarkably unanimous. They agree with the eruption age of 1707 A.D., based on similarity to the paleomagnetic secular variation model (JRFM2K.1). The results of ThD indicate that the magnetic minerals are titanomagnetite as the highest blocking temperature is 500-580 degrees C. In the erosion valley of Gotenniwa, the NRM of the accessory materials have high and low temperature components bounded at 340 degrees C or more. It is clear that the low temperature component coincides with the directions of the essential materials of Hoei eruption, so that it was heated by the eruption and cooled after the emplacement. Furthermore, some of the accessory materials in the ridge of Mt. Hoei show magnetic directions different from those of the spatters, so that it was not or weak heated. Mt. Hoei is composed not only abundant various accessory materials but also spatters and pyroclastic deposits of the Hoei basalt which can be corelated to the Ho-III tephra (Miyaji et al.,2011) by petrography. Our findings suggest that paleomagnetic method can clarify the simultaneity of volcanic ejecta, and the Mt. Hoei was rapidly formed by ultraproximal fall or surge deposits of the Hoei eruption in 1707 A.D.

Keywords: Fuji volcano, Mt.Hoei, paleomagnetic method

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Reconstruction of paleointensity during 5 to 9 th century from Mt. Fuji lavas

Hiromichi Komatsu[2], *Tadahiro Hatakeyama[1,4], Akira Baba[3]

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The origin of the Earth's magnetic field is due to the electromagnetic fluid motion in the Earth' core by self-exciting dynamo. Therefore, the geomagnetic field varies each place, and it is changing over time. Observation of the changing geomagnetic field in each place is indispensable for the development of the global geomagnetic field model.

In Japan, measurements of paleointensity since the dawn of history are made using archeological materials that is well known age. On the other hand, in this study, we measured the paleointensity of the samples taken from 16 sites of basaltic lava flows showing the secular variation of geomagnetic field direction in the 5th - 9th century erupted from Mt. Fuji where geologic stratigraphy was described in more detail in recent years. The obtained paleointensity was compared with the archaeo- and paleointensity measured by the old methods and with the recent archeointensity work derived from the floor surface of the old kiln.

In this study, we used the latest, Tsunakawa-Shaw method (Tsunakawa and Shaw, 1994). We obtained successful results from 39 specimens out of 62 specimens taken from 16 sites, and we could calculate the mean and variance from 9 sites where more than 3 acceptable samples were obtained. From these results, it was concluded that the basaltic lavas from Mt. Fuji is suitable to restore the paleointensity.

Many of the old works done in the last century using old methods(Thellier and Thellier, 1959) indicated high paleointensity around 60 μT in this time window, while, paleointensity by modern methods, IZZI Thellier method (Tauxe and Studigel, 2004) and Tsunakawa-Shaw method, indicated lower values of intensities (Kitahara, 2018). The palaeointensities obtained in this study are consistent with the latter with similar trends of the field fluctuation. In addition, the results of this study inter- and extrapolated the paleointensity of the age of the recent work and the geomagnetic field variation in Japan becomes clear.

Keywords: Paleointensity, Mt. Fuji

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Reconstruction of full-vector archaeomagnetic reference curve in East Asia from 200 CE to 1100 CE

*Yu Kitahara[1], Daiki Nishiyama[2], Masao Ohno[1], Yuhji Yamamoto[3], Tadahiro Hatakeyama[4]

1. Faculty of Social and Cultural Studies, Kyushu University, 2. Faculty of Science, Kochi University, 3. Center for Advanced Marine Core Research, Kochi University, 4. Information Processing Center, Okayama University of Science

Paleomagnetic information reconstructed from archaeological materials is used to estimate the archaeological age of excavated relics, in addition to revealing the geomagnetic secular variation and core dynamics. The direction and intensity of the Earth’ s magnetic field (archaeodirection and archaeointensity) have been estimated using different methods, many of which have been proposed over the past decades. Among them a new experimental technique for archaeointensity estimate is the Tsunakawa-Shaw method.

This study carried out the reconstruction of the archaeointensity using the Tsunakawa-Shaw method for a large number of samples of baked clay belonging to different ages from archaeological relics in Osaka Prefecture mainly, and constructs a dataset and the reference curve of archaeointensity in Japan (East Asia).

As the result, we estimated archaeointensities from 98 specimens belonging to 39 relics. We screened these data, compiled them for each pottery sequence, and finally obtained 10 mean intensity values of the pottery sequence level. All of the mean intensity values satisfy the selection criteria, which indicates that they have sufficient reliability. It is notable that these newly estimated archaeointensity values are lower than those in previous studies in Japan. On the other hand, new archaeointensity values show a harmonic trend in the archaeointensity data set obtained by the IZZI-Thellier method reported recently in Korea. We combined the dataset of Japan newly obtained in this study and the dataset in Korea, and drew an interpolation curve to construct an archaeointensity reference curve covering from around 200 CE to around 1100 CE in East Asia. This reference curve includes events of decrease and increase of archaeointensity occurred at around 600 CE and around 950 CE. The trends of rapid decrease and increase in intensity are a characteristic pattern of the intensity variation found for the first time in this study.

Keywords: Archaeointensity, Reference curve, East Asia, Tsunakawa-Shaw method, Old kiln

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A high resolution paleomagnetic record across and around the Matuyama-Brunhes polarity transition from the Chiba composite section

*Makoto Okada[1], Yuki Haneda[2], Yusuke Suganuma[3,4]

1. Department of Earth Sciences, Faculty of Science, Ibaraki University, 2. Graduate School of Scinece and Engineering, Ibaraki Univeristy, 3. National Institute of Polar Research, 4. Graduate University for Advanced Studies

We report a high-resolution paleomagnetic direction and relative paleointensity records from a continuous marine succession, consisting of 80 meters in thickness, exposed on the Chiba composite section of the Kokumoto Formation, Kazusa Group, Japan. The Chiba composite section is a candidate for the Lower-Middle Pleistocene boundary GSSP. Our records provide detailed behaviors of the virtual geomagnetic poles (VGPs) and relative paleointensity changes during and after the Matuyama-Brunhes (M-B) polarity transition. The resultant relative paleointensity and VGP records show a significant paleointensity minimum near the M-B boundary, which is accompanied by a clear “polarity switch” like change in terms of the paleomagnetic direction. The relative paleointensity seems to keep in a low level for more than 10 thousand years associated with an unstable normal polarity. A high-resolution oxygen isotope chronology for the Chiba composite section indicates that the M-B boundary is located in the middle of Marine Isotope Stage (MIS) 19 and yields an age of 772.9 ka for the boundary. This age is consistent with those based on the latest astronomically tuned marine and ice core records and with the recalculated age of 771.7 ±7.3 ka deduced from the U-Pb zircon age of the Byk-E tephra. Moreover, our relative paleointensity record exhibits a consistent variation with other paleointensity records including Be10 derived intensity proxy from deep sea and ice cores. Our paleomagnetic data especially for the relative paleointensity represent one of the most detailed records on this geomagnetic field reversal so far obtained from marine sediments and will therefore be key for understanding the dynamics of the geomagnetic dynamo and for calibrating the geological time scale.

Keywords: Chiba Composite Section, Matuyama-Brunhes boundary

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Brunhes-Matuyama contact aureole surrounding the Kurobegawa Granite

*Koji Fukuma[1], Hisatoshi Ito[2], Mami Takehara[3], Ryuji Yamada[4], Takashi Kubo[5]

1. Department of Environmental System Science, Faculty of Science and Engineering, Doshisha University, 2. Central Research Institute of Electric Power Industry, 3. National Institute of Polar Research, 4. National Research Institute for Earth Science and Disaster Prevention, 5. MAIBUNKAN

Contact test is most powerful paleomagnetic field test to give tight constraints on the timing of magnetization acquisition for both country and intrusive rocks. Especially when the country rock is normally magnetized and later thermally metamorphosed during a reversed polarity chron and vice versa, totally or partially remagnetized zones in the country rock can be unequivocally identified as a function of distance from the contact. Here we show an example of contact test for a youngest pair of country and intrusive rocks emplaced during the Matuyama and Brunhes chron respectively. The Quaternary Kurobegawa Granite, which is the youngest granite with U-Pb ages of about 0.8 Ma, forms a volcanic-plutonic complex with the Jiigatake Volcanic Rocks dated about 1.6 Ma by several geochronological methods. Paleomagnetic analyses including contact test for the volcanic-plutonic complex contribute to elucidate the emplacement and deformation processes related to the building of the Hide Mountains. We collected oriented blocks at 14 sites of the Kurobegawa Granite and 6 sites of the Jiigatake Volcanic Rocks. As we expected multidomain grains carry significant portions of natural remanent magnetization, we applied low temperature demagnetization with liquid nitrogen and then performed thermal demagnetization at every 25 degC step from room temperature up to 600 degC with the automated magnetometer-demagnetizer system Tspin. Low temperature demagnetization effectively erased 10-75% of initial magnetization and the middle to high temperature characteristic remanent magnetizations were retrieved at most sites except for some samples struck by lightning. Characteristic remanence directions from a single site are well clustered and the site-mean directions are of normal polarity without exception for the Kurobegawa Granite. The primary magnetizations postdated the age ~0.8 Ma of U-Pb geochronology of a closure temperature 900 degC and are presumed to be acquired during the Brunhes chron (< 0.77 Ma). In the contact aureole of the Jiigatake Volcanic Rocks metamorphosed by the Kurobegawa Granite, we found one totally remagnetized normal-polarity site and two partially remagnetized sites having hybrid normal and reversed magnetizations. This positive contact test suggests that the characteristic magnetization of the Kurobegawa Granite is not of recent viscous origin although the direction is not distinguishable from that of the present geomagnetic field. Neither large-scale tilting nor deformation was found out from the site-mean directions of the Kurobegawa Granite.

Keywords: contact test, granite, low temperature demagnetization, tectonics

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Paleomagnetic study of the IODP Site U1335 sediments in the eastern equatorial Pacific - relative paleointensity and inclination anomaly over the last 8 Myr

*Yuhji Yamamoto[1], Toshitsugu Yamazaki[2]

1. Center for Advanced Marine Core Research, Kochi University, 2. Atmosphere and Ocean Research Institute, University of Tokyo

Obtaining continuous records of relative paleointensity (RPI) and inclination anomaly (ΔI) is inevitable to understand the fundamentals of the geodynamo, but available records older than ~3 Ma are still very limited in time and space. We performed a paleomagnetic study of the Integrated Ocean Drilling Program (IODP) Site U1335 sediments in the eastern equatorial Pacific to obtain continuous RPI and ΔI records since ~8 Ma. Slow deposition, ~8.4 m/Myr or less, limits the resolution of the records but did allow for determination of long-term variations. Rock-magnetic measurements showed that biogenic magnetite dominates the magnetic mineral assemblages, and the proportion of biogenic to terrigenous magnetic minerals increases prior to ~4 Ma. The average paleointensity between ~4 and 8 Ma is approximately 30% lower than that from 0 to ~4 Ma. The apparent reduction of RPI at ~4 Ma reaches approximately ~50%, but ~20% of this is estimated to be artificial, induced by the increase in the proportion of biogenic magnetite. No relation between paleointensity and polarity length is recognized for the last ~8 Myr. The magnitude of ΔI is slightly larger during reversed polarity chrons (4.43° ±1.47°) than normal polarity chrons (0.69° ± 2.98°) over the last ~5 Myr, which agrees with the available TAF models of this time span. Prior to ~6 Ma, the sign of ΔI during the normal chrons might have switched to positive, and ΔI during reversed chrons might have been slightly larger than that after ~5 Ma.

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[J] Oral | S (Solid Earth Sciences)：S-EM Earth's Electromagnetism

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[S-EM18] Geomagnetism, paleomagnetism and rock magnetism

convener:Hisayoshi Shimizu(Earthquake Research Institute, University of Tokyo), Masahiko Sato(Department of Earth and Planetary Science, The University of Tokyo), Chairperson:Yu Kitahara(Graduate School of Social and Cultual Studies, Kyushu University), Hisayoshi Shimizu(The University of Tokyo)

We are going to discuss the issues on the magnetic fields of the Earth and planets, paleomagnetism, rock-magnetism, and their applications. This session includes following topics: (1) observation and analysis of the magnetic fields of the Earth and planets, (2) paleomagnetic field variations obtained from natural and archaeological materials, (3) numerical simulations on the magnetic fields of the Earth and planets, (4) measurements and theories of magnetic properties of rocks, minerals, meteorites, and other materials, (5) climate changes and surface tectonics based on the paleomagnetic measurements of rocks and sediments, (6) observations of the magnetic anomalies and the crustal magnetization models of the Earth, planets, and satellites, and (7) developments of the measurement method and data analysis. The presentation and discussion will be made in Japanese or English in this session.
This session contributes toward development of the SEDI-Japan community.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SEM18-07] Sensor Response Estimate and Calibration of Superconducting Rock Magnetometers

*Hirokuni Oda[1], Chuang Xuan[2] (1.Institute of Geology and Geoinformation, Geological Survey of Japan, AIST, 2.University of Southampton)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SEM18-08] Magnetic separation of ordinary solid particles using a pokcet size magnetic circuit

*Chiaki Uyeda[1] (1.Institute of earth and Space Science Graduate School of Science Osaka University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SEM18-09] Experimental evaluation of remanence carriers in coercivity-blocking temperature diagram

*Masahiko Sato[1], Takuma Terada[2], Nobutatsu Mochizuki[3], Ayako Ito[2], Hideo Tsunakawa[2] (1.The University of Tokyo, 2.Tokyo Institute of Technology, 3.Kumamoto University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SEM18-10] **Mineralogical study on magnetite exsolution and host plagioclase crystal**

*Yujiro Tamura[1], Ryoichi Nakada[2], Masahiko Sato[3], Shinji Yamamoto[4] (1.Graduate schoole of Environment and Information Sciences, Departmennt of Natural Environment, Yokohama National University, 2.Kochi Institute of Core Sample Reserch, Japan Agency for Marine-Earth Science and Technology, 3.Department of Earth and Planetary Science, The University of Tokyo, 4.Graduate schoole of Environment and Information Sciences, Yokohama National University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SEM18-11] Numerous nano-sized magnetite and hematite inclusions in muscovite in loess

*Masayuki Hyodo[1], Takuro Sano[2], Megumi Matsumoto[3], Yusuke Seto[2], Kota Suzuki[2], Tianshui Yang[4] (1.Research Center for Inland Seas, Kobe University, 2.Graduate School of Science, Kobe University, 3.Graduate School of Science, Tohoku University, 4.China University of Geosciences)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SEM18-12] Density separation and magnetic measurements of magnetotactic bacteria *Magnetospirillum magnetotacticum* MS-1

*Kohei Masaoka[1], Yuki Morono[2], Naotaka Tomioka[2], Go-Ichiro Uramoto[1], Yuhji Yamamoto[1] (1.Kochi University, 2.Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology)

Sensor Response Estimate and Calibration of Superconducting Rock Magnetometers

*Hirokuni Oda[1], Chuang Xuan[2]

1. Institute of Geology and Geoinformation, Geological Survey of Japan, AIST, 2. University of Southampton

Pass-through superconducting rock magnetometers (SRM) offer rapid and high-precision remanence measurements for continuous sediment samples that are essential for modern researches on paleomagnetism and environmental magnetism. However, continuous SRM measurements are smoothed and distorted due to the convolution effect of SRM sensor response. Thus, deconvolution is necessary to restore accurate magnetization from pass-through SRM data, and robust deconvolution requires reliable estimate of SRM sensor response. In the presentation, we present a new software tool ‘uresponse’ developed for the purpose of evaluation and optimization of SRM sensor response. The example sensor responses were acquired for two SRMs at University of Southampton; i.e. liquid He-operated (old) and liquid He-free (new) ones. Precise point source held in the center of 5×5×5mm plastic cube was used for the measurement with a magnetization pointing to one of the faces together with a gridded measurement block. With the software, each tensor components of sensor response for magnetization in X-, Y-, Z-axes to a pick-up coil in X-, Y-, and Z-axes acquired for the measurement grids are smoothed, interpolated and integrated over the cross-sectional area of a measured u-channel sample. In addition, absolute magnetization of the point source was estimated by cross calibration with a palladium standard using MPMS at National Institute of Advanced Industrial Science and Technology. By comparing repeated measurements of a u-channel sample containing geomagnetic reversal on the two SRMs before and after deconvolution, we demonstrate the significant differences in measurements caused by different sensor responses of the two types of magnetometers, and show how deconvolution with well-constrained response functions can help to largely overcome the convolution effects and distortion for measurements on both SRMs.

Keywords: SQUID Rock magnetometer, Deconvolution, sensor response curves

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Magnetic separation of ordinary solid particles using a pokcet size magnetic circuit

*Chiaki Uyeda[1]

1. Institute of earth and Space Science Graduate School of Science Osaka University

An ensemble of heterogeneous solid particles, composed namely of bismuth, enstatite (Myanmar), olivine (San Carlos), gold and graphite, are separated into fractions of different materials by small magnetic circuit composed of two NdFeB plates (4.0×4.0×1.0cm).[1] The abovementioned separation & identification followed a recently-reported principle [2][3] that acceleration of a particle, induced by magnetic volume force in an area of field gradient, is uniquely determined by intrinsic susceptibility of material, and its acceleration was independent to mass of particle. The small magnetic circuit produced a field distribution that monotonically decreased along a x-axis that was located between the two plates (0.4 cm in width [1]. The mixture of the particles was maintained at the bottom of a half-piped scape (0.2 cm in depth). An orifice (diameter: 0.07 cm) was located at the bottom of the halfpipe, which was set just above the circuit gap. An area with a height of 4cm was located below the circuit, and a cross-sectional paper was horizontally set at the bottom of this area to collect the translating particles. The horizontal separation, *x*, of the individual particles with respect to the position of the orifice were measured after they were collected on the plate. The particles were manually pushed towards the orifice position one by one using a thin copper wire and were dropped from the orifice with small initial velocity. Among the separated materials, graphite is known to have the smallest diamagnetic susceptibility of popular materials; whereas, the paramagnetic susceptibility observed in many of the rock forming minerals are smaller than that of San Carlos Olivine. Accordingly, the susceptibilities reported for the most existing materials in nature overlap with the values of the abovementioned five materials.

The efficiency of the proposed material separation is improved by increasing the variance of horizontal velocity between the two particles, because it directly increases the separation of the particles observed on collecting plate. The velocity can be enhanced by increasing the field-gradient of the magnetic circuit. A circuit having a compact size suitable for on-site researches (edge length: ~10 cm, weight: ~1.5 x10^3g) was previously designed and developed. The field gradient produced by the circuit was as large as 6250 G/cm, which could increase the field-induced velocity of particle by an order of magnitude.

It is presently considered that most solid particles, composed of diamagnetic or weak paramagnetic materials, are magnetically inert; the conventional magnetic separators were not used to extract these materials. Hence the new method proposed in the present study may extend to an effective technique of pre-treatment in analysing aggregates, because such technique is desired in various research fields of science; it may play a role of a “chromatography technique” conventionally used in the analysis of organic molecules. The portable and low-cost system may provide a breakthrough for on-site research in industrial and medical fields as well as in resource explorations in nature.

[1] Uyeda, Terada, Hisayoshi, (2019) Sci., Reps., *in print.*

[2] Hisayoshi, Uyeda & Terada (2016) Sci., Reps., 6, 38431.

[3] Yamaguchi, Hisayoshi, Uyeda & Terada (2017) J. Phys., Conf. Ser.903, 012026.

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Keywords: magnetic separation, diamagnetic material, paramagnetic material

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Experimental evaluation of remanence carriers in coercivity-blocking temperature diagram

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1. The University of Tokyo, 2. Tokyo Institute of Technology, 3. Kumamoto University

Knowledge of the remanence carrier in recording media is crucial for obtaining reliable paleomagnetic data. Here we report newly developed technique to evaluate the remanence carrier of natural rock samples using anhysteretic remanent magnetization (ARM) spectra in coercivity (H_c) and blocking temperature (T_B) plane (hereafter referred to as H_c-$T_B$diagram). Experimental procedures are as follows: (1) imparting ARM at 50 μT DC field and 140 mT AC field, (2) thermal demagnetization (THD) for the ARM at a certain temperature, (3) stepwise alternating field demagnetization (AFD) for the remaining ARM, (4) repeating steps 1–3 with THD treatment at a higher temperature, and (5) calculating second derivative of ARM on the H_c-$T_B$plane. Samples from three basaltic lavas and two welded tuffs were used for H_c-T_B diagram experiments. The basaltic lava samples consist of HW95 from Hawaiian 1995 lava flow of pahoehoe, OS86 from Izu-Oshima 1986 lava flow at the northwest flank of Mihara Volcano (Japan), and UN01 from Kiso-ontake lava flow (called Ueno basaltic rocks) in Nagano (Japan), which extruded during the Matuyama chron. The welded tuff samples were KM01 from Komagatake welded tuff and SK03 from Shikotsu welded tuff, both of which extruded 30-35 ka in Japan. In the cases of HW95, UN01, and KM01 samples, remanence carriers are composed mainly of a single phase in the H_c-$T_B$diagram. The OS86 sample showed two phases in the H_c-$T_B$diagram which can be distinguished from each other by AFD treatment but not THD treatment because of similar $T_B$spectra. In the case of SK03 sample, second derivatives of ARM showed not only positive values but also negative values in the H_c-$T_B$diagram. The negative value implies significant effects of thermal alteration due to laboratory heating. On the basis of H_c -$T_B$diagrams, we will further discuss remanence carriers in the measured samples.

Keywords: Anhysteretic remanent magnetization, Coercivity, Blocking temperature, Paleointensity

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Mineralogical study on magnetite exsolution and host plagioclase crystal

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1. Graduate schoole of Environment and Information Sciences, Departmennt of Natural Environment, Yokohama National University, 2. Kochi Institute of Core Sample Reserch, Japan Agency for Marine-Earth Science and Technology, 3. Department of Earth and Planetary Science, The University of Tokyo, 4. Graduate schoole of Environment and Information Sciences, Yokohama National University

Since natural plagioclase crystal sometimes contains fine-grained magnetite as an exsolution lamellae, single plagioclase crystals are used for recent paleointensity study (e.g. Kato et al., 2018). Especially, plagioclase in plutonic rocks can record average paleointensity due to their long cooling time scale (Tunakawa et al., 2009). However, such magnetite esxolution in plagioclase does not always observed in plutonic rocks. Moreover, magnetite exsolution in plagioclase sometime shows heterogeneous distribution in each plagioclase crystals. Because maximum solubility in plagioclase decreases during cooling, magnetite lamellae formation is restricted by chemical composition of whole rock and plagioclase. Furthermore, its formation is restricted by valence state of iron in each crystal, because divalent and trivalent iron are required for magnetite crystallization.

The sample investigated in this study was collected from the Doshi gabbro, northwest of Tanzawa tonalitic complex. Plagioclase crystals in the gabbro show that magnetite lamellae exsolve along oscillatory zoning in plagioclase. To describe fine exsolution lamellae, thin sections with double-side polished were made. Afterward we observed the sample by polarizing microscope and electron microscope and analyzed composition of plagioclase by Electron-Probe-Micro-Analyzer. We obtained high resolution X-ray fluorescence mapping of Fe and Ca followed by Fe K-edge X-ray absorption near-edge structure (XANES) analysis at the BL37XU of SPring-8.

In polarizing microscope observation, magnetite exsolutions with grain size up to a few microns show parallel orientations and most of them appear prolate spheroid morphology. In element mapping of Ca, plagioclase crystals have multiple oscillatory zonations and magnetites are exsolved at the area of lower anorthite content. Distribution of iron in plagioclase is almost uniform except for the rim. In XANES analysis, valence state of iron in plagioclase vary in from 2.47 to 2.55, and correlated with anorthite content.

Oscillatory zoning of plagioclase generally reflects their crystallization process, and anorthite rich plagioclase is usually crystallized in the early stage of crystallization. It is known that trivalent iron is easier to be distributed to plagioclase than divalent iron form melt (Lundgaard & Tegner 2004). According to the correlation between anorthite content and valence state of iron, trivalent iron is distributed to higher anorthite content area. In other words, during a process of plagioclase crystallization, divalent iron is distributed to lower anorthite content area. In another aspect, partition coefficient of iron to plagioclase depends on oxygen fugacity in magma chamber. Mineralogical features of magnetite exsolution and host plagioclase crystal suggest that there are multiple origins of the magnetite exsolutions in plagioclase even in single crystal.

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Lundgaard KL & Tegner C (2004) Partitioning of ferric and ferrous iron between plagioclase and silicate melt, Contrib Mineral Petrol, 147, 470-483

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Keywords: Magnetite exsolution, Plagioclase

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Numerous nano-sized magnetite and hematite inclusions in muscovite in loess

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1. Research Center for Inland Seas, Kobe University, 2. Graduate School of Science, Kobe University, 3. Graduate School of Science, Tohoku University, 4. China University of Geosciences

Magnetic enhancement of Chinese loess–paleosol sequences has been used extensively as a proxy for the East Asian summer monsoon. This magnetic enhancement occurs due to neoformation of pedogenic ferrimagnets. However, these ferrimagnets are difficult to extract; consequently, how they are formed is not well understood. Here, we show the shape of the crystals and the presence of nano-sized pedogenic magnetic particles using electron microscopy, a synchrotron radiation X-ray diffraction technique, and rock magnetic methods. The magnetic particles comprise pedogenic magnetites, detrital magnetites with maghemite shells, and detrital/pedogenic hematites. Among the fraction samples, the medium grain-size (1–10 μm) fraction was responsible for most of the magnetic enhancement of the paleosols. Magnetic extraction experiments revealed that muscovites and chlorites in the paleosol samples showed weak spontaneous magnetization. In the medium grain-size paleosol fraction, we found a weathered muscovite grain that included many hundreds of nanometer-sized magnetite and hematite particles in aggregates with biotites, which are Fe-bearing silicates. There were similar aggregates surrounding muscovite and chlorite fragments. The concentration of pedogenic magnetite/hematite inclusions was much higher in this muscovite grain than in the submicron-sized iron oxides found on the silicate surfaces. The nano-sized magnetite/hematite inclusions must be responsible for the weak spontaneous magnetization of the muscovites and chlorites, significantly contributing to the magnetic enhancement of the mature paleosols. These magnetite inclusions are mainly responsible for the paleosol pseudo-single-domain magnetic properties extensively observed across the Chinese Loess Plateau. The protective silicates account for the low extraction efficiency and the near absence of oxidation by surrounding air.

Keywords: loess magnetism, pedogenic magnetic particles, TEM, SEM, Synchrotron radiation x-ray diffraction, weathering

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Density separation and magnetic measurements of magnetotactic bacteria *Magnetospirillum magnetotacticum* MS-1

*Kohei Masaoka[1], Yuki Morono[2], Naotaka Tomioka[2], Go-Ichiro Uramoto[1], Yuhji Yamamoto[1]

1. Kochi University, 2. Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology

Variation of the past geomagnetic field is recorded in marine sediments as a fossil magnetization, called natural remanent magnetization (NRM). NRM is carried not only by detrital and eaolian magnetic grains but also by biogenic magnetic grains originated from magnetotactic bacteria. To investigate characters of NRM carried by biogenic magnetic grains we have cultured the microaerobic bacteria *Magnetospirillum magnetotacticum* MS-1 (here under, MS-1) in laboratory and made sample using them for remanent magnetization measurements by simulating a very early process of sediment formation.

Preliminary reports on properties and characters of the remanent magnetization carried by the samples have been presented in Masaoka et al (2018JpGU; 2018SGEPSS), but MS-1 cells used for making samples rarely contain magnetite grains in these cells (3 percent of the total cells). To try to increase number of the cells containing magnetite grains, we have tested a density separation method using different density gradient centrifugation and made samples for magnetic measurements using these cells. We will report these results including observations under transmission electron microscope.

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[J] Oral | S (Solid Earth Sciences)：S-EM Earth's Electromagnetism

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[S-EM18] Geomagnetism, paleomagnetism and rock magnetism

convener:Hisayoshi Shimizu(Earthquake Research Institute, University of Tokyo), Masahiko Sato(Department of Earth and Planetary Science, The University of Tokyo), Chairperson:Masahiko Sato(Department of Earth and Planetary Science, University of Tokyo), Hisayoshi Shimizu(The University of Tokyo)

We are going to discuss the issues on the magnetic fields of the Earth and planets, paleomagnetism, rock-magnetism, and their applications. This session includes following topics: (1) observation and analysis of the magnetic fields of the Earth and planets, (2) paleomagnetic field variations obtained from natural and archaeological materials, (3) numerical simulations on the magnetic fields of the Earth and planets, (4) measurements and theories of magnetic properties of rocks, minerals, meteorites, and other materials, (5) climate changes and surface tectonics based on the paleomagnetic measurements of rocks and sediments, (6) observations of the magnetic anomalies and the crustal magnetization models of the Earth, planets, and satellites, and (7) developments of the measurement method and data analysis. The presentation and discussion will be made in Japanese or English in this session.
This session contributes toward development of the SEDI-Japan community.

1:45 PM - 2:05 PM JST | 4:45 AM - 5:05 AM UTC

[SEM18-13] Effects of the intrinsic magnetic field on the atmospheric escape from terrestrial planets

★Invited Papers

*Kanako Seki[1], Shotaro Sakai[1], Shogo Inui[1], Ryoya Sakata[1], Naoki Terada[2], Hiroyuki Shinagawa[3], David A. Brain[4] (1.Graduate School of Science, University of Tokyo, 2.Graduate School of Science, Tohoku University, 3.NICT, 4.LASP, University of Colorado, Boulder)

2:05 PM - 2:20 PM JST | 5:05 AM - 5:20 AM UTC

[SEM18-14] Numerical modeling of a lunar dynamo and its long-term evolution

*Fumi Hyodo[1], Futoshi Takahashi[2], Satoshi Kaneshima[2], Hisayoshi Shimizu[3], Hideo Tsunakawa[4] (1.Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2.Department of Earth and Planetary Sciences, Kyushu University, 3.Earthquake Research Institute, University of Tokyo, 4.Deparment of Earth and Planetary Sciences, Tokyo Institute of Technology)

2:20 PM - 2:40 PM JST | 5:20 AM - 5:40 AM UTC

[SEM18-15] Investigation of sub-grid scale (SGS) model in dynamo simulations with small Ekman and magnetic Prandtl numbers

★Invited Papers

*Hiroaki Matsui[1] (1.Dept. of Earth and Planetary Sciences, University of California, Davis)

2:40 PM - 2:45 PM JST | 5:40 AM - 5:45 AM UTC

Discussion

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SEM18-16] Growth rates of kinematic dynamos in a finite domain

*Ataru Sakuraba[1] (1.Department of Earth and Planetary Science, University of Tokyo)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SEM18-17] Detection of jerk-like magnetic field variation in a numerical dynamo model using wavelet analysis

*Futoshi Takahashi[1], Yoshiki Manabe[2] (1.Faculty of Sciences, Kyushu University, 2.Department of Earth and Planetary Sciences, Kyushu University)

Effects of the intrinsic magnetic field on the atmospheric escape from terrestrial planets

*Kanako Seki[1], Shotaro Sakai[1], Shogo Inui[1], Ryoya Sakata[1], Naoki Terada[2], Hiroyuki Shinagawa[3], David A. Brain[4]

1. Graduate School of Science, University of Tokyo, 2. Graduate School of Science, Tohoku University, 3. NICT, 4. LASP, University of Colorado, Boulder

Mechanisms of atmosphere escape from Mars to space is one of important problems to understand drastic climate change in the ancient Mars. The geological studies suggest that the climate change occurred from 4 to 3.5 billion years (Ga) ago. It is known that the time period interestingly corresponds to the period just after the ancient Mars lost its global intrinsic field between 4 and 4.1 Ga ago. Observations by NASA's Mars Atmosphere and Volatile EvolutioN (MAVEN) have provided new insights about the atmospheric escape processes in operation at Mars. Among them, the cold ion escape is a promising candidate to enable a large number of heavy ions to escape from the ionosphere. In this study, we present an overview of the results of a statistical analysis of the ion composition measurements by MAVEN as well as global multi-species MHD simulations of solar wind-Mars interactions with a focus in effects of the intrinsic magnetic field. Based on these results, we will discuss the effects of the intrinsic magnetic field on the atmospheric escape from terrestrial planets.

Keywords: intrinsic magnetic field, Mars, Atmospheric escape, climate change, ion outflow, multi-species MHD simulation

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Numerical modeling of a lunar dynamo and its long-term evolution

*Fumi Hyodo[1], Futoshi Takahashi[2], Satoshi Kaneshima[2], Hisayoshi Shimizu[3], Hideo Tsunakawa[4]

1. Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2. Department of Earth and Planetary Sciences, Kyushu University, 3. Earthquake Research Institute, University of Tokyo, 4. Deparment of Earth and Planetary Sciences, Tokyo Institute of Technology

Now the Moon has no global magnetic field unlike the Earth, and there are only local crustal fields which are of approximately several hundred nT on the lunar surface [Tsunakawa et al., 2015]. However, lunar paleomagnetic studies indicate evidence for ancient lunar dynamo, and that the Moon had a global magnetic field of about 70 μT on the lunar surface at least between 4.2 and 3.56 Ga [e.g., Garrick-Bethell et al. 2009; Shea et al., 2012; Suavet et al., 2013]. In this study, we assume that the lunar dynamo is powered by compositional buoyancy due to inner core growth, which enabled the dynamo to work for such a long time interval. Based on the assumption, we perform a series of numerical simulations of MHD dynamo by varying the ratio of the inner core and outer core radii $\chi = r_i/r_o$ from *0.1* to 0.7 like Heimpel et al. [2005], where r_i and r_o are the inner core radius and the outer core radius, respectively. Long-term variations of the Rayleigh number *Ra* and the Ekman number *E*, which are key dimensionless parameters controlling the dynamo action, used in the dynamo simulations are calculated as functions of χ from a thermal history model of the lunar core. Then a relative core evolution curve is drawn, along which we perform a suite of dynamo runs with a given value of χ and with the values of *Ra* and *E* that are calibrated by scales of Ra_0*=4000,* 8000 and 10000, and $E_0 = O(10^{-4})$. We investigate features of lunar dynamo evolution in scenarios with different values of Ra_0. In summary, we find three types of dynamo regimes during the evolution of lunar core: self-sustaining regime, failing-dynamo regime with convection, and failing-dynamo regime without convection. From the results of the simulations, we find that dynamos cease under a low magnetic Reynolds number that causes the termination of convection because of slow inner core growth in a late phase. We also find that it is difficult to drive convection in the cases of thin shell (χ *=0.6* and 0.7) even with the highest Ra_0. This result might suggest a possible scenario in which the lunar dynamo driven by compositional convection shuts off.

Keywords: Lunar dynamo , Magnetic field of the Moon, Evolution of the Moon, Thermal history, Inner core growth, Compositional convection

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Investigation of sub-grid scale (SGS) model in dynamo simulations with small Ekman and magnetic Prandtl numbers

*Hiroaki Matsui[1]

1. Dept. of Earth and Planetary Sciences, University of California, Davis

The flow in the Earth's outer core is expected to have vast length scale from the geometry of the outer core to the thickness of the boundary layer. Because of the limitation of the spatial resolution in the numerical simulations, sub-grid scale (SGS) modeling is required to model the effects of the unresolved field on the large-scale fields. We model the effects of sub-grid scale flow and magnetic field using a dynamic scale similarity model. Four terms are introduced for the momentum flux, heat flux, Lorentz force and magnetic induction. The model was previously used in the convection-driven dynamo in a rotating plane layer and spherical shell using the Finite Element Methods.

In the present study, we perform large eddy simulations (LES) using the dynamic scale similarity model. The scale similarity model is implement in Calypso, which is a numerical dynamo model using spherical harmonics expansion. To obtain the SGS terms, the spatial filtering in the horizontal directions is done by taking the convolution of a Gaussian filter expressed in terms of a spherical harmonic expansion, following Jekeli (1981). A gaussian field is also applied in the radial direction.

In the present study, we evaluate SGS terms from direct simulation (DNS) without using SGS model. The resolved DNS is performed on the truncation degree $L = 1023$ using the Ekman number $E = 1.0 \times 10^{-6}$. To investigate optimal size of spatial filtering and limit of spatial resolution for the present SGS model, we evaluate the SGS terms with L = 255, 342, and 511, and compare with the SGS terms directly evaluated on the original fine resolution.

The results show that the amplitude of SGS inertia terms is larger than the SGS Lorentz force in the all length scale in the momentum equation, because the magnetic field has larger length scale than the velocity. The inertia term obtained by the resolved field decreases with the coarser resolution in all horizontal length scales. The amplitude of the SGS inertia term is approximately 0.28 times of the inertia term obtained by resolved fields.

Keywords: Geodynamo, Sub-grid scale model

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Growth rates of kinematic dynamos in a finite domain

*Ataru Sakuraba[1]

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Kinematic dynamos have been intensively studied since 1950s to get an insight into generation mechanisms of planetary magnetic fields. Even today when computer simulations of geophysically realistic dynamo models are possible, importance of that classical problem cannot be neglected because of its use in understanding basic dynamo processes. For example, a linear growth rate of a kinematic dynamo model can be an important measure to estimate a timescale of geomagnetic field recovery from a weak-field state in a reversal transition, and to understand energy transfers from fluid flow to magnetic fields and dissipation. Most of previous studies on growth rates of kinematic dynamos have assumed fluid flows extending infinitely in space such as three-dimensionally periodic ABC flows (see a review by A. Soward, Fast dynamos, in Lectures on Solar and Planetary Physics, Cambridge Univ. Press, 1994). Here we consider a cylindrical annulus model of kinematic dynamo. The flow is periodic along the azimuthal direction but finite in the radial and axial directions. The magnetic field satisfies a pseudo-vacuum boundary condition for the sake of computational simplicity. The induction equation is integrated in time from a random field and a linear growth rate is estimated after calculation of several magnetic diffusion times. A background flow is chosen so that the flow component can be represented as a few terms of trigonometric functions in the cylindrical coordinates and the kinetic helicity is antisymmetric about the equator. The growth rate can be summarized as a function of the magnetic Reynolds number, R, and the azimuthal wavenumber, m, of the background flow. In a parameter domain of $R < 1000$, we observed an increase of the growth rate as mR to the power of 2/3.

Keywords: planetary magnetic field, dynamo, magnetohydrodynamics

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Detection of jerk-like magnetic field variation in a numerical dynamo model using wavelet analysis

*Futoshi Takahashi[1], Yoshiki Manabe[2]

1. Faculty of Sciences, Kyushu University, 2. Department of Earth and Planetary Sciences, Kyushu University

Geomagnetic jerk is known as a sudden change in the trend of geomagnetic secular variation, which typically occurs in annual timescale. A conventional and direct way to identify jerks is by looking for V- or \Lambda-shaped changes in the slope of the secular variation of a field component at observatories. Instead, to find geomagnetic jerks, Alexandrescu et al. (1995) applied wavelet analysis to geomagnetic field data obtained at ground observatories in Europe. They detected geomagnetic jerks in 1901, 1913, 1925, 1969 and 1978, and showed that regularity of the magnetic field variation is about 1.5 rather than 2.

Although dynamo action in the Earth’ s core should generate such a singular variation, physical mechanisms responsible for jerks are still unknown. In this respect, numerical dynamo modeling could be useful, because all information within the core relating magnetic field variations can be obtained. However, magnetic field variation in dynamo models occurs more slowly compared with the geomagnetic secular variation probably due to assumed values of the fluid viscosity very far from that in the Earth’ s core. Therefore, it is not evident that any jerk-like fast magnetic field variation can be observed in numerical dynamo models. In this study, we report results of our attempt to detect jerk-like magnetic field variation in a numerical dynamo model using wavelet analysis. The Ekman number of the model is 3×10^{-5}, which is not the state-of-the-art but comparatively small, giving a good starting point.

Brief summary of the results is as follows: (1) Jerk-like magnetic field variation is detected in all of the three components; (2) Regularity of such variations is typically larger than 2; (3) Jerk-like variation occurs both globally and locally. Relevance of the present results to the geomagnetic jerk and relation to the internal dynamics are discussed based on these findings.

Keywords: Geomagnetic jerk, Dynamo, Wavelet analysis

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[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-VC36] Volcanic and igneous activities, and these long-term forecasting

convener:Teruki Oikawa(GSJ, National Institute of Advanced Industrial Science and Technology), Takeshi Hasegawa(Department of Earth Sciences, College of Science, Ibaraki University), Daisuke MIURA(Department of Physical Science, Graduate School of Science, Osaka Prefecture University), Nobuo Geshi(Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Chairperson:Daisuke Miura, Nobuo Geshi(GSJ/AIST)

This session focuses on generation and accumulation processes of magmas, magma-crust interaction and degassing, and modes of eruption, long-term forecast of eruption, dispersal and emplacement of the volcanic products. The discussion spans petrological, geochemical, geophysical, and geological processes related with volcanic activity and products in the past, the present and the future.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SVC36-01] The entire magmatic history of the Toba Caldera Complex that influenced human evolution, northern Sumatra, inferred from zircon U-Pb geochronology

*Hisatoshi Ito[1] (1.Central Research Institute of Electric Power Industry)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SVC36-02] Pre-eruptive magmatic processes of "Hakone Tokyo Pumice eruption"

*Ryo Tsujihara[1,2], Tetsu Kogiso[1], Takashi Sano[3], Hidemi Ishibashi[4] (1.Graduate School of Human and Environmental Studies, Kyoto University, 2.Asia Air Survey Co., Ltd., 3.National Museum of Nature and Science, 4.Faculty of Science, Shizuoka University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SVC36-03] Transition of magma plumbing system deduced from the melt inclusions contained in tephra minerals originated from Aso central cones.

*ryota nagaishi[1], Toshiaki Hasenaka[2], Masayuki Torii[2], ATSUSHI YASUDA[3], Natsumi Hokanishi[3] (1.Graduate of Science and Technology, Kumamoto University, 2.Center for water cycle, marin environment and disaster management , 3.Earthquake Reserach Institute, The University of Tokyo)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SVC36-04] Pre-eruptive magma dynamics of the climactic 110ka eruption of Toya caldera, Japan

*Akihiko Tomiya[1], Yoshihiko Goto[2], Tohru Danhara[3], Shanaka L de Silva[4] (1.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2.Muroran Institute of Technology, 3.Kyoto Fission-Track Co., Ltd., 4.Oregon State University, College of Earth, Ocean and Atmospheric Sciences)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SVC36-05] Voluminous silicic magma formation for the 30 ka Aira catastrophic caldera-forming eruption: contributions of crust-derived mafic and felsic magmas

*Ayumu Nishihara[1], Yoshiyuki Tatsumi[2,1], Keiko Suzuki-Kamata[2,1], Katsuya Kaneko[1,2], Jun-Ichi Kimura[3], Qing Chang[3], Hironobu Hinata[4], Takashi Miyazaki[3], Bogdan Stefanov Vaglarov[3] (1.Department of Planetology, Graduate School of Science , Kobe University, 2.Kobe Ocean-Bottom Exploration Center, 3.Department of Solid Earth Geochemistry, Japan Agency for Marine-Earth Science and Technology, 4.Kobe Municipal Tarumi Junior High School)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SVC36-06] Stratigraphy and petrological relations of pre-Aso volcanic rocks in Tateno district, Minami-Aso village

*Shota Togawa[1], Toshiaki Hasenaka[2], Masayuki Torii[2], Yasushi Mori[3] (1.Graduate school of science and technology, 2.Center for Water Cycle, Marine Environment and Disaster management, Kumamoto University, 3.Kitakyushu Museum of Natural History and Human History)

The entire magmatic history of the Toba Caldera Complex that influenced human evolution, northern Sumatra, inferred from zircon U-Pb geochronology

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The entire magmatic history of the Toba Caldera Complex (TCC), which involves the climactic Youngest Toba Tuff (YTT) super-eruption at ~74 ka, was investigated using zircons from the Oldest Toba Tuff, a post-caldera lava dome and detrital zircons from Toba lake sediments (whitish tuffaceous fine sand) deposited after the YTT activity. It was reconfirmed by U-Pb method that magmatic activity of the TCC started at ~1.3 Ma and it was newly found that the zircon-forming magmatic activity of TCC culminated at ~0.3 Ma, well before the ~0.07 Ma YTT eruption. Therefore, the climatic YTT eruption was not triggered by intensive/rapid magma supply at the time of eruption. The trigger should have been a small magmatic input or some other mechanisms (such as mechanical roof failure and roof subsidence into the magma reservoir). The TCC magma was stored incrementally over 1 million years as cold storage and finally it vented voluminous tephras at ~0.07 Ma. The remarkable accordance of zircon U-Pb age distribution between YTT and a post YTT lava dome (Tuk Tuk lava dome) indicates that post-caldera magmatic activity/resurgence occurred using essentially the same magma with YTT.

Keywords: super-eruption, Toba Caldera, U-Pb dating

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Pre-eruptive magmatic processes of "Hakone Tokyo Pumice eruption"

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Hakone volcano is an active volcano located at the closest from the Tokyo metropolitan area, and had repeated caldera-forming eruption several times. The largest-ever eruption of Hakone volcano is the latest caldera-forming eruption that occurred at ~60 ka (VEI 6), and formed caldera structure at Gora area. This eruption started with a plinian phase, and followed by a pyroclastic flow phase. The plinian fall pumice, called Hakone Tokyo Pumice (HTP), covered all over Kanto area, and the pyroclastic flow reached about 50 km away from the eruptive center (Kasama and Yamashita, 2008). It is very important to investigate the pre-eruptive magmatic processes of this eruption, hereafter called "Hakone Tokyo Pumice eruption", in detail to evaluate the risk that an eruption of the same magnitude will occur in the future. Therefore, in this study, we clarified the pre-eruptive processes of the Hakone Tokyo Pumice eruption.

Samples were collected at Ashinoyu, Kanagawa prefecture. Pumice and scoria were found as essential clasts, and pumice with mafic enclaves was also observed. We analyzed whole-rock compositions using XRF (National Museum of Nature and Science), carried out the petrographic structure analysis using polarization microscope and SEM (Kyoto Univ.), and analyzed the major element compositions using EPMA (Kyoto Univ.).

Pumice was rhyolite from dacite (SiO_2 = 64-71 wt.%) with plagioclase, clinopyroxene, orthopyroxene, magnetite, ilmenite, apatite and olivine phenocrysts. Scoria was andesite (SiO_2 = 58-60 wt.%) with plagioclase, clinopyroxene, orthopyroxene, magnetite, apatite and olivine phenocrysts. Mafic enclaves were basalt to basaltic andesite (SiO_2 ~52 wt.%) with plagioclase, magnetite and olivine phenocrysts. The chemical compositions of the glass and phenocryst minerals suggest that four types of melts coexisted, and it is considered that there were four types of chemically different magmas in the magma chamber before the eruption. Whole rock compositions of SiO_2 > ~67 wt.% and SiO_2 < ~67 wt.% show different trends. According to the whole rock compositional trends at SiO_2 > ~ 67 wt.% and chemical zoning of plagioclase phenocrysts, it is suggested that the crystal differentiation occurred in the most silicic magma. According to the whole rock compositional trends at SiO_2 < ~ 67 wt.% and chemical zoning of plagioclase and olivine phenocrysts, it is suggested that magma mixing occurred in the magma chamber. Pre-eruptive temperature are estimated by using Fe-Ti oxides geothermometer to be 820-880 ℃. Pre-eruptive melt water content is estimated by using melt-plagioclase geothermo-hygrometers to be 4.2-7.2wt.%. These estimations indicate that the magma chamber was located at the depth of 5.5-10.5 km assuming that silicic melt was saturated with water. Timescale from the last magma mixing to the eruption was estimated to be 30 days to 1 year on the basis of the Fe-Mg diffusion modeling of an olivine phenocryst.

These observations suggest that the pre-eruptive processes of the Hakone Tokyo Pumice eruption progressed as follows: first a differentiated silicic magma existed in the magma chamber existed at depth $\geq$5.5-10.5 km, there mafic magma intruded and mixed, and the eruption began after about 30 days to 1 year from the last magma mixing.

The depth of the magma chamber at the Hakone Tokyo Pumice eruption roughly agrees with the depth of the current magma chamber estimated based on geophysical observations (~10 km: Yukutake et al.,

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2015). In order to accurately evaluate the risk of the future eruption, it is necessary to clarify the details of the pre-eruptive processes after Hakone Tokyo Pumice eruption.

Keywords: Hakone volcano, pre-eruptive magmatic process, caldera-forming eruption

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Transition of magma plumbing system deduced from the melt inclusions contained in tephra minerals originated from Aso central cones.

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Aso central cones produced basaltic to rhyolitic lavas and tephras after four gigantic pyroclastic eruptions, i.e. Aso-1, Aso-2, Aso-3, and Aso-4. Aso central cone pumice 1 ~ 6 (ACP1 ~ 6; Takada, 1989) represent voluminous volcanic products in post-caldera stage, and become key beds in Aso area. In the course of this study we found olivine-rich tephra between ACP4 and ACP3 (We call this as ACP3/4 scoria). In this study, we analyzed minerals, melt inclusions contained in tephra minerals, and volcanic glasses contained in ACP4, ACP3/4 scoria, ACP3, and ACP2 in order to compare with their result with ACP1 (Brouillet et al., 2018), Holocene scoria (Kishimadake, Ojodake, Kamikomezuka, and Nakadake) (Kawaguchi, 2018, personal communications), Aso-3 and Aso-4 (Kaneko et al., 2007, 2015), and deduce magma plumbing system of post-caldera stage of Aso volcano. The peak plagioclase composition contained in ACP4 ~ ACP1 is An# = 60~70, which is different from that of Aso-3 and Aso-4. The composition of melt inclusions in ACP2 and ACP4 does not change irrespective of host minerals and is almost the same as that of matrix glass. On the other hand, melt inclusions in ACP3/4 scoria show different compositions depending on host minerals. The composition of melt inclusions in ACP3 pyroxene is completely different from matrix glass. The maximum water content of melt inclusions in ACP4, ACP3/4 scoria, ACP2 is 1.3 wt.%, 3.8 wt.%, 3.0 wt.%, respectively. The P-T conditions of magma reservoirs of ACP2 and ACP4 are estimated as ACP2 : 890 ~ 920 ℃, 2 kbar, ACP4 : 900 ~ 920 ℃ (P = 2 kbar) from the composition of minerals and melt inclusions, and water content of melt inclusions.

Keywords: Aso volcano, Melt inclusion, FT-IR

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Pre-eruptive magma dynamics of the climactic 110ka eruption of Toya caldera, Japan

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[Introduction & Methods] Caldera-forming eruptions are among the most hazardous of natural events and need to be properly predicted. An important part of this effort is to elucidate the pre-eruptive history of the magma systems through detailed petrological studies. Toya caldera, Japan, is an ideal laboratory for this purpose because of its youth and excellent preservation. It has two post-caldera volcanoes, Nakajima and Usu, the latter of which is one of the most active volcanoes in Japan.
According to previous studies (e.g., Suzuki et al, 1970; Ikeda & Katsui, 1986; Machida et al., 1987; Feebrey, 1995; Lee, 1996; Machida & Yamagata, 1996), a catastrophic eruption occurred at ca. 110 ka, producing large-scale pyroclastic flows and a wide-spread co-ignimbrite ash (>150km^3), and the magma was mainly a homogeneous high-silica rhyolite. The eruption sequence and pre-eruptive magma processes are, however, not yet well understood because the stratigraphic units differ between different researchers and previous petrological interpretations includes some errors. Therefore, we have conducted new geological and petrological studies, including analyses of bulk-rock compositions (XRF) and volcanic glass and mineral compositions (EPMA, LA-ICP-MS). Part of the geological studies has been published by Goto et al. (2018).

[Results] We divided the eruptive product into units 1 to 6 [see Goto et al. (2018) for detail]. Unit 1 is an ash-fall deposit consisting of glass shards. Units 2, 4, 5, and 6 are pyroclastic surge and flow deposits. Unit 3 consists of base surge and ash-fall deposits. Large lithic clasts occur in unit 4 and the lower parts of units 5 and 6.
Most pumice clasts are homogeneous white pumice (SiO_2=ca.77%, K_2O=ca.2.8-3.2%; similar to the opx-HSR of Feebrey(1995)). Half of pumice clasts in unit 6 are banded and gray pumice, showing two types of chemical variations. One (hb-LSR, ibid) trends toward the Nakajima andesite, and the other (cum-HSR, ibid) toward the Usu rhyolite.
Glass and mineral compositions also have variations in unit 6. For plagioclase, we identified 3 types (A, B, and C). Type A (An=ca.12) is dominant. Type B is anorthitic (An>=90) with a sub-type B' (An=ca.80). Type C is subdivided into C1 (An=ca.20), C2 (ca.35), and C3 (ca.55). Types C2 and C3 show dissolved textures. Orthopyroxene and magnetite also have similar variations, whereas quartz is type A, clinopyroxene is type B', and both hornblende and ilmenite are types C2 and C3. Magma A, from which type-A phenocrysts derived (the same hereafter), is the high-silica rhyolite. Magma B is a mafic magma. Others are intermediate magmas. Temperatures, estimated with geothermometers by Putirka (2008) and Andersen & Lindsley (1985), are <=800 C for magma A, 800-890 C for C1, C2, C3, and B', and >=900 C for B. Trace element concentrations and zoning profiles of phenocrysts reveal that C2, C3, and B' were closely related to each other but were not in contact with A and C1 until just prior to the eruption, that B' was derived from B, and that C1 interacted with A before eruption.
Type-A phenocrysts do not show significant reverse zonings. Diffusion times estimated for magnetite are < days. On the other hand, type-B phenocrysts show significant diffusion (e.g., Mg in plagioclase), indicating hundreds of years between the injection of magma B and the eruption.

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[Inferred magma processes] The Toya eruption commenced with a phreato-Plinian eruption (unit 1), followed by a large-scale pyroclastic surge eruption (unit 2). The eruption once decreased in intensity and changed into small-scale phreatomagmatic eruptions (unit 3). Shortly after that, the caldera-collapse began (unit 4), resulted in a large-scale pyroclastic flow eruption (units 5 and 6). The caldera collapse, following the temporary decrease in intensity, was probably caused by underpressure in the magma chamber due to the evacuation of unit 2.
Just prior to the eruption, there was a large main chamber of magma A with subordinate magma pockets C1, C2, C3, B', and B. Magma A was probably produced by extraction from a crystal mush (e.g., Wolff et al., 2015). Mafic magma (B) injected hundreds of years before the eruption, remelted the mush, producing magmas C2, C3, and B'. Magma A was not disturbed by the mafic magma until just prior to the eruption. Magma mixing occurred during the eruption probably by suction due to the decrease in chamber pressure. The eruption trigger was probably not a mafic injection but an external cause, such as fault movement (e.g., Gregg et al., 2015). The compositional variation in unit 6 indicates a close relationship with Nakajima and Usu magmas, and requires a further examination.

Keywords: Toya caldera-forming eruption, ignimbrite, high-silica rhyolite, silicic magma, magma mixing, time scale

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Voluminous silicic magma formation for the 30 ka Aira catastrophic caldera-forming eruption: contributions of crust-derived mafic and felsic magmas

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Aira catastrophic caldera-forming (CCF) eruption occurred at 30 ka and discharged voluminous silicic magma with a small amount of less silicic magma. In order to understand the genesis of magmas in the Aira CCF eruption, petrological and geochemical characteristics of the juvenile clasts and plagioclase phenocrysts in them were investigated. Important petrological and geochemical features of the Aira ejecta and related rocks are described as follows:
1. Juvenile ejecta discharged by the Aira CCF eruption consist of three types of clasts; white pumice, dark pumice, and scoria clasts. Whole-rock chemical compositions of the dark pumices are less SiO_2 contents (67.5-75.7 wt.%) than those of the white pumices (74.3-77.2 wt.%). The scoria shows andesitic composition (SiO_2=59.0 wt.%).
2. In whole-rock characteristics, the SiO_2-poor juvenile clasts have higher $^{87}Sr/^{86}Sr$ (0.70856±0.00001 of the dark pumice and 0.70738±0.00001 of the scoria) than the white pumice (0.70597±0.00001).
3. An-contents of plagioclase cores in the white and dark pumices show bimodal distributions with peaks of An_{45} and An_{80}, while the scoria contains solely high-An (>An_{65}) plagioclase.
4. In plagioclase phenocrysts of the Aira juvenile clasts, Sr isotopic ratios of the high- and low-An plagioclase cores are different (0.70680±0.00117 and 0.70575±0.00040, respectively).
5. Basement rocks beneath the Aira caldera consist of Shimanto sediments and Miocene granites. These materials have much higher $^{87}Sr/^{86}Sr$ (Shimanto sediments: >0.70965; Miocene granites: >0.70885) than the Aira juvenile clasts.
6. Pre-caldera basaltic lavas, which are the most SiO_2-poor ejecta around the Aira caldera, have lower $^{87}Sr/^{86}Sr$ (0.70425-0.70469) than the Aira juvenile clasts.
The above features suggest that voluminous silicic magma bearing the white pumices in the Aira CCF eruption was produced by mixing between low-$^{87}Sr/^{86}Sr$ felsic and high-$^{87}Sr/^{86}Sr$ mafic magmas, crystallizing the low- and high-An plagioclase, respectively. The low-$^{87}Sr/^{86}Sr$ felsic magma was distinguished from both the upper crust and pre-caldera basaltic materials in $^{87}Sr/^{86}Sr$ characteristics. If the basaltic materials show the mantle signature, the low-$^{87}Sr/^{86}Sr$ felsic magma was derived from a lower crust material. The geochemical signature of the high-$^{87}Sr/^{86}Sr$ mafic magma can be explained by assimilation of high $^{87}Sr/^{86}Sr$ upper crust materials. The lowest $^{87}Sr/^{86}Sr$ recorded in the high-An plagioclase is higher than the whole-rock $^{87}Sr/^{86}Sr$ of the pre-caldera basalts, suggesting the mafic end-member magma for the Aira CCF eruption was the lower crust origin. A frequency ratio of the low- to high-An plagioclase in the white pumice proposed that the mixing ratio of the felsic and mafic magmas was estimated at a ratio of ~8:2, which is consistent with whole-rock $^{87}Sr/^{86}Sr$ variations of the white pumice. In conclusion, the crust-derived low-$^{87}Sr/^{86}Sr$ felsic and high-$^{87}Sr/^{86}Sr$ mafic magmas had contributed to the formation of voluminous magma discharged by the Aira CCF eruption.

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Keywords: Aira caldera, caldera-forming eruption, Sr isotope ratio, magma mixing, crustal assimilation

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Stratigraphy and petrological relations of pre-Aso volcanic rocks in Tateno district, Minami-Aso village

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Petrological study of pre-caldera volcanic products is important in order to understand precursory phenomena of catastrophic caldera- forming eruptions. Volcanic activity of Aso pre-caldera stage is characterized by dominant lava flows. We report the petrography and chemical compositions of Aso pre-caldera stage lavas.
At least twelve lava flows are seen in Tateno district and they have maximum layer thickness of 20 m. They are characterized by platy joints and the top of the lava. Each lava flow interposed tuff breccia and red soil. Tuff breccia is composed of red soil, lithic fragments and weathered pumice. We made columnar section of each route and confirmed the stratigraphic relation in each.
Almost samples are olivine-two pyroxene andesite (17 samples) or olivine-hornblende-two pyroxene andesite (7 samples). And we confirmed minor types, olivine-clinopyroxene andesite (1 sample) and two pyroxene potassium-rich latite (1 sample). We realized two group lava flows. Group 1 includes three samples and group 2 does two samples. Other samples do not have the correspondence because they are different from content of major elements. The result of K-Ar age is also suggested that group 2 samples are same flow unit.
Although K-Ar age of pre-Aso lavas distributed at an altitude of 665-690m are 0.66±0.34 (Ma) and 0.78± 0.19 (Ma), the result of group 2 lava located at a height of 500m are 0.45±0.04 (Ma) and 0.48±0.03 (Ma). It is suggested that the sources of each lava were different and that the younger source was located lower in altitude than the older source. In the present Tateno Valley, Akase lava (3 ka) has a relationship sticking to the lower position of the Tateno lava (5.5 ka). It has possibility that the same relation existed in the pre-caldera stage, and that the valley may have formed due to exercise of fault or the like.

Keywords: pre-caldera stage, lava flow, tuff breccia

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[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-VC36] Volcanic and igneous activities, and these long-term forecasting

convener:Teruki Oikawa(GSJ, National Institute of Advanced Industrial Science and Technology), Takeshi Hasegawa(Department of Earth Sciences, College of Science, Ibaraki University), Daisuke MIURA(Department of Physical Science, Graduate School of Science, Osaka Prefecture University), Nobuo Geshi(Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Chairperson:Nobuo Geshi(GSJ/AIST), Daisuke Miura

This session focuses on generation and accumulation processes of magmas, magma-crust interaction and degassing, and modes of eruption, long-term forecast of eruption, dispersal and emplacement of the volcanic products. The discussion spans petrological, geochemical, geophysical, and geological processes related with volcanic activity and products in the past, the present and the future.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SVC36-07] Caldera structure delineated by airborne gravity gradiometry

*Atusi NINOMIYA[1], Hiromasa ISHIKAWA[1], Shunsuke NOGAMI[1], Yoshio NAKASATO[1] (1.Sumiko Resources Exploration and Development Co., Ltd.)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SVC36-08] The initial fine ash deposit of the Shikotsu caldera-forming eruption at ca. 45 ka

*Chiharu Tomijima[1], Daisuke MIURA[1], Shimpei Uesawa[2], Mizuho Amma-Miyasaka[3] (1.Department of Physical Science, Graduate School of Science, Osaka Prefecture University, 2.Central Research Institute of Electric Power Industry, 3.Graduate School of Sciences, Hokkaido University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SVC36-09] Characterization of the Small-volume Pyroclastic Flows from the Kuchinoerabu-jima Volcano during 2018-2019, Southwest Japan

*Ryuta FURUKAWA[1], Teruki Oikawa[1], Nobuo Geshi[1] (1.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SVC36-10] An explanation of size and position of Mt. Fuji

*Yasushi Harada[1], Miyu Takahashi[1] (1.School of Marine Science and Technology, Tokai University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SVC36-11] Arc magmatism in the northernmost part of Kamchatka caused by the aseismic subducted Bering slab

*Tatsuji Nishizawa[1], Hitomi Nakamura[2,3,4,5], Tatiana Churikova[6,7], Boris Gordeychik[6,8], Maria Pevzner[9], Osamu Ishizuka[2,10], Hikaru Iwamori[3,4,11] (1.Volcanic Fluid Research Center, School of Science, Tokyo Institute of Technology, 2.Institute of Earthquake and Volcano Geology, Geological Survey of Japan, AIST, 3.Department of Solid Earth Geochemistry, Japan Agency for Marine-Earth Science and Technology, 4.Depeartment of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology, 5.ORCeNG, Chiba Institute of Technology, 6.GZG, Abt. Geochemie, Universität Göttingen, 7.Institute of Volcanology and Seismology, Far East Branch, Russian Academy of Sciences, 8.Institute of Experimental Mineralogy, Russian Academy of Sciences, 9.Geological Institute, Russian Academy of Sciences, 10.R & D Center for Ocean Drilling Science, Japan Agency for Marine-Earth Science and Technology, 11.Earthquake Research Institute, The University of Tokyo)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SVC36-12] Redox state of magma in the deep crust beneath NE Japan arc: constraints from cumulate xenoliths from Ichinomegata Maar

*Naoya Tsushima[1], Michihiko Nakamura[1], Yasuhiro Yanagida, Takeyoshi Yoshida[1] (1.Division of Earth and Planetary Materials Science, Department of Earth Science, Graduate School of Science, Tohoku University)

Caldera structure delineated by airborne gravity gradiometry

*Atusi NINOMIYA[1], Hiromasa ISHIKAWA[1], Shunsuke NOGAMI[1], Yoshio NAKASATO[1]

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The airborne gravity gradiometry (e.g., JOGMEC, 2017) revealed that collapsed caldera shows a polygonal structure consisting of a combination of fractures in the direction along the caldera contour and radial fractures cutting through them. This structure is commonly found in the Quaternary calderas such as Kutcharo caldera, Teshikaga caldera, Sen-Yakeyama caldera, Sanzugawa caldera, Southern Kurikoma volcano caldera, Onikobe caldera, Hanayama caldera, Shiobara caldera, Shishimuta caldera, and Aso caldera.
Three-dimensional inversion of the airborne gravity gradiometry data enables to stereoscopically visualize the caldera structure.

Reference: JOGMEC, 2017, Report of survey on the potential of geothermal resources.

Keywords: airborne gravity gradiometry, caldera structure

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The initial fine ash deposit of the Shikotsu caldera-forming eruption at ca. 45 ka

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We have studied a thin and fine-grained ash deposit that occurs at the bottom of a massive plinian fall unit from Shikotsu caldera, southwest Hokkaido, Japan. This fine ash deposit could be a sign of the initial stage for a catastrophic caldera-forming eruption. The ash is extensively observed at the large number of outcrops for the Shikotsu plinian fall deposit. It is believed that the Shikotsu caldera-forming eruption (SCFE) took place at ca. 42–45 ka.
The lowermost part of the fall unit is divided into two units, A1 and A2. The unit A1 is a well-sorted, thin and fine-grained ash deposit, whereas the unit A2 is constituted by four layers with the alternation of ash and pumice fall deposits. The unit A1 further comprises two sub-layers: the lower layer is a thin (~4 mm thick) and very fine-grained ash layer with sheet-like carbide and the upper one is a crystal rich fine ash layer (~30 mm thick). While the total thickness of A2 is gradually decreasing as far from the source caldera, the thickness of A1 was almost constant everywhere, which extends throughout a distance up to 70 km from the source caldera.
Dry sieve analyses at 0,5 interval between -1 and +4 in ϕ scale were carried out on 8 samples of A1 deposit. The results of grain-size distribution show a bit of change between 1.26 and 2.25 in Mdϕ and between 0.38 and 0.83 in $\sigma\phi$. These changes of Md ϕ and $\sigma\phi$ correspond to distance from 11 km to 70 km, indicating that A1 is quite well sorted and homogeneous grain-sized deposit in its long-distance transportation. These findings suggest that the unit A1 is a well-sorted, widely dispersed and high temperature dilute flow deposit. It seems to be different from the normal pyroclastic surge deposits and may be resulted from a kind of critical mode of eruption just prior to the caldera-forming plinian eruption.

Keywords: Caldera, transport system, eruption dynamics

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Characterization of the Small-volume Pyroclastic Flows from the Kuchinoerabu-jima Volcano during 2018-2019, Southwest Japan

*Ryuta FURUKAWA[1], Teruki Oikawa[1], Nobuo Geshi[1]

1. Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology

A small-scale pyroclastic flow which flows several hundreds meters to several kilometers is a frequent phenomenon in volcanic eruptions. However, since pyroclastic flow often appears in short period of time, there are not many reports of direct detailed observation. Such the small-scale pyroclastic flows occurred at Kuchinoerabu-jima volcano on 18 December 2018, 17 and 29 January 2019. Images by JMA monitoring camera and aerial observation allow us to analyze these pyroclastic flows in view of aerial extents, depositional feature and flow velocity.
For the pyroclastic flows occurred at Kuchinoerabu-jima volcano at 18 December 2018 and 17 January 2019, partial collapse of eruption column resulted in pyroclastic flow just after the onset of these eruptions. The pyroclastic flow on December 18, 2018 ranged from the Shin-dake Crater (center) to 1.1 km northwest, 0.9 km southwest and 0.9 km east. The pyroclastic flow had flowed downward around the crater and descended to the foot of the volcano, lobate topography along the valley was observed. There were no signs of burning nor falling down trees due to pyroclastic flow passage. The pyroclastic flow on January 17, 2019 extends 1.9 km northwest, 1.5 km southwest and 1 km(+) east side. Pyroclastic flow extent can be identified with 3 regions: area of thick accumulated pyroclastics, thinly deposited pyroclastics with abundant collapsed trees and thin pyroclatics recognized by vegetation discoloring. The second and third regions occasionally have white smoke by forest fires as the result of hot pyroclastic material. For the pyroclastic flow of January 29, 2019, it can be identified up to about 600 m to the west from the Shin-dake Crater and there is no observation on the east side of the crater. These pyroclastic flows show similar or smaller extents compared with them of the distribution of pyroclastic flows occurred in 2014 to 2015. Most of the pyroclastic flows flowed down to the west side of Shin-dake Crater. Detailed examination of pyroclastic flow deposits in the field is expected.
Analyses of volcano-monitoring camera images of the Japan Meteorological Agency may measure the flow velocity of the pyroclastic flow occurred between 2015 and 2019. The average flow velocity of the pyroclastic flow ranges of 5 - 47 m/s and mean values of about 20 - 30 m/s. The pyroclastic flow of May 29, 2015 which flowed the furthest, was the fastest and the shortest distance was January 29, 2019 is the latest. In general, the pyroclastic flow with higher speed tends to have a longer travel distance. The pyroclastic flow that occurred on May 29, 2015, December 18, 2018, January 17, 2019 occurred by partial column collapse immediately after the eruption. The pyroclastic flow on January 29, 2019 occurred by overflow from the crater suggesting different mechanisms of generation. Multiple mechanisms of generation and flowage can be help us to understand small-scale pyroclastic flows.
Acknowledgments: The Japan Meteorological Agency, Fukuoka District Meteorological Observatory, Volcano Monitoring and Warning Center and the Kagoshima Local Meteorological Observatory provided valuable images of the eruptions.

Keywords: Kuchinoerabu, pyroclastic flow, eruption

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An explanation of size and position of Mt. Fuji

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On Mt. Fuji, there are three unsolved features. First, the volume is so large (1400km^3) as typical volume of Japanese volcano is less than 100km^3 . Second, There is a big gap(200km) between the Nasu volcanic zone and Fuji volcanic zone on which the Mt. Fuji exists at northern end. Third, the Mt. Fuji is on 150km isodepth position of the Pacific Plate surface, whereas the average depth of the Nasu volcanic front is 100km. On the other hand, we created a VRML file for 3D plate boundaries, 3D volcano position with conduits, and positions of hypocenters around Japan, and we noted that there is a convex shape of the Philippine sea plate below the Mt. Fuji position. We performed a simple 3D simulation for magma conduits originated from 100km isodepth of the Pacific plate surface. Those conduits are blocked by the Philippine sea plate and deflected to the position of Mt. Fuji. Thus, we conclude that the shape of the Philippine sea plate well explains the size, position and depth of Mt. Fuji magma.

Keywords: Mt. Fuji, Philippine sea plate, 3D simulation

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Arc magmatism in the northernmost part of Kamchatka caused by the aseismic subducted Bering slab

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1. Volcanic Fluid Research Center, School of Science, Tokyo Institute of Technology, 2. Institute of Earthquake and Volcano Geology, Geological Survey of Japan, AIST, 3. Department of Solid Earth Geochemistry, Japan Agency for Marine-Earth Science and Technology, 4. Depeartment of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology, 5. ORCeNG, Chiba Institute of Technology, 6. GZG, Abt. Geochemie, Universität Göttingen, 7. Institute of Volcanology and Seismology, Far East Branch, Russian Academy of Sciences, 8. Institute of Experimental Mineralogy, Russian Academy of Sciences, 9. Geological Institute, Russian Academy of Sciences, 10. R & D Center for Ocean Drilling Science, Japan Agency for Marine-Earth Science and Technology, 11. Earthquake Research Institute, The University of Tokyo

Marginal parts of a subducting slab and plate can play important roles in geodynamics. For example, the strength for plate boundaries affects the driving stress of the plates and especially spin motion of relatively small plate without slabs (Matsuyama and Iwamori, 2016), slab-derived fluid from subducted aseismic slab edge is distributed beyond the seismically determined edge and contributes the arc magmatism (Nakamura et al., 2018), and mantle flow around slab edge and corner flow in a mantle wedge could generate toroidal and poloidal components in the mantle convection (Yogodzinsky et al., 2001). The northwestern edge of Pacific (PAC) Plate, the largest oceanic plate on Earth, is subducting beneath Kamchatka, which forms a massive volcanic arc consisting of three subparallel volcanic belts: the Eastern Volcanic Front (EVF), the Central Kamchatka Depression (CKD) and the Sredinny Range (SR). The northwestern edge of PAC Plate has great influences on the geodynamics of Kamchatka-Aleutian junction but many parts of this region remain unexplained. Examples include arc magmatism in the north beyond the junction and inconsistency between petrological determined thermal structure of the wedge mantle and tectonically determined mantle flow direction (e.g., Yogodzinski et al., 2001; Portnyagin et al., 2005; Portnaygin and Manea, 2008).

We investigated the northern part of SR (N-SR) from N58°05’ and up to N58°38’ located north beyond the seismically determined PAC slab edge and found several the Quaternary-age fresh lava flows, young monogenetic cones and stratovolcanoes formed on the old basement rocks of plateau lavas. The N-SR lavas are classified as medium-K series basalt to andesite and show typical arc signatures with strong but variable LILE and LREE and low HFSE concentration, which indicates that fluid components have been supplied to the area where a subducted slab is not detected seismically. The fluid components could have been derived from the lower crust and/or lithospheric mantle or aseismic subducted slab (e.g., Volynets et al., 2010; Nekrylov et al., 2018). Compared with the volcanic front lavas of EVF and the Klyuchevskoy Volcanic Group located in CKD, the N-SR lavas have relatively high Nb and Ta contents. Such arc lavas with high Nb and Ta contents have also been reported from the Quaternary southern part of SR (S-SR) (e.g., Volynets et al., 2010; Nekrylov et al., 2018) and Nachikinsky and Hailula volcanoes in the northernmost part of CKD (N-CKD) (Portnyagin et al., 2005), where have the common point that an active Wadati-Benioff zone of the PAC slab is not observed underneath (Gorbatov et al., 1997).

On the other hand, we found a left-lateral strike-slip fault crossing N-SR in NW-SE direction and also found several similar faults in the south side of N-SR. These faults seem to have formed when southeastward trench retreat accompanied with slab rollback occurred due to a recent collision of the “Kronotski Arc terrain” with Kamchatka during 7 to 2 Ma, which extinguished the northern part of the older subduction zone and formed the modern subduction structure (Lander and Shaprio, 2007; Volynets

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et al., 2010). However, according to the focal mechanisms of the earthquakes that occurred at the northern continental boundary of the Bering (BER) Plate, the BER Plate rotates clockwise about the rotation pole located at 67˚N, 176˚E (Gordeev et al., 2015). This model suggests that the BER Plate is still subducting from the northern old trench and its convergence rate decreases toward the north, which is consistent with the observation that the number of young (Quaternary) volcanoes in N-SR decreases toward the north. Therefore, the subducted aseismic BER slab beneath N-SR supplied the fluid components to the mantle wedge and caused the arc magmatism in the north beyond the seismically determined PAC slab edge. Two processes can be responsible for supplying a fertile mantle component with high Nb and Ta contents to the northernmost part and backarc area of Kamchatka: 1) a toroidal flow around the northern PAC slab edge and 2) mantle flow from the NW due to the slab rollback in SE direction.

Keywords: slab edge, Pacific Plate, Kamchatka

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Redox state of magma in the deep crust beneath NE Japan arc: constraints from cumulate xenoliths from Ichinomegata Maar

*Naoya Tsushima[1], Michihiko Nakamura[1], Yasuhiro Yanagida, Takeyoshi Yoshida[1]

1. Division of Earth and Planetary Materials Science, Department of Earth Science, Graduate School of Science, Tohoku University

Significant number of previous studies suggest that arc magmas have relatively higher fO_2 than that of mid ocean ridge basalt (MORB) or oceanic island basalt. It has been a matter of debate whether the oxidized nature of subduction zone magmas is derived from the mantle source or acquired through their differentiation in the crust. Behavior of sulfide and sulfate is sensitive to and thus can be a tracer of the redox state (or oxygen fugacity, fO_2) of magmas, because the valence state of sulfur in the magma changes from -2 to +6 through oxidation. The arc's lower crust in the subduction zones has been recently attracting many attentions as a region where magmas may change their chemical compositions significantly. The Ichinomegata maar, located in the back arc of NE Japan, is known for the rare occurrence of deep-crustal xenoliths in subduction zones. A recent petrographic study revealed that mafic xenoliths are fractionated cumulates of the calc-alkaline host magmas (Yanagida et al., 2018). Those cumulates are, therefore, the best samples to investigate the differentiation conditions of arc magmas.

In this study, we found both pyrrhotite and anhydrite from the deep crustal mafic xenoliths from the Ichinomegata maar. Almost all the pyrrhotite grains occur as small rounded inclusions whereas some as relatively large irregular shaped interstitial phases. Pyrrhotite inclusions are mainly in hornblende and some inclusions are in clinopyroxene and plagioclase. Magmatic pyrrhotite shows approximately constant non-stoichiometoric compositions (Fe+Ni+Cu/S) and a trend from Ni-rich to Cu-rich metal composition. Anhydrite occurs as inclusions in plagioclase. The occurrence of anhydrite and the fO_2 calculated from the pyrrhotite non-stoichiometry show fO_2 of +1 log unit above Ni-NiO buffer, which is almost the same as the average value of arc magmas and clearly higher than that of MORB. This study shows that the oxidized nature of the magmas of the Ichinomegata-maar was already achieved in the deep crust and the shallow oxidation model should be discarded.

Keywords: Sulfide , Sulfate , Ichinomegata maar, Mafic xenoliths

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[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-VC36] Volcanic and igneous activities, and these long-term forecasting

convener:Teruki Oikawa(GSJ, National Institute of Advanced Industrial Science and Technology), Takeshi Hasegawa(Department of Earth Sciences, College of Science, Ibaraki University), Daisuke MIURA(Department of Physical Science, Graduate School of Science, Osaka Prefecture University), Nobuo Geshi(Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Chairperson:RYUTA FURUKAWA, Teruki Oikawa

This session focuses on generation and accumulation processes of magmas, magma-crust interaction and degassing, and modes of eruption, long-term forecast of eruption, dispersal and emplacement of the volcanic products. The discussion spans petrological, geochemical, geophysical, and geological processes related with volcanic activity and products in the past, the present and the future.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SVC36-13] Deformation of a rhyolite lava below the Curie temperature: the Sanukayam lava in Kouzusima Island, Japan

*Takuma Kamio[1], Kuniyuki Furukawa[2], Tatsuo Kanamaru[3], Koji Uno[1] (1.Okayama University, 2.Aichi University, 3.Nihon University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SVC36-14] Evolution of magmatic chemistry for the Asama-Maekake volcano since 10ka revealed by whole-rock chemical analysis of pumice obtained by the trenching of air-fall tephra deposits

*Masaki Takahashi[1], Maya Yasui[1], Tatsuo Kanamaru[1] (1.Department of Earth and Environmental Sciences, College of Humanities and Sciences, Nihon University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SVC36-15] Late Pleistocene–Holocene tephra ejecta in the trench log at the southern apron of Esan volcanic complex, Japan

*Daisuke MIURA[1], Ryuta FURUKAWA[2], Kenichi Arai[3] (1.Graduate School of Science, Osaka Prefecture University, 2.Institute of Earthquake and Volcano Geology, GSJ/AIST, 3.Asia Air Survey)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SVC36-16] **Transition of eruption sequence and magma plumbing system at the 1.4 ka Nakamachineshiri eruption of Me-Akandake volcano, eastern Hokkaido, Japan.**

*Kosuke Ishige[1,2], Mitsuhiro Nakagawa[1] (1.Department of Natural History Sciences, Graduate School of Science, Hokkaido University, 2.Mitsubishi Materials Corporation)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SVC36-17] Kilo-year-evolution of magma plumbing system with dominant modes of eruption at Suwanosejima volcano, Southwest Japan

*Taketo Shimano[1], ATSUSHI YASUDA[2] (1.Graduate School of Environment and Disaster Research, Tokoha University, 2.Earthquake Research Institute, University of Tokyo)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SVC36-18] Temporal variation of the magma compositions of the Miyakejima volcano during the last 2700 years

*Nobuo Geshi[1], Teruki Oikawa[1] (1.Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology)

Deformation of a rhyolite lava below the Curie temperature: the Sanukayam lava in Kouzusima Island, Japan

*Takuma Kamio[1], Kuniyuki Furukawa[2], Tatsuo Kanamaru[3], Koji Uno[1]

1. Okayama University, 2. Aichi University, 3. Nihon University

High-viscosity rhyolite lava may have a vertical lithofacies variation with more than one hundred meter thickness. Because the interior is kept warm by its thickness and the breccia on the surface during flowing, the internal fluid lava penetrates the tip (breakout) after the flow stopped Breakout of such a time difference may be developed into a disaster. Therefore, it is necessary to understand the rheological characteristics of the rhyolite lava; however, rhyolite lava eruption has few opportunities to be observed directly. In this study, we aimed to clarify the made of lava advancing during cooling by conducting a magnetic study on Kozushima sandbank lava which is thought to have been erupted several thousands of years ago.
Paleomagnetic samples were taken from 4 pumice sites (29 samples) and an obsidian site (10 samples) in the upper glassy part. In addition, crystalline rhyolite (7 samples) and obsidian overlying the clastic layer (4 samples) were sampled. We call obsidian and pumice sites as glassy part. Analysis of thermoremanent magnetization (TRM) of the inner crystalline part and obsidian overlying the clastic layer shows a single TRM component in the orthogonal diagrams. The TRM results of the 3 pumice sites and an obsidian site shows up to two sharp demarcations in remanence directions in the orthogonal diagrams. The remaining pumice site did not provide interpretable remanence magnetization component during thermal demagnetization. The glassy part is, therefore, considered to have been deformed at least two times below 580 C due to the advance of the inner part. The sampling sites located at greater altitudes show lower temperatures at which components are demarcated. Since this is interpreted as the temperature difference inside the lava, each deformation occurred simultaneously .Mode of each deflection seems to be similar among 3 pumice sites; however, this is not the case for the obsidian site. The deformation of the thick glassy part of the rhyolite lava is not completely uniformly distributed. The obsidian site overlying the clastic layer gave a single TRM component, likely due to thermal annealing associated with abundant spherulite formation in the clastic layer.

Keywords: Rhyolite lava, Obsidian, Lava deformation, Kozushima, Paleomagnetism

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Evolution of magmatic chemistry for the Asama-Maekake volcano since 10ka revealed by whole-rock chemical analysis of pumice obtained by the trenching of air-fall tephra deposits

*Masaki Takahashi[1], Maya Yasui[1], Tatsuo Kanamaru[1]

1. Department of Earth and Environmental Sciences, College of Humanities and Sciences, Nihon University

The high-resolution stratigraphy of pumice deposits, which were formed by the pumice eruptions of Asama-Maekake volcano, is revealed by the trenching. It is clarified that the pumice beds consist of twenty-three units from As1 to As23 and the eruptive history comprises three active stages (I (9.5 to 8.3ka), II (6.5 to 4.7ka) and III (1.8ka>)) and two dormant stages (1 (8.3 to 6.5ka) and 2 (4.7 to 1.8ka)). The major element chemistry for pumice clasts of each pumice bed are analyzed by XRF. The pumice of the active stage I and II are enriched in Al_2O_3 and depleted in CaO, suggesting that both suffered chemical weathering. The pumice clast of the active stage III with high MgO, which is free from chemical weathering, are also high in FeO* and MnO, and depleted in TiO_2, P_2O_5 and Na_2O. The pumice in the active stage I and II shows also the similar tendency. The SiO_2 contents for most pumices of As15 to As22 are less than 60wt% and mafic andesite, while those of As1 to As13 are more than 60wt% and felsic andesite to dacite. The MgO content at 58wt%SiO_2 (Mg_{58}) of pumice of each pumice bed repeats the increase and decrease with time, but it appeares to increase temporally as a whole. It means that the MgO content of mafic end -member magma fed to the magma chamber filled with felsic end-member magma changes with time, because the pumice of Asama-Maekake volcano is produced by the magma mixing between mafic end-member magma with various MgO contents and felsic end-member magma with similar SiO_2 and MgO contents.

Keywords: Asama-Maekake volcano, tephra stratigraphy, whole-rock chemistry

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Late Pleistocene–Holocene tephra ejecta in the trench log at the southern apron of Esan volcanic complex, Japan

*Daisuke MIURA[1], Ryuta FURUKAWA[2], Kenichi Arai[3]

1. Graduate School of Science, Osaka Prefecture University, 2. Institute of Earthquake and Volcano Geology, GSJ/AIST, 3. Asia Air Survey

In the Esan volcanic complex (EVC), northern Japan, large number of phreatic ejecta are found at around the volcanic aprons, and could be threaten to the local residences due to the close proximity. Our trench excavation study has been performed at two digging sites, and 11 samples of the black paleo soils and the charcoal for ^{14}C dating have been measured there. A source explosion crater is inferred at 2.6 and 2.2 km far from the site A and B, respectively. This close proximity between the crater and trench sites indicates that the most of deposit exposed in the trench logs are the proximal facies. At least eleven and twelve units of volcaniclastic deposits are identified at the sites A and B. The first phreatic deposit in Holocene is newly identified just prior to the EsMP episode, and it had erupted in ca. 11 ka (Es-0). Holocene phreatic episodes of Es-1 and 3 can be divided into three and five subunits. The pyroclastic surge deposit in Es-1 and 3 was confirmed, suggesting that the phreatic surge also could be threaten to the local residences. The sequence of Holocene eruptions at the EVC comprises at least 13 phreatic tephra events in 10 thousand years, implying that the cyclic phreatic eruption could manifest in every thousand years. With regards to the characteristics of phreatic explosions, it is expected that grain size plot for the phreatic deposit becomes scattering. Grain size analysis in comparison with the magmatic ejecta may not be better way to discriminate the phreatic depositional process. It is also pointed out that the deposited area of phreatic ejecta is largely constrained by a regional topography. Parts of this work was financially supported by MEXT “Integrated Program for Next Generation Volcano Research and Human Resource Development.

Keywords: Esan volcanic complex, phreatic explosion, trench excavation

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Transition of eruption sequence and magma plumbing system at the 1.4 ka Nakamachineshiri eruption of Me-Akandake volcano, eastern Hokkaido, Japan.

*Kosuke Ishige[1,2], Mitsuhiro Nakagawa[1]

1. Department of Natural History Sciences, Graduate School of Science, Hokkaido University, 2. Mitsubishi Materials Corporation

Me-Akandake volcano ,which was formed on the southwest wall of the Akan caldera, is a stratovolcano group composed of 8 volcanoes (Katsui, 1951). Nakamachineshiri is the volcanic body that occured the most explosive eruption in the Me-Akandake volcano and is an active volcano with continues fumarolic activity. Among its activities, especially the eruption approximately 14,000 years ago, was called the Nakamachineshiri Crater Activity Period 1 (NC - 1), and widely distributed pyroclastic flow and pyroclastic fall deposit from foot of the volcano to a distance.
However, detailed geological studies have not been carried out sufficiently and the details of the eruption sequence are still unclear. In addition, the petrological study of magma plumbing system associated with transition of eruption style has not been carried out sufficiently. We performed a detailed geological survey in order to clarify the eruption sequence and style of NC-1. In addition, we performed petrological study and component analysis of the volcanic deposit in order to investigate the developmental process of the conduit during eruption and magma plumbing system. As a result, detailed eruption transition of NC-1 and transition of mafic magma became clear.
NC-1 eruptive deposits can divide into 4 unit (unit 1-4) by the result of geological survey. Unit 1 compose of pyroclastic surge deposit at the vicinity of the crater and compose of closs layer of pyroclastic flow deposit and pyroclastic surge deposit contained accretionary lapilli above the silty volcanic tuff layer at the foot of the volcano. The characteristics of Unit 1 are that volcanic deposit have suffered alteration and contain a large amount of rock fragments. Unit 2 consists of pyroclastic surge deposits and pyroclastic flow deposits, which are distributed from the vicinity of the crater to the foot of the volcano and far away, but pyroclastic flow deposits dominate at the foot of the mountain. The pyroclastic flow sediment characteristically contains fresh andesite lava fragments. As a result of observation of thin sections, these lava fragments were found to be welded pyroclastic rocks. Unit 3 is mainly pyroclastic fall deposit composed of pumice and scoria. In the vicinity of the crater, it thickness thickly and the pyroclastic surge sediment is sandwiched between the pyroclastic fall deposit. This unit is the NaPS pyroclastic fall deposit described by Wada et al. (1988). Unit 4 is distributed only in the vicinity of the crater, it is composed of pyroclastic surge deposits and the composition is characterized by many scoria and rock fragments. An erosion gap was observed between Unit 1 and Unit 2, and it is considered that there was a time gap.
The rocks of the ejecta of NC-1 are basaltic andesite to dacite. These rocks contain plagioclase, clinopyroxene, orthopyroxene and Ti-magnetite as phenocrysts, associated with minor amounts of olivine in some rocks. The whole-rock SiO_2 contents range from 62.5-64.7 wt.% for pumice and from 55.0-58.1 wt.% for scoria. Pumice and scoria tend to show different trends in many elements on the Harker diagram. Pumice exhibits little variation in petrological features through all the unit. In contrast, scoria is distinguishable according to unit by Sr and P_2O_5 contents.
From these results, based on the time gap, the volcanic activity can be divided into 2 stages. The transition of the eruption is as follows.
In stage 1 (: Unit 1) which is the first activity, magma rose and phreatomagmatic explosion occurred by the magma-aquifer interactions, and the crater was expanded by repeating the explosive eruption.

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After the time gap, the mafic magma rose again and stage 2 (: Unit 2,3,4) activity began. The first activity of stage 2 is predominantly pyroclastic surge due to phreatomagmatic explosion, welded pyroclastic rock formed in or near the crater in Stage 1 were destroyed by explosive eruption. Moreover, several pyroclastic surge which flowed down the foot of the volcano became pyroclastic flow. When eruption rate rapidly increased in middle of stage 2, eruption style became sub-Plinian eruption and eruption column was formed by declining interaction of magma-water. After that, the eruption rate decreased and eruption style changed to phreatomagmatic explosion.
In NC-1 eruption, it is thought that eruption style was dominated by interaction of magma-water because aquifer was developed in volcano body. Hence, it is assumed that Nakamachineshiri edifice is a tuff cone or maar formed by repeated phreatomagmatic explosion.

Keywords: Me-Akandake volcano, Nakamachineshiri, phreatomagmatic explosion, eruption sequence

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Kilo-year-evolution of magma plumbing system with dominant modes of eruption at Suwanosejima volcano, Southwest Japan

*Taketo Shimano[1], ATSUSHI YASUDA[2]

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Suwanosejima volcano is one of the most active volcanoes in Japan since at least 1950’s, but its eruption history had not been established well. In addition, the petrological knowledge of magma plumbing system has been accumulated only for a few decades (Shimano and Koyaguchi, 2001; Ishibashi and Saito, 2009). Shimano et al. (2013) established a rough history of the volcano, that Otake volcano, in the central part of the island, has been active for recent 60-70 kys. The dominant eruption style of Otake volcano was effusive in the first half period until ca. 30 ka, then explosive in the later half. This explosive period can be subdivided into two stages; Plinian pumice eruption stage until around 10 ka with long dormancy for each, and scoria eruption stage with intervening continuous ash emission until now. The mechanisms of such transitions in eruption styles and intervals, and products from pumice dominant to scoria dominant stage are substantially important for understanding long-term forecast of eruption. Thus this study summarizes the petrological features of eruptive materials of this explosive period to understand the magma plumbing system. Eruptive materials of 10 ka pumice eruption, 1813 subplinian scoria, and recent ash have been investigated in terms of EPMA and FTIR to discuss the history by estimating temperature and volatile content for these eruptions. We measured chemical compositions of phenocrysts, groundmass glass, and melt inclusions by EPMA, and glass water content of melt inclusions by FTIR.

The materials of 10 ka eruption are characterized by banded pumice that shows mingling of basaltic and dacitic magmas with wide compositional variation of phenocrysts. In contrast, the 1813 product is very homogeneous basaltic andesite but it also shows some evidence of mixing among similar basaltic andesite. The products of recent activity are a little bit different but rather similar to those of the 1813 but show much lower contrast among mixed magmas. Mineral assemblages are similar for all products with phenocrysts of plagioclase, two pyroxenes, and trace amount of olivine and oxide minerals. EPMA analyses revealed multi-modal characteristics of phenocryst compositions indicating mixing of some end-member components of magmas. On the other hand, the water content of melt inclusions shows that magmas of recent activity are degassed whereas those of 10ka and the 1813 are 2-3 wt.% H2O.

This study has been supported financially by ERI JURP 2018-G-3, and partly by the project “Integrated program for next generation volcano research and human resource development.”

Keywords: Suwanosejima, magma plumbing system, melt inclusion

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Temporal variation of the magma compositions of the Miyakejima volcano during the last 2700 years

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1. Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology

Evolution of the magma system of the Miyakejima Volcano between the last two caldera-forming eruptions, 2.6-2.7ka Hatchodaira eruption and the 2000 AD eruption, was reconstructed based on the new dataset of radiocarbon ages. The activity of Miyakejima during this period can be divided into three magmatic stages as follows; I) from the 6th century BC to the 2nd century AD, after the formation of the Hatchodaira caldera. This stage is characterized by the decreasing of the range and absolute value of whole-rock SiO2 concentration. II) from 7th century to 14th century after the Suoana-Kazahaya eruption in the northern slope. This stage is characterized by the gradual increasing of whole-rock SiO2 concentration from less-evolved basaltic andesite (52-53 wt% SiO2) to andesite with evolved composition. III) from the 16th century to the end of the 20th century, with gradual increasing of whole-rock SiO2 concentration from less-evolved basaltic andesite (52-53 wt% SiO2) to andesite with evolved composition. Presence of relatively large fissure eruptions with less-evolved basaltic andesite suggests the injection of less-evolved magma into the shallow magma system at the beginning of these compositional stage.

The Suoana-Kazahaya eruption in the 7th century is an eccentric activity during this period. This eruption is characterized by the eruption of andesite with highly-evolved composition (SiO2= 59-63 wt%). The aphyric andesite magma erupted at the beginning of the eruption. As the progress of the eruption, anorthosite and olivine megacryst were entrained into the andesitic magma and form porphyritic lavas. The whole-rock SiO2 of these megacryst-bearing lava ranges from 49 t- 60 wt% reflecting the abundance of the crystals. The eruption of strongly-evolved magma from the lateral fissure can be fed from the isolated small magma batch, as proposed for the plumbing system of the B and C fissures of the 1986 Izu-Oshima eruption.

Keywords: volcano, eruption, magma, Miyakejima

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[J] Oral | S (Solid Earth Sciences)：S-TT Technology & Techniques

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-TT44] Airborne surveys and monitoring of the Earth

convener:Shigekazu Kusumoto(Graduate School of Science and Engineering for Research, University of Toyama), Takao Koyama(Earthquake Research Institute, University of Tokyo), Yuji Mitsuhata(AdvancedIndustrial Science and Technology), Shigeo Okuma(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Chairperson:Shigekazu Kusumoto, Takao Koyama(東京大学 地震研究所 火山センター), Shigeo Okuma(産業技術総合研究所), Yuji Mitsuhata(国立研究開発法人　産業技術総合研究所)

Airborne surveys are useful to better understand the whole and/or the detailed structures of the Earth and their variations. They can be implemented from a traditional manned and newly-developed unmanned aircraft to efficiently map very large or remote areas with difficult access. We invite studies on theory, instrumentation, processing, modeling or inversion and applications of airborne surveys.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[STT44-01] A Case Study on the Application of a Magnetic Survey Using Magnetometers Carried by Multicopter-type Drones

★Invited Papers

*Shiga Nobuhiko[1], Harada Haruo[1], Wada Kazushige[1] (1.Mitsui Mineral Development Engineering Co., Ltd.)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[STT44-02] Development for upgrading the generalization capability of the seismic damage detection of building based on the deep-learning utilizing aerial photographs

★Invited Papers

*Shohei Naito[1], Hiromitsu Tomozawa[2], Yuji Mori[2], Naokazu Monma[3], Hiromitsu Nakamura[1], Hiroyuki Fujiwara[1] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Mizuho Information and Research Institute, Inc., 3.Pasco Corporation)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[STT44-03] The resistivity distribution under the ground on bedrock creep slopes in Kii mountain area by the airborne electromagnetic survey

*Atsuhiko Kinoshita[1,2], Yasutaka Tanaka[2], Wataru Sakurai[1], Taro Uchida[1], Koichiro Hayashi[3], Katsushi Kawato[4], Minoru Okumura[4] (1.National Institute for Land and Infrastructure Management, 2.Sediment Disaster Prevention Technology Center, Kinki Developing Regional Bureau, Ministry of Land, Infrastructure, Transport and Tourism , 3.OYO Corporation, 4.NIPPON ENGINEERING CONSULTANTS CO.,LTD.)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[STT44-04] Study of UAV photogrammetry toward efficiently grasping volcanic landform

*Yuichi Iwasa[1], Takeshi Matsushima[2] (1.department of earth and planetary sciences, graduate school of sciences, Kyushu University, 2.SEVO, Kyushu Univ.)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[STT44-05] Volcanic gas measurements using UAVs

*Takeshi Hashimoto[1], Akihiko Terada[2], Toshiya Mori[3], Ryo Tanaka[1] (1.Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido University, 2.Volcanic Fluid Research Center, Tokyo Institute of Technology, 3.Geochemical Research Center, Graduate School of Science, The University of Tokyo)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[STT44-06] Repeated Drone Magnetic Survey over Usu Volcano, Hokkaido Japan

*Shigeo Okuma[1], Masahiko Makino[2], Tadashi Nakatsuka[1], Ayumu Miyakawa[1], Makoto Yanagida[3], Minoru Okumura[4] (1.Institute of Geology and Geoinformation, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST), 2.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST), 3.Hanshin Consultants Co., Ltd., 4.Nippon Engineering Consultants Co., Ltd.)

A Case Study on the Application of a Magnetic Survey Using Magnetometers Carried by Multicopter-type Drones

*Shiga Nobuhiko[1], Harada Haruo[1], Wada Kazushige[1]

1. Mitsui Mineral Development Engineering Co., Ltd.

Recently, large radio-controlled helicopters have been successfully used to take magnetic measurements of active volcanoes due to their long cruising distance and large payload. On the other hand, in mineral exploration, multicopter-type drones can conduct successful surveys in spite of their shorter cruising distance by repeating a number of short-distance flights. The drones can be used for faster and more extensive reconnaissance magnetic surveys compared with land magnetic surveys, by flying at about 50m above ground level, with 100m of flight separation. The drones can also provide high-resolution results that cannot be acquired easily by manned airplanes or helicopters.

Since 2017, magnetic measurements have been taken by a drone as reconnaissance for a domestic gold exploration project survey, with a total flying distance of 680km so far. This type of drone is commercially available, with 5.5kg of payload. It carries an optical pumping magnetometer, a 4K camera, and a circuit board for data processing and telecommunications, among other equipment. It also has a hanging magnetometer sensor that is suspended from a single 2.5m Kevlar cable.

The TMI data quality has mostly been good, and the data repeatability is always satisfactory. Usually, the discrepancies at the intersecting points between regular flight lines and tie-lines are small enough to be negligible. And no magnetic influence of the drone has been found, so there has been no need to compensate for drone airframe magnetism. However, the optical pumping magnetometer has a dead zone in the incident angle of the input magnetic field. Because the magnetic sensor is suspended from the drone, measurements can sometimes be interrupted if the sensor is strongly shaken or tilted by the wind or by an abrupt change in the cruising speed.

Since 2017, we have been conducting drone magnetic surveys at an existing gold mine and surrounding area. As a result, a low magnetic zone was found around an outcrop of silica sinter with strongly silicified rocks. The location of the low magnetic zone coincides with the peak of the horizontal gravitational gradient strength in this area. The peak was interpreted to show the locations of faults, and the low magnetic zone was derived from the thermal demagnetization by hydrothermal fluids came up throuh the fault, which brought about mineralization and the silica sinter. Since the silica sinter and strongly silicified rocks were mineralized (Au:1g/t-- Ag:16g/t), an epithermal gold-silver deposit is likely to exist beneath the sinter area.

(Acknowledgement)
We would like to express our deep appreciation to Irving Resources Inc. for their valuable assistance for this survey and for their permission to use materials from their surveys in this presentation.

Keywords: magnetic survey, drone, mineral exploration

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Development for upgrading the generalization capability of the seismic damage detection of building based on the deep-learning utilizing aerial photographs

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1. National Research Institute for Earth Science and Disaster Resilience, 2. Mizuho Information and Research Institute, Inc., 3. Pasco Corporation

NIED has been developing the real-time damage estimation and identification system for use in supporting decision-makings for emergency responses. In this study, we developed the immediate damage detection method of buildings utilizing remote sensing images, by sequentially updating the result of the real-time damage estimation system as a complementary.

The image consists from images of multiple ortho-rectified vertical aerial photos taken soon after the 2016 Kumamoto earthquake, the 1995 southern Hyogo Prefecture earthquake, and the 2011 off the Pacific coast of Tohoku earthquake. By combination of these images, we constructed training data and the damage discriminant model which have high generalization performance.

First, we classified building damages into four levels by means of the visual judgment; LEVEL1: No damage, LEVEL2: slight damage, LEVEL3: moderate damage, LEVEL4: collapsed. Then we divided building types as wooden and non-wooden based on the shape of roofs. And we organized these as GIS data, utilizing the building polygon provided by the Geospatial Information Authority of Japan.

Next, we normalized the resolution of each photographs as approximately 20 centimeters per pixel, and regularized brightness of images utilizing cumulative sum of luminance histograms.

Subsequently, we acquired patch images of 80-pixels square which include the main part of a common residence from each photographs, then extracted total 311,281 patches including each building damage levels proportionally.

Furthermore, we developed the damage discriminant model based on the CNN referring the VGG, then trained this model with these patch images. By this model, a discrimination accuracy of validation data which extracted from 3 earthquakes except of training data indicates over 70% in each damage levels.

In this study, an output of discriminant result is produced as a 4 color image created by raster scanning as a unit of 80-pixels square and a stride width of 20-pixels. Then by overlapping of building polygons, we classify the damage level of each building based on the threshold value of area ratios. Additionally, we assumed the sum of LEVEL3 and LEVEL4 as the totally collapsed buildings, and the sum of LEVEL2 and LEVEL3 and LEVEL4 as the totally or partially collapsed buildings, on the basis of the comparison between the governmental inspection result and the visual judgment result with aerial photographs.

By these methods, the immediate damage detection of the extensive area with an aerial photograph is achieved. Besides, by application of the Bayesian updating method, the estimation result based on the distribution of ground motion can be updated into the higher precision.

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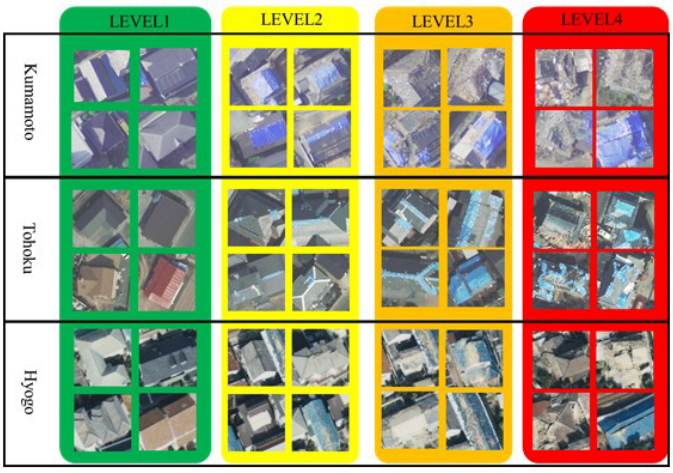
For all these reasons, the automatic damage detection with an aerial photo can approve the accuracy of the damage estimation based on the ground motion, and it is possible to utilize for disaster responses. However, this method has difficult tasks such as the damage discrimination based on a vertical image sometimes under-estimates the building damage except of wooden building which have tiled roof, and survey with optical images by airplane is difficult to observe during the cloudy weather and the night-time.

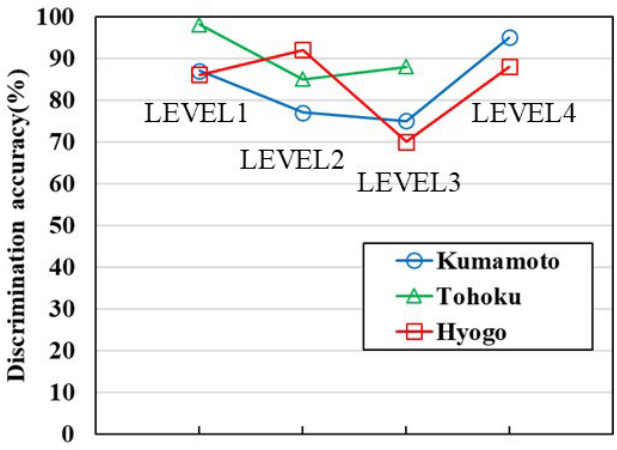
In the future, by utilizing the image acquired by different platforms and different sensors, we are going to develop the damage detection methods which have more immediacy and higher accuracy, then we intend to utilize these methods not only the initial disaster response, but also the recovery and reconstruction stage.

Acknowledgement:

This work was supported by Cross-ministerial Strategic Innovation Promotion Program (SIP), titled “Enhancement of societal resiliency against natural disasters”. We used the ArcGIS for developing training data, the OpenCV and the Python for image analyses, and the Keras as the deep-learning framework.

Keywords: Deep-learning, Convolutional Neural Network, Remote Sensing, Damage Detection, Aerial photograph, Bayesian Updating





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The resistivity distribution under the ground on bedrock creep slopes in Kii mountain area by the airborne electromagnetic survey

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In typhoon Talas of September 2011, numerous deep-seated landslides were occurred in the Kii Peninsula. In order to reduce the damage, it is necessary to grasp the dangerous slopes for landslides in advance. For the method to extract the dangerous slopes, there are a method using topography data such as the laser profiler, a method to judge from geology / topography, a method to judge from the amount of spring water at the end of slope and the quality of water. These methods have advantages and disadvantages, and there are insufficient aspects to estimate the degree of the danger and the scale of the dangerous slopes. Therefore, in order to complement these methods, we propose the method to estimate the risk and the landslide size based on the resistivity distribution of the ground obtained by the airborne electromagnetic survey. In this study, two bedrock creep slopes in the Akadani-west area were considered as the research fields and the validity of the estimation method was verified.
In this study, the vertical resistivity distributions of the slopes were created from the airborne electromagnetic survey obtained in the past. First, we calculated the average penetration depth from the frequency and the specific resistance of the ground. Next, the blank portion where data was not obtained was supplemented. Final, the smoothing processing was performed for the purpose of eliminating the noise. The vertical resistivity distribution of the ground is displayed in color, so it is easier to judge the danger level and estimate the slip surface. For this reason, we adopted the method of separating colors according to the frequency from all resistivity values obtained in the Akadani-west area.
In the slopes of the Akadani-west area, we have found that the resistivity value steeply changed in the vertical direction at the slip surface. For this reason, the degree of the landslide risk and the depth of the slip surface can be estimated from the resistivity distribution. In addition, we have found that the depth of the slip surface can be estimated in more detail by first differentiating the resistivity value in the vertical direction.

Keywords: Airborne electromagnetic survey, Resistivity distribution, Bedrock creep

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Study of UAV photogrammetry toward efficiently grasping volcanic landform

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In this study, we conducted three-dimensional modeling of volcanic landform using photogrammetry by UAV aerial photography with the aim of efficiently grasp landform. This method, which has been spread in recent years, can grasp landform as not points but planes, and it is thought that this observation can be conducted inexpensively, quickly, and without high-risks. In this study, aiming to make UAV observation efficient, we investigated relation between some factors of UAV observation and the accuracy of 3D model created.

We conducted mission flight on March and August 2018 at Kirishima Iwo-yama located Ebino city, Miyazaki prefecture. Iwo-yama erupted on April 2018, and landform change has occurred. We were able to get photogrammetric data before and after eruption. The UAV used on this study is DJI Mavic pro. The flying altitude from take-off point was 50 m, and the resolution of the images was 1.5 cm/pix. The photographed area was about 0.26 km2, and we set frontlap: the overlap of image along flight route, to 90 %, and sidelap: the overlap of image between flight routes, to 60 %. The UAV flew 60 minutes, and we got 1379 images during each flight. In addition, we measured 16 points as Check points and Ground Control Points (GCP): the points used as standard of coordinates, by GNSS and Total station.

Using Agisoft’ s software Photoscan, we created a three-dimensional model before and after eruption from images taken. By increasing a number of measured points, we got more accurate model than that of similar observation in 2017, On the other hand, there were partial vacancy on the model after eruption. This is probably because image processing was not successful due to a lot of volcanic gasses in the photographed image. For solving this problem, at next observation, we photograph from oblique angle in addition to vertical angle only around fumarole.

According to the above data, comparing models, we grasp volcanic landform change due to eruption on April 2018. Furthermore, we investigate relation between particularly GCP and the accuracy of 3D model in order to make UAV observation efficient.

This work was partly supported by MEXT under Integrated Program for Next Generation Volcano Research and Human Resource Development, and under Earthquake and Volcano Hazards Observation and Research Program. Also it was supported by ERI, The University of Tokyo under Joint Usage Program.

Keywords: UAV, photogrammetry, volcano

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Volcanic gas measurements using UAVs

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Volcanic gas is a mixture of volatile contents separated from magma and its composition may reflect the temperature and pressure conditions at a degassing depth, and the processes of phase change, interaction with rocks, and so on. In addition, since the ascent speed of volcanic gas is much larger than that of magma itself, it provides the earliest signals of subsurface processes such as the magma supply rate and/or the depth of the magma head. For this reason, volcanic gas composition is an important quantity to infer the current state of volcanic activity and to predict its transition in the future. In volcanic gas measurements, one of the conventional methods is the direct sampling and post-analyses in laboratory. However, such a direct sampling is often dangerous, especially when the volcano is erupting. In such a situation, measurements using UAVs are quite useful (Hashimoto et al., 2018). In this study, we review the recent progress in this research field, focusing on the case studies that we have been working on in these years.

Regarding the chemical composition, the Multi-GAS system is widely used, in which the sensors of some chemical species with a recording system are integrated into an apparatus and gas composition is directly measured on site. Recently, we made the apparatus smaller and lighter to mount on an unmanned aircraft. An electric-motor-type multi-rotor drone was used in the survey that was conducted two months after Mt. Ontake eruption in 2014 (Mori et al., 2016). This type of measurement can be done more easily in a field where we can use an engine-type compact unmanned helicopter that has much larger payload than small drones. In our experiment conducted in Noboribetsu, Hokkaido, we used the concentration meters of three gas species, which are relatively inexpensively available, and a thermo-hygrometer. We put them together in a net, hung it on an unmanned helicopter, and suspend it in the plume. The concentration ratios between CO_2, H_2S, SO_2, and H_2O were measured. At Kusatsu Shirane volcano, it has been proven that a trained researcher can perform similar operations with a drone.

With regard to gas emission rate, remote sensing of sulfur dioxide by an ultraviolet spectrometer is often used for volcano monitoring. The operation is normally performed on ground by driving a vehicle that mounts a measuring apparatus, looking the UV light in the sky. After the considerable miniaturization and weight reduction of the instruments in recent years, even an operation using a hobby-use drone has become possible (Tanaka and Mori, 2017).

In summary, volcanic gas measurements using UAVs are technically reaching a practical level. Further development in the research field is expected when the researchers acquire the operation skills of UAVs. We are also engaged in training and educational activities for improving such skills with the aid of the Next-generation Volcano Research and Human Resource Development Project by the MEXT.

Keywords: volcanic gas, chemical composition, drone, unmanned helicopter

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Repeated Drone Magnetic Survey over Usu Volcano, Hokkaido Japan

*Shigeo Okuma[1], Masahiko Makino[2], Tadashi Nakatsuka[1], Ayumu Miyakawa[1], Makoto Yanagida[3], Minoru Okumura[4]

1. Institute of Geology and Geoinformation, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST), 2. Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST), 3. Hanshin Consultants Co., Ltd., 4. Nippon Engineering Consultants Co., Ltd.

We have been developing a drone magnetic survey system using a portable magnetometer with a differential GNSS system (Okuma et al., 2018a). This time we employed a hexacopter with a diagonal axis distance of 995 mm and with a maximum payload of 5.7 kg (Okuma et al., 2018b). A main console of Geometrics G-858 Cs magnetometer, a NovAtel OEM615 GNSS receiver with its antenna and the GNSS data logger were attached to the drone. A Cs sensor was suspended from the drone by a string. We have tested flying attitudes and magnetic noise of the drone by changing a suspending length of the sensor cable. We concluded that an optimum cable length of our system was 0.85 m for surveys over rugged terrains because of the power of our drone. In this case, magnetic noise caused by the drone was estimated to be around 15 nT at the maximum by our experiments (Okuma et al., 2018b).

Using this drone magnetic survey system, we have conducted magnetic surveys over the Usu 2000 eruption area (Nishiyama craters area, Area A) and the southwestern flank of the main edifice of Usu volcano (Area B), Hokkaido Japan (Okuma et al., 2018b). In Area B, a curious magnetic anomaly had been observed by a previous helicopter-borne EM and magnetic survey in late 2000, which was flown at an altitude of 70–100 m above terrain along north–south survey lines and east–west tie lines, spaced 100 m and 1,000 m apart.

In May 2018, the drone surveys were flown at an altitude of 30 m above terrain along east–west survey lines (Area A) and north–south survey lines (area B), spaced 25 m apart. Total magnetic intensities were observed in every 0.1 seconds by the Cs magnetometer with GNSS positioning. According to data processing, the surveys were successful for mapping magnetic anomalies whose general pattern were well retrieved in the both areas, compared to known magnetic anomalies compiled from the 2000 survey.

Then, we applied the generalized mis-tie control method (Nakatsuka et al., 2009) to the magnetic anomalies of both 2000 and 2018 surveys in Area A and calculated temporal magnetic variations at crossover points. Although the survey specification of each survey was different, the result was successful to derive positive magnetic changes larger than 100 nT in and around intensive fumarolic areas of the 2000 eruption. The areas were characterized as apparent negative magnetic anomalies by the 2000 survey and are estimated to be underlain by Pleistocene volcanic rocks with reverse magnetization. Since the beginning of the eruption, the fumarolic activity gradually extended from the eruption center to the NNW along a ridge and lasted for several years. This implies that Pleistocene volcanic rocks constituting the area have been demagnetized by the strong fumarolic activity related to dyke intrusions at the 2000 eruption.

Based on the results above, it is concluded that drone magnetic survey is a promising method to derive long-term temporal magnetic changes and can play an important role to monitor volcanic activity.

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Keywords: Drone, UAS, UAV, Magnetic Survey, Repeated Magnetic Survey, Usu Volcano

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[J] Oral | S (Solid Earth Sciences)：S-TT Technology & Techniques

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | 304 3F

[S-TT47] Creating future of solid Earth science with high performance computing (HPC)

convener:Takane Hori(R&D Center for Earthquake and Tsunami, Japan Agency for Marine-Earth Science and Technology), Yuji Yagi(Graduate School of Life and Environmental Sciences, University of Tsukuba, Tsukuba), Katsuhiko Shiomi(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Takane Hori

Due to the development in computer science and computational science, large-scale or many times forward simulations and/or inversion analyses have become available recently. In solid Earth science, large-scale seismic wave propagation and crustal deformation with high fidelity models based on high resolution observation data have been demonstrated; uncertainty in crustal deformation caused by material properties and structures can be investigated based on many-time calculations for different material properties and structures; fault slip inversion analyses for non-Gaussian error distribution, etc. Thus, we will invite researchers who are applying HPC technology in forward simulations and inversion analyses and discuss how to improve more the collaboration between computer & computational sciences and solid Earth science. We are welcome submission by the researchers who are interested in this scope, especially students and young researchers.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[STT47-01] Expectations to more realistic Green's function with modeling errorfor the real-time estimation of the coseismic fault model

*Yusaku Ohta[1] (1.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[STT47-02] Development of high-performance low order unstructured implicit finite-element solvers for solid earth science problems

★Invited Papers

*Kohei Fujita[1], Tsuyoshi Ichimura[1], Takuma Yamaguchi[1] (1.Earthquake Research Institute, The University of Tokyo)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[STT47-03] Optimal spectral element method for elastic wave computation

*Kei Hasegawa[1], Nobuaki Fuji[2], Kensuke Konishi[3] (1.Earthquake Research Institute, University of Tokyo, 2.Institut de Physique du Globe de Paris, 3.Institute of Earth Sciences, Academia Sinica)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[STT47-04] Multi scale tsunami simulation from earthquake initiation to tsunami run-up into the coastal area and high performance particle simulator

*Mitsuteru Asai[1], Mikito Furuichi[2], Daisuke Nishiura[2] (1.Kyushu University, 2.JAMSTEC)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[STT47-05] Digital-Ensemble Concept for Making Resilient Society against Natural Hazard

*Satoru Oishi[1] (1.RIKEN Center for Computational Science)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[STT47-06] Expected Role of High Performance Computing to Promote Earthquake Research

★Invited Papers

*Naoshi Hirata[1] (1.Earthquake Research Institute, the University of Tokyo)

Expectations to more realistic Green's function with modeling errorfor the real-time estimation of the coseismic fault model

*Yusaku Ohta[1]

1. Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University

Rapid understanding of the magnitude of large earthquakes and their associated fault dimensions are extremely important. Recently, Geospatial Information Authority of Japan (GSI) and Tohoku University are jointly developing the GEONET real-time analysis system (REGARD). REGARD system rapidly estimates two types of coseismic fault models, which are slip distribution along the plate interface and single rectangular fault model, using permanent displacement field based on the real-time GNSS time series. Currently, REGARD adopted the maximum likelihood approach to estimate the optimum model. The system, however, has problem to be improved. The current system is difficult to estimate the quantitative uncertainty estimation of the obtained result because of the estimated result should contain both of the observation error of the real time GNSS and modeling error caused by the model settings including uncertainty of the Green’ s function. Among them, the uncertainty of the Green’ s function is the most serious problem. Currently, REGARD adopted the simple elastic half-space model. It should cause the large estimation uncertainty in the coseismic slip fault model especially in offshore region whose structure is complex due to plate subduction. Thus, the more realistic Green’ s function with quantitative uncertainty will be needed. I will briefly introduce current development status of REGARD and show the expectations to more realistic Greens’ function with modeling error realized by Monte Carlo simulation using the HPC technology.

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Development of high-performance low order unstructured implicit finite-element solvers for solid earth science problems

*Kohei Fujita[1], Tsuyoshi Ichimura[1], Takuma Yamaguchi[1]

1. Earthquake Research Institute, The University of Tokyo

Problems in solid earth science, such as crust deformation problems and earthquake wave propagation problems, involve large problem sizes with complex 3D geometry and heterogeneous material properties. Use of implicit low-order finite-element methods on high-performance computers are expected to enable such analyses; however, these methods are not straightforward to attain performance on modern computer architectures due to heterogeneity of the problem. Thus, we have been developing algorithms and implementations to improve performance of low-order finite-element methods targeting recent CPU and heterogeneous supercomputer systems. In this talk, we will introduce our development for the CPU based systems (e.g., K computer, Intel Xeon-Phi Knights Landing based Oakforest-PACS) as well as heterogeneous systems (e.g. NVIDIA GPU accelerated Piz Daint and Summit), and show some application examples using these high-performance computing enhanced methods.

Keywords: finite-element method, high-performance computing

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Optimal spectral element method for elastic wave computation

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1. Earthquake Research Institute, University of Tokyo, 2. Institut de Physique du Globe de Paris, 3. Institute of Earth Sciences, Academia Sinica

We introduce new numerical integration operators which compose the mass and stiffness matrices of a modified spectral element method for simulation of elastic wave propagation. While these operators use the same quadrature nodes as does the original spectral element method, they are designed in order that their lower-order contributions to the numerical dispersion error cancel each other. As a result, the modified spectral element method yields two extra-orders of accuracy, and is comparable to the original method of one order higher. The theoretical results are confirmed by numerical dispersion analysis and examples of computation of waveforms using our operators. Replacing the ordinary operators by those proposed in this study could be a non-expensive solution to improve the accuracy.

*A significant portion of this presentation was published in Computer Methods in Applied Mechanics and Engineering (doi: 10.1016/j.cma.2018.07.025).

Keywords: Elastic wave, Numerical analysis, Finite-Element Method, Spectral Element Method, Error optimization, Computational seismology

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Multi scale tsunami simulation from earthquake initiation to tsunami run-up into the coastal area and high performance particle simulator

*Mitsuteru Asai[1], Mikito Furuichi[2], Daisuke Nishiura[2]

1. Kyushu University, 2. JAMSTEC

Due to future tsunami disaster prevention planning, it is strongly desired a simulation tool that accurately predicts possible damage level for structures and human resources in the inundation area. For the tsunami run-up simulation, we must calculate the crustal deformation as an input of the initiation of tsunami wave around the seismic fault. A stagger elasticity theory, in which homogeneous and spatial infinity is assumed to formulate the theory, is applied in practical and conventional crustal deformation estimation. The elastic theory cannot consider the heterogeneous crustal structure in space and the fracture propagation in time. Therefore, there is no guarantee that the conventional tsunami simulation estimates the largest possible inundation. In this paper, we conducted a series of disasters simulation from earthquake scenario, crustal deformation and tsunami propagation sequentially in order to discuss the necessity of consideration of seismic fault rupture propagation in tsunami simulation.

When modeling the entire city with a high fidelity particle model, one must deal with an enormous number of degrees of freedom, and implementation of highly parallel calculation is indispensable. In this paper, we developed a computational algorithm with high parallelization efficiency for the liquid spreading phenomenon over a flat plane problem, for later apply on tsunami run-up simulation. In particular, we propose an expanding slice grid method with a dynamic load balancer to utilize maximum efficiency on memory utilization and computational speed.

At the end of this paper, high fidelity tsunami run-up simulation in Kochi City by the Expanding slice grid method were conducted, and the utility of the proposed method was discussed.

Keywords: Tsunami, Crustal deformation, Large Scale Computation

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Digital-Ensemble Concept for Making Resilient Society against Natural Hazard

*Satoru Oishi[1]

1. RIKEN Center for Computational Science

In order to designing resilient society including developing or renovating cities, infrastructure management like making redundant route for not only transportation but also suppling water, energy as well as waste, we need digital-twin for simulating situations under catastrophic disasters. Digital-twin is a concept meaning “a virtual model of process, product or service and the paring of virtual and physical worlds allows analysis of data and monitoring of systems to head off problems before they even occur, prevent downtime, develop new opportunities and even plan for the future by using simulations”, according to Marr (2017). Previously, digital-twin concept was used for product manufacturing through computer aided engineering (CAE) to examining the performance and duration of target manufacture like rocket engine. Now, we are using the word for designing resilient society against natural hazard because designing resilient society requires paradigm shift of disaster mitigation strategy from “government saves public and it costs” to “private invests cities through market”. Private sectors require precise statistics of impacts of natural hazard for considering investment, however, we could not expect the quantitative impact without numerical simulation of large-scale disaster.

Large-scale disaster simulations consists of solvers and urban construction objects. Integrated Engineering System (IES) has both functions (Hori et al. 2018). There are several solvers for each kind of disasters like earthquake and tsunami. However, urban construction objects have been made one by one. Therefore, it is required to develop a tool that automatically generates the detailed construction objects of urban buildings for target cities. O-tani et al. (2014) have been developing such an automation tool, named Data Processing Platform (DPP), so that it can deal with multiple numerical simulations including tsunami inundation and evacuation, and seismic response analysis of ground and buildings. We have implemented a MPI-based parallelization of DPP, then it has generated objects of urban cities in the whole Japan which includes about sixty million buildings. Now, once given a certain appropriate ground property and motion, a simulation-based assessment of disasters can be achieved for the whole Japan.

Digital-twin of urban structures gives quantitative impacts of earthquake by putting expected seismic wave which has been calculated or monitored through the seismic simulation. Simulation of the earthquake impact by using the pair of the seismic wave and its probability revealed the risk of the society numerically. It changes the concept of fragility curve coming from extrapolation of experience to physics-based numerical simulation with multi-scenario. In other word, we assume digital-ensemble concept for numerically calculated risk of natural disaster which is required for our paradigm that private invests cities through market.

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Keywords: Digital-Ensemble, Resilient Society, Quantitative Risk Assessment

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Expected Role of High Performance Computing to Promote Earthquake Research

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Headquarters for Earthquake Research Promotion (HERP) has been led earthquake observation, measurement, surveys and research in Japan for 20 years since the first 10-year basic comprehensive policy for the promotion set in April 23, 1999. During this 20 years, nation-wide basic observation networks have been established such as MOWLAS and GEONET. The observation data from the networks provide us rich information beneath Japan and are used by world-wide researchers discovering new phenomena such as slow earthquakes. On the other hand, data analysis methods and models, which are assumed in the analyses, are rather simple and not enough to extract rich information from the data. The necessity of the 3D realistic structure model for the data analyses has become clearer recently because of the ocean bottom observation data, such as the postseismic deformation of the 2011 Tohoku earthquake. To construct realistic model for the complex subduction zone in Japan, where two plates are subducting, large scale high-fidelity models are required and high performance computing is necessary to calculate crustal deformation and/or seismic wave propagation with the realistic models. For the next 10 years, we expect that high-performance computing will play an intrinsic role to promote earthquake research through higher level data analyses with realistic 3D structure in and around Japan. This will lead us a new stage in earthquake science.

Keywords: Headquarters for Earthquake Research Promotion, The basic comprehensive policy, Higher level data analyses

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-CG56] Ocean Floor Geosciences

convener:Kyoko Okino(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:shuhei Totsuka, Ayanori Misawa

Most of Earth's volcanism and much of its tectonic activity occur on and beneath the seafloor. Various phenomena on the seafloor are closely linked to plate tectonics, Earth and atmosphere. Seafloor rocks and sediments record Earth's evolution and heat and material fluxes on the Earth. Ocean Floor Geosciences session covers a broad range of research on LIPs, crustal movement and structure etc. Any fields of research and approach are welcomed. The session aims to encourage discussion among scientists from different study fields and to integrate our understanding of ocean floor.
The session is co-chaired by K. Tadokoro (Nagoya Univ.), O. Ishizuka (AIST), T. Toki (Univ. Ryukyus), and N. Takahashi (JAMSTEC).

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SCG56-01] The restoration of precipitation record of iron hydroxide about seven years in Nagahama Bay, Satsuma Iwo-jima, Kagoshima.

*Naoya Sakamoto[1], Shoichi Kiyokawa[2] (1.Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2.Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SCG56-02] Mineralogical and geochemical study of hydrothermal deposits beneath the seafloor at the Gondou field in the Okinawa Trough

*Shuhei Totsuka[1], Jun-ichiro Ishibashi[2], Kazuhiko Shimada[2], Kei Ikehata[3], Hideaki Machiyama[4], Koichi Iijima[4], Hirofumi Yamamoto[4], Hidenori Kumagai[4], Ken Ikehara[5], Toru Yamasaki[5], Yutaro Takaya[6], Toshiro Nagase[7], Thomas Tindell[8], Kotaro Yonezu[8], Yuki Tada[8] (1.Department of Earth and Planetary Sciences, Graduate School of Sciences, Kyushu University, 2.Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University, 3.Faculty of Life and Environmental Sciences, University of Tsukuba, 4.Research and Development Center for Submarine Resources, JAMSTEC, 5.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 6.Department of Resources and Environmental Engineering School of Creative Science and Enginerring, Waseda University, 7.Tohoku University Museum, 8.Department of Earth Resources Engineering, Faculty of Engineering, Kyushu University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SCG56-03] Strontium isotope study of sulfate minerals obtained by scientific drilling from seafloor hydrothermal fields in the Okinawa Trough

Akihi Tsutsumi[1], Naru Tsukamoto[1], Kazuhiko Shimada[1], *Jun-ichiro Ishibashi[1], Ryuichi Shinjo[2] (1.Department of Earth and Planetary Sciences, Kyushu University, 2.Faculty of Science, University of Ryukyus)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SCG56-04] Numerical modeling of seafloor hydrothermal system in the Izena Caldron, Okinawa Trough

*Shohei Albert Tomita[1], Katsuaki Koike[1], Tada-nori Goto[1], Katsuhiko Suzuki[2], Takafumi Kasaya[2] (1.Graduate School of Engineering, Kyoto University, 2. Japan Agency for Marine-Earth Science and Technology)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SCG56-05] Electrical conductivity and spectral IP characteristics in the rock samples obtained in seafloor hydrothermal area and interpretation of them

*Yusuke Ohta[1], Tada-nori Goto[1], Katsuaki Koike[1], Weiren Lin[1], Koki Kashiwaya[1], Tadai Osamu[3], Takafumi Kasaya[2], Toshiya Kanamatsu[2], Hidenori Kumagai[2], Hideaki Machiyama[2] (1.Kyoto University, 2.Japan Agency for Marine-Earth Science and Technology, 3.Marine Works Japan)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SCG56-06] Geological structure north offshore Ishigaki-Jima estimated from seismic reflection survey

*Ayanori Misawa[1], Seishiro Furuyama[2,1], Masahiko Sato[3,1], Jih-Shin Chang[1], Takahiko Inoue[1], Kohsaku Arai[1] (1.Geological Survey of Japan, AIST, 2.Tokyo University of Marine Science and Technology, 3.The University of Tokyo)

The restoration of precipitation record of iron hydroxide about seven years in Nagahama Bay, Satsuma Iwo-jima, Kagoshima.

*Naoya Sakamoto[1], Shoichi Kiyokawa[2]

1. Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2. Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University

Satsuma Iwo-jima, located 38km south of Kyusyu island, Japan, is volcanic island in the northwestern rim of Kikai caldera. In Nagahama Bay the acidic mineral-rich hot springs cause various tonal changes of seawater. And oxidation of Fe^{2+} ions discolors the seawater into a reddish brown (Shigaura and Tazaki,.2001). This Bay is a semi-closed environment, iron hydroxide precipitation and deposition are likely to occur and precipitation rate of 33 cm/year. (Kiyokawa and Ueshiba, 2015). We restored the depositional record from10 m diameter and 1 m long acrylic plastic cores (total 50 core) that collected in Nagahama Bay from 2009 to 2018 (about 9 years). In this study, we revealed that the relationships precipitation of iron hydroxide and weather and seafloor environment in Nagahama Bay. the following studies were conducted: (a) Observation of sediment trap (CT image and observation of sediments using polarizing microscope and electronic microscope). (b) Meteorological observation and a survey of typhoon records in the past in Nagahama Bay. (c) Seafloor observation (Temperature in sediments and water pressure). By combining the sediment records in traps (34 Traps) from seven years from 2011, the stratigraphy of the total layer thickness of 5 m 70 cm was restored. From the CT image, it is divided into a high-density layer (iron hydroxide layer containing sand particles: 35 layers), a low-density layer (iron hydroxide layer: 28 layers), a high-density low-density alternate layer (7 layers) Seven thick high density - low density layer - high density low density alternate cycle was seen. Also, from the observation of smear slides and SEM, in the high-density layer, there are a structure in which iron hydroxide particles of about 100 μm aggregate to several μm, a volcanic glass of several tens to 200 μm, diatoms, the low-density layer mainly contains 50 nm of the iron hydroxide particles agglomerated to several μm in size. 37 typhoons approached or passed near Satsuma Iwo-Jima from June 2011 to September 2018. 17 of them were huge typhoons (Under 960hPa, over 30m/s). From meteorological data in Nagahama Bay, there were six Typhoon approached or passed between April 2018 and September 2018. When the typhoon passes south or west side of Satsuma Iwo-jima, it becomes south wind. The thick white layer was precipitated by the influence of the typhoon. So, the April to October the thick fine-grained sand layers and iron hydroxide layer precipitated due to typhoon. It is considered that fine-grained sand iron hydroxide alternating layers precipitaed in November to March without the influence of typhoon. When the typhoon passes south or west side of Satsuma Iwo-jima, it becomes south wind, Thick fine sand layer containing about 20 to 70% quartz and volcanic ash. Observed trap sediments, Trap sediments are composed iron hydroxide particles, and we consider that it is a chemical precipitation. The low-density layer excluding the high-density layer and the thickness of the alternating layer are recorded as iron hydroxide as the formation layer, and its layer thickness is 220 cm. The iron hydroxide accumulated on the Nagahama Bay (about 6000 m^2) in 7 years and it reached 13,200 m^3. As the interstitial water of this sediment is about 80%, the dry weight of iron hydroxide has reached 8,976 tons in seven years. And about 1282 tons of iron hydroxide were recorded in the formation every year in this Bay.

Keywords: Satsuma Iwo-jima, precipitation of iron hydroxide

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Mineralogical and geochemical study of hydrothermal deposits beneath the seafloor at the Gondou field in the Okinawa Trough

*Shuhei Totsuka[1], Jun-ichiro Ishibashi[2], Kazuhiko Shimada[2], Kei Ikehata[3], Hideaki Machiyama[4], Koichi Iijima[4], Hirofumi Yamamoto[4], Hidenori Kumagai[4], Ken Ikehara[5], Toru Yamasaki[5], Yutaro Takaya[6], Toshiro Nagase[7], Thomas Tindell[8], Kotaro Yonezu[8], Yuki Tada[8]

1. Department of Earth and Planetary Sciences, Graduate School of Sciences, Kyushu University, 2. Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University, 3. Faculty of Life and Environmental Sciences, University of Tsukuba, 4. Research and Development Center for Submarine Resources, JAMSTEC, 5. Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 6. Department of Resources and Environmental Engineering School of Creative Science and Enginerring, Waseda University, 7. Tohoku University Museum, 8. Department of Earth Resources Engineering, Faculty of Engineering, Kyushu University

The Gondou field is located at the western flank of the Daisan-Kume Knoll, at a water depth of 1330-1470 mbsl (meters below sea level). Many hydrothermal spire and mound structures were recognized in an area of ca. 1400 m ×400 m (Minami and Ohara, 2017). Previous study (Ishikawa et al., 2016) reported high Cu content in hydrothermal deposits collected from the Gondou field. Scientific drilling was performed by J-MARES during the SIP Integrated Ocean Resource Surveying System JM17-04 Cruise from October to November, 2017. Sediment cores were obtained from 5 Sites in Southern area of the Gondou field using BMS (Benthic Multi-coring System) installed on *Shincho-maru*. Mineralogical and geochemical studies of sulfide minerals in the obtained cores were conducted by microscopic observations, electron probe microanalyzer (EPMA) analysis, and X-ray diffractometer (XRD) analysis.
Massive and disseminated sulfide layers were recognized at Site GDUC06, which was covered with silty clay sediment and underlaid by silicified volcaniclastics. Two distinctive types of massive sulfide were recognized; the upper one is composed of sphalerite, pyrite, galena and associated with barite, while the lower one is composed of pyrite, chalcopyrite and associated with quartz, illite and chlorite. The underlaid silicified volcaniclastics layer includes pyrite. It is notable that formation of sphalerite-rich massive sulfide and chalcopyrite-rich sulfide is comparable to the black ore and yellow ore found in Kuroko-type deposits.
Similarity to the Kuroko-type deposits can be found in chemical composition of sulfide minerals. Iron content in sphalerite from the Gondou field ranges from 0.22 to 5.72 atm%, which would be comparable to the reported value from 0.07 to 0.35 atm% for the Matsumine and the Shakanai deposits of the Hanaoka mine, one of typical Kuroko-type deposits in the Hokuroku district (Shimazaki and Horikoshi, 1990)). Tetrahedrite-tennantite series occurred in the sphalerite-rich massive sulfide exhibit high As/(As+Sb) and Zn/Fe ratios, which are close to the range found in massive sulfide from the Hanaoka mine (Shikazono and Kouda, 1979). Since chemical composition of sulfide minerals is considered to reflect chemical condition such as f_{S2} during the formation, these similarities would provide keys to understand the mineralization processes.

Acknowledgements
This study is conducted under the framework of the Next-Generation Technology for Ocean Resources Exploration Project, Cross-ministerial Strategic Innovation Promotion Program (SIP) by the Japanese cabinet office. We are thankful to J-MARES (Research and Development Partnership for Next Generation Technology of Marine Resources Survey) for providing sediment cores used in this study.

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Keywords: Submarine hydrothermal deposits, Back-arc basin

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Strontium isotope study of sulfate minerals obtained by scientific drilling from seafloor hydrothermal fields in the Okinawa Trough

Akihi Tsutsumi[1], Naru Tsukamoto[1], Kazuhiko Shimada[1], *Jun-ichiro Ishibashi[1], Ryuichi Shinjo[2]

1. Department of Earth and Planetary Sciences, Kyushu University, 2. Faculty of Science, University of Ryukyus

Since hydrothermal fields in the Okinawa Trough develop within sediment-rich geologic setting of a backarc rifting in the continental margin, significant fluid mineral interactions and fluid migrations are expected to occur within the sediment layer. We have demonstrated that pore fluid chemistry in the vicinity of active vents in these hydrothermal fields were represented by two distinctive components; one is entrained-seawater component and the other is hydrothermal component which has the same origin as the vent fluid. Sulfate minerals such as barite and anhydrite are known to occur abundantly in and around the hydrothermal fields, because they form by precipitation caused by encounter of these two components. Isotope ratios of Sr incorporated in these sulfate minerals would provide key information to understand these processes.

We studied barite and anhydrite occurred in sediment cores obtained from three hydrothermal fields, Aki Site at the Iheya North Knoll, Hakurei field at the Izena Hole and Gondou field at the western flank of Dai-san Kume Knol, in the mid-Okinawa Trough. The sediment cores were obtained by scientific drilling campaigns conducted in 2014, 2016 and 2017 under the framework of the Next-Generation Technology for Ocean Resources Exploration Project. Determination of Sr isotope ratios was conducted employing LA-ICP-MC-MS (laser ablation inductively couple plasma multi-collector mass spectrometry) technique, which enabled multi-point measurement of a single mineral crystal or mineral aggregate using a polished section. Using the same polished section, Sr/Ba ratio of barite or Sr/Ca ratio of anhydrite was determined by EPMA (electron probe micro analyzer) analysis.

Strontium isotope ratios of anhydrite in all three fields were close to that of the present-day seawater with a few exceptions. Strontium isotope ratios of barite showed wider ranges biased from that of the seawater. Higher $^{87}Sr/^{86}Sr$ ratios are recognized in Hakurei field while lower $^{87}Sr/^{86}Sr$ ratios in Aki site and Gondou field. Difference in Sr isotope ratio between barite and anhydrite is attributed to that barite precipitates from mixture of the hydrothermal fluid and seawater while anhydrite precipitates from heated-seawater. As supportive evidence for this idea, we confirmed Sr isotope ratio in the sediment core from Hakurei field agreed with the reported value of barite in an inactive chimney-shape sulfide/sulfate breccia had been collected. Occurrence of barite in limited layers whereas common occurrence of anhydrite in the sediment core would be attributed to a result of subseafloor migration of the hydrothermal fluid.

Acknowledgements

This study was conducted under the framework of the Next-Generation Technology for Ocean Resources Exploration Project, Cross-ministerial Strategic Innovation Promotion Program (SIP) funded by the Japanese cabinet office. A part of the sediment cores used in this study were provided from J-MARES (Research and Development Partnership for Next Generation Technology of Marine Resources Survey).

Keywords: Seafloor hydrothermal activity, seafloor massive sulfide, LA-ICP-MC-MS, subseaflor fluid migration

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Numerical modeling of seafloor hydrothermal system in the Izena Caldron, Okinawa Trough

*Shohei Albert Tomita[1], Katsuaki Koike[1], Tada-nori Goto[1], Katsuhiko Suzuki[2], Takafumi Kasaya[2]

1. Graduate School of Engineering, Kyoto University, 2. Japan Agency for Marine-Earth Science and Technology

Regional heat flow measurements in the Izena Caldron and detailed heat flow measurements in the Jade hydrothermal field situated on the NE slope of the Izena Caldron were conducted by Kinoshita et al. (1997). They clarified that an enormous heat flow variation (10^{-1} to 10^{2}W/m^2) in the Jade site. In addition, near the Jade black smoker, the heat flow varies from >30W/m^2 at a hydrothermally altered area to 1.7W/m² within 100m distance from it. From large-scale heat flow measurements, 500m-wide rectangular zone (hereinafter called “Corridor”) with high heat flow (>1W/m^2) along the NE suggests the existence of linear heat source under the Corridor. In the research cruise of CK16-05, drilling and temperature measurements using Thermo Label were conducted in the Hakurei site, hydrothermal area of southern part in the Izena Caldron, and high temperature over 290℃ was measured at C9026. Although many heat flow data were obtained in the Izena Caldron, no heat flow data was obtained in the Hakurei site. Therefore, in this study, we conducted dense heat flow survey at 11 points with 550m measurement length and 50m measurement interval along EW direction in the Hakurei site in the research cruise of KM18-08C in September 2018. Moreover, we conducted a numerical simulation of multi-phase fluid flow using TOUGH2 to reveal distribution of physical properties and hydrothermal fluid flow pattern in the seafloor hydrothermal systems in a back-arc basin.

Heat flow value is calculated as the product of temperature gradient and thermal conductivity. In this study, we obtained temperature gradient values on the seafloor using a stand-alone heat flow (SAHF) meter operated by ROV. In the simulation, the size of study area was defined as 4.8×5.6×1.7 km and the seafloor was set as the top boundary where the temperature and pressure were fixed at 4 ℃ and hydrostatic condition, respectively. As the initial condition, we assigned the hydrostatic pressure, the average thermal gradient 0.16 ℃/m around the Izena Cauldron except for the hydrothermal area, and physical rock properties by referring to the borehole data. The values of discharge rate, mass in rate, and permeability (k) were adjusted appropriately through trial and error. As the geologic settings, we set conduits with $k = 1.0\times10^{-13}$m^2 under the discharge area of Jade and Hakurei sites and fault with k=3.0×10^{-14}m^2 under the Corridor along the vertical direction from bottom to surface, to realize the vertical flow of hydrothermal fluids from the deep part. In addition, caprock with k= 1.0×10^{-16}m^2 was located near the surface to generate the lateral hydrothermal fluid flow. Other places were set as volcanic rock with k= 1.0×10^{-14}m^2. Under these conditions, we simulated a natural state condition.

From heat flow measurements, we clarified very high heat flow (76W/m^2) at a 150m west site covered by mud from C9027, which suggests an existence of hydrothermal fluid flow beneath the seafloor at shallow part. In other places, the heat flow was varied from 3 to 12W/m^2. Through the simulation, a plausible large-scale temperature distribution and flow pattern were obtained. In terms of heat flow, by comparing the calculated and measured values along the Corridor and Hakurei site, the calculated values were conformed to correspond well with the measured values. According to the sensitivity analysis, the importance of caprock and conduit in the seafloor hydrothermal system was revealed. By a model without the conduit, the hydrothermal fluids did not ascend to the seafloor along the vertical direction and the tendency of measured heat flux could not be reproduced. Furthermore, by a model without caprock, heat cannot be preserved because it flows in all directions and the calculated heat flux did not accord with the observed flux. Consequently, the location and physical properties of the conduit and caprock were identified as the critical control factors on the accuracy of hydrothermal fluid flow simulation.

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Keywords: Izena Caldron, Numerical simulation, Seafloor hydrothermal system, TOUGH2, Heat flux

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Electrical conductivity and spectral IP characteristics in the rock samples obtained in seafloor hydrothermal area and interpretation of them

*Yusuke Ohta[1], Tada-nori Goto[1], Katsuaki Koike[1], Weiren Lin[1], Koki Kashiwaya[1], Tadai Osamu[3], Takafumi Kasaya[2], Toshiya Kanamatsu[2], Hidenori Kumagai[2], Hideaki Machiyama[2]

1. Kyoto University, 2. Japan Agency for Marine-Earth Science and Technology, 3. Marine Works Japan

Various geophysical explorations have recently been conducted in the seafloor hydrothermal field to estimate the scale of the seafloor massive sulfide. However, information obtained from geophysical exploration is limited. Therefore, in order to interpret the geological information under the seafloor based on the results of the geophysical exploration, it is necessary that the detailed analysis is carried out on hard-rock and sediment samples obtained on the surface and the lower of the seafloor, for comparing their features with results of geophysical exploration. In this study, we obtained rock samples in several hydrothermal fields; then we measured various physical properties and analyzed the chemical compositions, and we also investigated their relationship. As for physical properties, in particular, electric conductivity and spectral IP characteristics were investigated in detail. In samples with high electrical conductivity, some sulfide minerals, known to have high conductivity, were found to be contained. In spectral IP, some samples having a plurality of frequencies causing a peak in the phase difference of the voltage across the sample was observed. It is thought that this is due to the mixture of a plurality of sulfide minerals having different average particle sizes. In fact, in this study, we succeeded in reproducing the frequency characteristics of the sample by the rock physics model we constructed, assuming such characteristics. In the future work, we will study the consistency of the phenomena observed in this research and our new rock physics model through experiments on artificial samples using plural sulfide minerals of different particle sizes and types.

Keywords: Electrical conductivity, Spectral IP

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Geological structure north offshore Ishigaki-Jima estimated from seismic reflection survey

*Ayanori Misawa[1], Seishiro Furuyama[2,1], Masahiko Sato[3,1], Jih-Shin Chang[1], Takahiko Inoue[1], Kohsaku Arai[1]

1. Geological Survey of Japan, AIST, 2. Tokyo University of Marine Science and Technology, 3. The University of Tokyo

Geological Survey of Japan (GSJ), AIST conducted the marine geological survey cruise around the Ishigaki-Jima, Ryukyu Islands using R/V Hakurei (Japan Oil, Gas and Metals National Corporation) in August 2018. This cruise deployed high-resolution Multi-Channel Seismic (MCS) reflection, Multi-Beam Echo Sounder (MBES) swath bathymetry, gravity observation, and magnetic field observation. This presentation shows the geological structure around the Ishigaki-Jima based on MCS profiles, MBES swath bathymetry, gravity anomaly, and magnetic anomaly data.

Two remarkable unconformities are recognized in the sedimentary sequence offshore northward Ishigaki-Jima, separating the sedimentary sequence in the slope region into three layers. In the offshore northward Ishigaki-Jima, northwestward-dipping normal faults are recognized at the NE-SW trending geomorphic lineament. Developments of normal faults suggest the involvement of the extensional stress associated with the back-arc lifting of the Okinawa Trough. Since one remarkable unconformity is recognized in the sedimentary sequence in the Okinawa Trough, separating the sedimentary sequence into two layers. West of the Ishigaki Knolls, many of ENE-WSW trending normal faults are recognized. These normal faults are appearing clearly on the seafloor and are identified as ENE-WSW trending lineaments. Along with the development of normal faults, the depression-like morphology is formed from the Ishigaki Knolls to westward in the Okinawa Trough. We consider that the depression-like morphology bounding the ENE-WSW trending normal faults are the most recent structural feature. In this presentation, we will show the latest results of 2018 survey cruise and discuss the origin of the depression-like morphology.

Keywords: Ryukyu Arc, Ishigaki-Jima, Okinawa Trough, Normal fault, submarine volcano

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-CG56] Ocean Floor Geosciences

convener:Kyoko Okino(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Keishiro Azami, Erika Tanaka

Most of Earth's volcanism and much of its tectonic activity occur on and beneath the seafloor. Various phenomena on the seafloor are closely linked to plate tectonics, Earth and atmosphere. Seafloor rocks and sediments record Earth's evolution and heat and material fluxes on the Earth. Ocean Floor Geosciences session covers a broad range of research on LIPs, crustal movement and structure etc. Any fields of research and approach are welcomed. The session aims to encourage discussion among scientists from different study fields and to integrate our understanding of ocean floor. The session is co-chaired by K. Tadokoro (Nagoya Univ.), O. Ishizuka (AIST), T. Toki (Univ. Ryukyus), and N. Takahashi (JAMSTEC).

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SCG56-07] The first report of the evidence for hydrothermal activity in old oceanic plate

*Keishiro Azami[1], Shiki Machida[2], Naoto Hirano[3], Tetsu Kogiso[4], Yasuhiro Kato[1,2] (1.Department of System Innovation, School of Engineering, The University of Tokyo, 2.Ocean Resources Research Center for Next Generation, Chiba Institute of Technology, 3.Center for Northeast Asian Studies, Tohoku University, 4.Graduate School of Human and Environmental Studies, Kyoto University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SCG56-08] X-ray computed tomography characterization of the distribution of biogenic apatite and sedimentary structures in pelagic clay around Minamitorishima Island, western North Pacific

*Yoichi Usui[1], Koichi Iijima[1], Hideaki Machiyama[1], Yuji Ichiyama[2,1], Erika Tanaka[3], Koichiro Fujinaga[4,3], Kazutaka Yasukawa[3,4] (1.Japan Agency for Marine-Earth Science and Technology, 2.Chiba University, 3.The University of Tokyo, 4.Chiba Institute of Technology)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SCG56-09] Geochemistry and distribution of REY-rich mud in the eastern off the Takuyo-Daigo Seamount within the Minamitorishima EEZ

*Koichiro Fujinaga[1,2], Kazutaka Yasukawa[3,1], Tatsuo Nozaki[4,2,1,5], Shiki Machida[1,2], Yutaro Takaya[6,2,1], Junichiro Ohta[1,2], Moei Yano[3], Ryo Shimomura[3], Erika Tanaka[3], Kazuhide Mimura[3], Koichi Horinouchi[3], Kenji Matsumoto[3], Yoichi Usui[4], Hirofumi Yamamoto[4], Kentaro Nakamura[3], Yasuhiro Kato[2,3,1], KM17-14C cruise members (1.Ocean Resources Research Center for Next Generation, Chiba Institute of Technology, 2.Frontier Research Centerfor Energy and Resources, School of Engineering, The University of Tokyo, 3.Department of Systems Innovation, School of Engineering, The University of Tokyo, 4.Japan Agencyfor Marine-Earth Science and Technology, 5.Department of Planetology, Graduate Schoolof Science, Kobe University, 6.Department of Resources and Environmental Engineering School of Creative Science and Engineering, Waseda University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SCG56-10] Extended lateral correlation of deep-sea sediments around the Minamitorishima EEZ based on downhole variation of bulk chemical composition

*Erika Tanaka[1], Kentaro Nakamura[1], Kazutaka Yasukawa[1,2], Koichiro Fujinaga[2], Koichi Iijima[3], Shiki Machida[2], Yasuhiro Kato[1,2] (1.School of Engineering, The University of Tokyo, 2.ORCeNG, Chiba Institute of Technology, 3.JAMSTEC)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SCG56-11] Tectonics of the abyssal basins surrounding the Ontong Java Plateau

*Masao Nakanishi[1], Shoka Shimizu[2], Daisuke Suetsugu[3], Takashi Sano[4] (1.Department of Earth Sciences, Graduate School of Science, Chiba University, 2.Department of Earth Sciences, Graduate School of Science and Technology, Chiba University, 3. Department of Deep Earth Structure and Dynamics Research, Japan Agency for Marine-Earth Science and Technology, 4.Department of Geology and Paleontology, National Museum of Nature and Science)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SCG56-12] **The Cretaceous Normal Superchron: records from the Pacific, Indian and Atlantic oceanic crust**

*Nobukazu Seama[1,2], Jerome Dyment[3], Taichi Sato[4,5], Yves Gallet[6], Kyoko Okino[7], Roi Granot[8], Yoshifumi Nogi[9], Nobutatsu Mochizuki[10], Toshitsugu Yamazaki[7] (1.Department of Planetology, Kobe University, 2.KOBEC (Kobe Ocean-Bottom Exploration Center), Kobe University, 3.Institut de Physique du Globe de Paris, 4.National Institute of Advanced Industrial Science and Technology, 5.The Institute for Geoscience Research (TIGeR), Curtin University , 6.French Centre National de la Recherche Scientifique, 7.Atmosphere and Ocean Research Institute, The University of Tokyo, 8.Department of Geological and Environmental Sciences, Ben-Gurion University, 9.National Institute of Polar Research, 10.Priority Organization for Innovation and Excellence, Kumamoto University)

The first report of the evidence for hydrothermal activity in old oceanic plate

*Keishiro Azami[1], Shiki Machida[2], Naoto Hirano[3], Tetsu Kogiso[4], Yasuhiro Kato[1,2]

1. Department of System Innovation, School of Engineering, The University of Tokyo, 2. Ocean Resources Research Center for Next Generation, Chiba Institute of Technology, 3. Center for Northeast Asian Studies, Tohoku University, 4. Graduate School of Human and Environmental Studies, Kyoto University

A petit-spot monogenic volcano erupted on flexural part of lithosphere are reported from the world ocean [1]. Many of studies about petrology, geochemistry and geochronology of petit-spot volcanos had been done to understand their origin and nature of the asthenosphere. However, there has not been any studies about hydrothermal activity because nobody has ever observed in-situ eruption of petit-spot volcanos. As petit-spot volcanic activity ubiquitously occurs in the world ocean despite its small volume, the hydrothermal activity in petit-spot volcanos must be an important process for metal flux from seafloor to ocean.

During the cruise KS-18-9 of *R/V Shinsei-maru* in August 2018, we collected some ferromanganese oxides by dredge in offshore of Fukushima prefecture where simultaneously corrected basalts show youngest eruption in previously reported petit-spot volcanoes of NW Pacific (i.e. very few alteration of glass). The metal luster and massive texture of the ferromanganese oxides are typical features of hydrothermal origin. Hence, we defined geochemical and mineralogical features of the ferromanganese oxides using (μ)XRF, ICP-MS and XRD.

Based on the ternary plot of (Ce + Y + Zr) vs. (Ni + Cu) vs. (Mn + Fe), all samples are plotted into the area of hydrothermal origin[2]. REE patterns show negative Ce anomaly and low REE content which are character of hydrothermal origin[3] besides low La/Lu ratio as low temperature hydrothermal deposits rather than high temperature (~ 350 ℃) hydrothermal deposits. The samples contain 7 Åmanganate (birnessite), quartz, plagioclase and smectite. 7 Åmanganate indicates low temperature hydrothermal activity[4] as well. As the petit-spot volcanic activity is unique heat source for hydrothermal activity at the old oceanic plate (approximately 130 Ma). Otherwise, the hydrogenetic rim of some samples which are characterized by vernadite and enrichment of Cu and Ni implies cessation of the hydrothermal activity.

This is the first report of the presence of hydrothermal activity on an old oceanic plate in NW Pacific. The hydrothermal activity possibly occurred on the foot of petit-spot knolls because hydrothermal vents and mounds, and ferromanganese samples showing sign of hydrothermal have never been found during dives of submersible *SHINKAI 6500*[5], which explore along the slope of the knoll. Petit-spot volcanoes must be more simple hydrothermal system than others because of simple heat supply from a monogenetic eruption. Hence, it is the most suitable example to understand a complete process of single hydrothermal circulation. Detailed investigations by submersible *SHINKAI 6500* are highly required to define the hydrothermal system and the metal flux from petit-spot to ocean in the future.

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Keywords: Petit-spot volcano, Ferromanganese oxide, Hydrothermal activity

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X-ray computed tomography characterization of the distribution of biogenic apatite and sedimentary structures in pelagic clay around Minamitorishima Island, western North Pacific

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The apparent absence of visible sedimentary structures in pelagic clay often humpers their systematic classification into lithostratigraphy. On the other hand, large variation in biogenic apatite content in some pelagic clay has been recently recognized. Because the density of apatite is higher than the bulk of pelagic clay, the spatial distribution of apatite may be detected through physical properties to detect sedimentary structures. Biogenic apatite in pelagic clay hosts rare earth elements and yttrium (REY), so capturing their distribution is also important for resource exploration. Here we examine non-destructive X-ray computed tomography (CT) in comparison with chemical analysis of REY and P_2O_5 for piston cores obtained around Minamitorishima Island. The depth profile of CT-based density estimates matches well with the direct measurements of bulk density and gamma-ray attenuation data. The density profiles also show clear positive correlation with the REY and P_2O_5 profiles. Some deviation is attributed to the presence of micro Mn nodules, which show characteristic textural pattern on CT images and are easy to distinguish. Moreover, X-ray CT reveals the relationship between sedimentary structures and the distribution of biogenic apatite: biogenic apatite can be transported vertically by bioturbation (burrowing) for more than 30 cm, while there are thin (<10 cm) layers of high apatite content where burrowing is less severe. These features can be overlooked by visual inspections or conventional chemical analysis of discrete samples. Our results demonstrate X-ray CT as a rapid and complementary tool to study biogenic apatite apatite and REY distribution as well as sedimentary structures within pelagic clay.

Keywords: pelagic clay, X-ray CT, sedimentary structures

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Geochemistry and distribution of REY-rich mud in the eastern off the Takuyo-Daigo Seamount within the Minamitorishima EEZ

*Koichiro Fujinaga[1,2], Kazutaka Yasukawa[3,1], Tatsuo Nozaki[4,2,1,5], Shiki Machida[1,2], Yutaro Takaya[6,2,1], Junichiro Ohta[1,2], Moei Yano[3], Ryo Shimomura[3], Erika Tanaka[3], Kazuhide Mimura[3], Koichi Horinouchi[3], Kenji Matsumoto[3], Yoichi Usui[4], Hirofumi Yamamoto[4], Kentaro Nakamura[3], Yasuhiro Kato[2,3,1], KM17-14C cruise members

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In 2013, we discovered deep-sea sediment containing 400 –8,000 ppm of total rare-earth elements and yttrium (REY), which was termed “REY-rich mud”, within the Japanese exclusive economic zone (EEZ) around the Minamitorishima Island (Kato et al., 2013; Iijima et al., 2016; Fujinaga et al., 2016; Ohta et al., 2016; Nakamura et al., 2016; Takaya et al., 2018; Yasukawa et al., 2018). To clarify the mineralogical/chemical characteristics and distribution of the REY-rich mud in the Minamitorishima EEZ, we conducted nine research cruises over five years. During the KM17-14C cruise by *R/V KAIMEI* from December 16th, 2017 to January 7th, 2018, we investigated the distribution of the REY-rich mud in the eastern off the Takuyo-Daigo Seamount within the Minamitorishima EEZ, one of the most promising areas for REY-rich mud development. We collected five sediment cores by piston/gravity coring, and implemented bulk chemical analyses by using inductively coupled plasma quadrupole mass spectrometry (ICP-QMS) for trace and rare-earth elements, and X-ray fluorescence (XRF) for major elements. In this presentation, we report the sedimentological and geochemical features of the deep-sea sediments including REY-rich mud, and discuss the distribution of the REY-rich mud in the eastern off the Takuyo-Daigo Seamount.

Keywords: rare earth elements and yttrium (REY), REY-rich mud, deep-sea sediment, Minamitorishima Island, deep-sea mineral resources

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Extended lateral correlation of deep-sea sediments around the Minamitorishima EEZ based on downhole variation of bulk chemical composition

*Erika Tanaka[1], Kentaro Nakamura[1], Kazutaka Yasukawa[1,2], Koichiro Fujinaga[2], Koichi Iijima[3], Shiki Machida[2], Yasuhiro Kato[1,2]

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Deep-sea sediments extremely enriched in rare-earth elements and yttrium (REY), showing up to 8,000 ppm of total REY concentration (ΣREY), exist within the Japanese exclusive economic zone (EEZ) near Minamitorishima Island in the western North Pacific Ocean [1, 2]. These deposits have stimulated interest as a new and highly promising mineral resource for REY. However, the number, occurrence depth and maximum ΣREY content of these REY-enriched layers appear to be quite variable, which makes it difficult to directly compare REY content peaks in different cores, and to investigate the geological factors controlling their formation and distribution.

Based on a careful consideration of a large geochemical dataset, we have recently recognized that deep-sea sediments within the Minamitorishima EEZ can be divided into nine types of stratigraphic layers, including three distinct REY peaks, with characteristic chemical compositions [3]. These layers deposited in a specific sequence and have lateral continuity in the Minamitorishima EEZ [3], which enables us to correlate the REY peaks in different cores.

In this study, we newly applied the chemostratigraphy to the piston core samples around the Minamitorishima EEZ collected by the MR16-07 cruise. The multi-elemental analysis suggests that the chemostratigraphy spreads out of the Minamitorishima EEZ and reaches at least ~500 km southeast of Minamitorishima Island.

References

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Keywords: REY-rich mud, chemostratigraphy, Minamitorishima Island, pelagic clay

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Tectonics of the abyssal basins surrounding the Ontong Java Plateau

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We present the tectonics of the abyssal basins that abut the Ontong Java Plateau using the resent geophysical investigations.

Ontong Java Plateau (OJP) is the largest of the major oceanic plateaus in the Pacific Ocean basin. OJP rises about 2 km above the surrounding deep ocean floor and has an area within the 4.5 km contour of about 1.8 x 10^6 km^2. A depth to the Moho discontinuity is more than 30 km (Gladczenko, 1994; Miura et al., 2004). The evidences from drilling samples indicate that most of the OJP formed rapidly about 122 Ma at mid-southern latitude in the Pacific Basin (Mahoney et al., 1993; Tejada et al., 1996, 2002). The widely accepted hypothesis of the formation of OJP is an emergence of a plume head (e.g., Coffin and Eldholm, 1993; Neal et al., 1997). The competing hypotheses are the mantle upwelling as the result of bolide impact (Ingle and Coffin, 2004) and the entrainment of dense fertile mantle by rapid seafloor spreading (Korenaga, 2005). Taylor (2006) proposed that the Ontong Java Plateau formed as a single large volcanic province together with the Manihiki and Hikurangi plateaus ca. 120 Ma, called Ontong Java Nui (Chandler et al., 2012). The OJP formation has been a major enduring problem of marine geology over the past more than 40 years. For settlement of the argument about the OJP formation, the tectonic setting of the abyssal basins around the OJP must be revealed.

Abyssal basins are contiguous withthe OJP: the Lyra Basin to the west, the East Mariana and Pigafetta basins to the north, the Nauru Basin to the northeast, and the Stewart and Ellice basins to the southeast. Tectonic histories of the Nauru, East Mariana, and Pigafetta basins, were revealed using the Mesozoic magnetic anomaly lineations (Nakanishi et al., 1992). Those of Lyra and Stewart basins are, however, still unknown because of lack of magnetic anomaly lineations.In at least three of these basins, the Nauru, East Mariana, and Pigafetta, Lower Cretaceous flood basalts overlie older oceanic crust (Abrams et al., 1993; Shipley et al., 1993; Nakanishi and Winterer, 1998).

To expose the tectonics of the abyssal basins around OJP, we conducted geophysical investigation in Nauru, Ellice, Stewart, and Lyra basins by R/Vs *Mirai*, *Kairei*, and *Hakuho-maru*. Our geomagnetic measurement western margin of Nauru Basin exposes the extension of magnetic anomaly lineations identified in Nauru Basin by Nakanishi et al. (1992). Our geophysical investigation in the Stewart Basin show the northeast-southwest rifting in the formation of the basin.

Keywords: Ontong Java Plateau, oceanic plateau, Pacific Plate

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The Cretaceous Normal Superchron: records from the Pacific, Indian and Atlantic oceanic crust

*Nobukazu Seama[1,2], Jerome Dyment[3], Taichi Sato[4,5], Yves Gallet[6], Kyoko Okino[7], Roi Granot[8], Yoshifumi Nogi[9], Nobutatsu Mochizuki[10], Toshitsugu Yamazaki[7]

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The Cretaceous Normal Superchron (CNS) is a ~40 Myr-long period extending between Chrons M0 and 34 (~120-83 Ma) during which the geomagnetic field polarity remained normal, although the possibility of some short reversed-polarity events cannot be ruled out. Systematic variations of the geomagnetic paleointensity have been suggested based on a deep-tow magnetic profile acquired in the Central Atlantic Ocean and selected sea-surface magnetic profiles worldwide crossing the whole CNS (Granot et al., *Nat. Geo.*, 2012). According to these authors, three sub-periods separated by two ubiquitous markers, Q1 and Q2, show successively moderate (M0-Q2), very dynamic (Q2-Q1) and very smooth (Q1-C34) geomagnetic paleointensity fluctuations. Here, we extend this study by using two additional data sets: a deep-tow magnetic profile acquired across the central, most dynamic part of the CNS in the South-Western Indian Ocean, and a set of sea-surface magnetic anomalies collected across two parts of the CNS in the Northern Pacific Ocean. These data sets are complementary. The high resolution of the deep-tow profiles is hampered by their uniqueness, with the risk to interpret spurious local effects as paleointensity variations. To alleviate this risk, we try to assess the two-dimensional character of the magnetized sources by analyzing vector magnetic data acquired during the South-Western Indian Ocean deep-tow survey. The advantage of the sea-surface Northern Pacific Ocean survey is the multiple profiles that can be compared and eventually stacked for a better signal/noise ratio. Unfortunately, the oceanic crust created during the CNS in the Northern Pacific Ocean displays a lot of anomalous volcanic seamounts. Again, we assess the two-dimensional character of the magnetized sources by analyzing vector magnetic data to avoid the effect of these seamounts. Only sea-surface magnetic profiles in the Northern Pacific Ocean have been collected ~5 km above the magnetic basement that results in much lower spatial resolution to compare to the ~1 km of the deep-tow profiles in the other area. But, the half-spreading rate there is 60-70 km/Myr, whereas it is ~30 km/Myr in the South-Western Indian Ocean and ~20 km/Myr in the Central Atlantic Ocean. This means that the time resolution of the deep-tow profiles becomes only about twice better than that of these sea-surface profiles in the Northern Pacific Ocean. We combine these data to evaluate the previous hypothesis of three sub-periods with distinct paleointensity signature within the CNS, assess the existence of the Q1 and Q2 markers, and tentatively build a more reliable geomagnetic paleointensity variation of the CNS.

Keywords: Cretaceous Normal Superchron, Geomagnetic paleointensity variation, Marine geomagnetic anomalies, Oceanic crust

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-CG56] Ocean Floor Geosciences

convener:Kyoko Okino(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Chie Honsho, Tadashi Ishikawa

Most of Earth's volcanism and much of its tectonic activity occur on and beneath the seafloor. Various phenomena on the seafloor are closely linked to plate tectonics, Earth and atmosphere. Seafloor rocks and sediments record Earth's evolution and heat and material fluxes on the Earth. Ocean Floor Geosciences session covers a broad range of research on LIPs, crustal movement and structure etc. Any fields of research and approach are welcomed. The session aims to encourage discussion among scientists from different study fields and to integrate our understanding of ocean floor. The session is co-chaired by K. Tadokoro (Nagoya Univ.), O. Ishizuka (AIST), T. Toki (Univ. Ryukyus), and N. Takahashi (JAMSTEC).

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SCG56-13] Offshore Postseismic Deformation of the 2011 Tohoku Earthquake Revisited: Application of an Improved GPS-Acoustic Positioning Method Considering Sloping Sound Speed Structure

*Chie Honsho[1], Motoyuki Kido[2], Fumiaki Tomita[3], Naoki Uchida[1] (1.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University, 2.International Research Institute of Disaster Science, Tohoku University, 3.Graduate School of Science, Hokkaido University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SCG56-14] Comprehensive analysis for the forearc structure and dynamics by using the S-net data

*Naoki Uchida[1], Ryosuke Azuma[1], Akira Ishigami[1], Tomomi Okada[1], Ryota Takagi[1], Genti Toyokuni[1], Norihito Umino[1], Yusaku Ohta[1], Makiko Sato[1], Syuichi Suzuki[1], Hidenobu Takahashi[1], Kazuya Tateiwa[1], Dapeng Zhao[1], Takashi NAKAYAMA[1], Akira Hasegawa[1], Ryota Hino[1], Satoshi Hirahara[1], Toru Matsuzawa[1], Keisuke Yoshida[1] (1.Research Center for Prediction of Earthquakes and Volcanic Eruptions Graduate School of Science, Tohoku University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SCG56-15] Shallow slow slip event inferred from GNSS-A seafloor geodesy

*Tadashi Ishikawa[1], Yusuke Yokota[2] (1.Hydrographic and Oceanographic Department, Japan Coast Guard, 2.Institute of Industrial Science, the University of Tokyo)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SCG56-16] Assessing strike-slip motion at the Shionomisaki Canyon along the Nankai oblique subduction zone using acoustic ranging system

*Motoyuki Kido[1], Eiichiro Araki[2], Takeshi Tsuji[3], Ryusuke Yamamoto[4], Yoshifumi Kawada[1] (1.International Research Institute for Disaster Science, Tohoku University, 2.JAMSTEC, 3.Dept. Earth Resources Engineering, Kyushu University, 4.School of Science, Tohoku University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SCG56-17] Development of seafloor realtime observation network for crustal deformation in the Nankai Trough: tiltmeter installation

*Eiichiro Araki[1], Takashi Yokobiki[1], Toshinori Kimura[1], Shuhei Nishida[1], Yuya Machida[1], Shuichi Kodaira[1] (1.Japan Agency for Marine-Earth Science and Technology)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SCG56-18] Calibration of the DONET pressure sensor network in the Nankai trough seismogenic zone using a mobile pressure gauge

*Yuya Machida[1], Shuhei Nishida[1], Toshinori Kimura[1], Eiichiro Araki[1] (1.Japan Agency for Marine-Earth Science and Technology)

Offshore Postseismic Deformation of the 2011 Tohoku Earthquake Revisited: Application of an Improved GPS-Acoustic Positioning Method Considering Sloping Sound Speed Structure

*Chie Honsho[1], Motoyuki Kido[2], Fumiaki Tomita[3], Naoki Uchida[1]

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One of the important issues on the GPS-acoustic (GPS-A) observation for sea bottom positioning is how to address the horizontal heterogeneity of the sound speed in oceans. We present an analysis method of GPS-A data in the presence of a sloping sound speed structure. By applying this method and revising the analysis scheme to make full use of existing data, we re-evaluated the horizontal postseismic deformations occurring ~1.5–5 years after the 2011 Tohoku earthquake. The revised horizontal movements have more uniform directions and rates between neighboring sites, suggesting enhancement of the array positioning accuracy. The revised displacement rate of the site on the incoming Pacific plate, located ~100 km northeast of the main rupture zone, was decreased significantly; it was only slightly, by 1.4 cm/year larger than the global motion of the Pacific plate, suggesting a relatively small effect of viscoelastic relaxation. The horizontal movements of the near-trench sites above the main rupture zone were generally landward and were significantly faster than the Pacific plate motion, indicating a viscoelastic relaxation of 5–10 cm/year. The distribution of the fast landward movements peaked near 38°N at an updip of the mainshock hypocenter and extended significantly farther to the north than to the south. This implies the existence of a secondary coseismic slip patch in the northern area in addition to a primary slip patch at ~38°N. The occurrence of episodic slow slip in early 2015 to the north of the main rupture zone was also verified from the GPS-A analyses.

Keywords: GPS-Acoustic observation, Postseismic deformation of the 2011 Tohoku earthquake

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Comprehensive analysis for the forearc structure and dynamics by using the S-net data

*Naoki Uchida[1], Ryosuke Azuma[1], Akira Ishigami[1], Tomomi Okada[1], Ryota Takagi[1], Genti Toyokuni[1], Norihito Umino[1], Yusaku Ohta[1], Makiko Sato[1], Syuichi Suzuki[1], Hidenobu Takahashi[1], Kazuya Tateiwa[1], Dapeng Zhao[1], Takashi NAKAYAMA[1], Akira Hasegawa[1], Ryota Hino[1], Satoshi Hirahara[1], Toru Matsuzawa[1], Keisuke Yoshida[1]

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The forearc area especially in the region under the Pacific Ocean is the frontier of the study on subduction zones. In this area, National Research Institute for Earth Science and Disaster Resilience (NIED) deployed the Seafloor Observation Network for Earthquakes and Tsunamis along the Japan Trench (S-net) which will open a new window to the Science on the structure and dynamics of the subduction zone. The 150 ocean-bottom cabled stations cover an offshore area of about 200 x 1000 km with a station separation of ~30 km perpendicular to the Japan and Kuril trenches and 50-60 km along the trenches. We obtained the continuous S-net velocity and acceleration seismograms from August 2016 to October 2018 which were made available by NIED in October 2018. We report first results of analysis that start with basic analysis of the data.

First, we estimated the direction of the three components of the sensors using the gravity and particle motion of teleseismic Rayleigh waves recorded by the accelerometers. The results show 1 degree or larger steps in the rotation about the axis of the cable for two earthquakes but stable for other periods. The directions of the axes were estimated with the uncertainty of 5 –10 degrees. The data was used to rotate waveforms of each station to N-S, E-W and U-D (Takagi et al., this meeting).

For the shallow structure, the thickness of sediments is estimated by using PS converted waves at the sedimentary basement. The PS-P traveltime difference shows a similar value of 1.3 to 1.5 s for most stations, which corresponds to a sediment thickness of 350-400 m. However, in the outer trench area of the Kuril –Japan trench junction and the inner trench area off Nemuro, thicker sediments are revealed (Azuma et al., this meeting). The cross-correlation analysis of ambient seismic noise suggests multiple velocities of ~1.5 km/s and ~0.3 km/s for 10 s or shorter periods. These two Rayleigh waves can be interpreted as the waves traveling in the sediments and Sea (Takagi et al., this meeting). The traveltime residuals of local earthquakes also suggest the effect of the shallow thin sediments. The P-wave travel time residuals for an existing 3-D velocity model exhibit variations of up to 2 seconds (Toyokuni et al. this meeting) and the residuals of near-shore earthquakes have up to 3 second for the outer trench areas (Okada et al. this meeting). These velocity structures are important for accurate hypocenter determinations (Okada et al. this meeting).

The deeper velocity structure is also investigated using the phase velocity of teleseismic and regional earthquakes. The teleseismic Rayleigh waves data result in a phase velocity of 3.6-3.9 km/s at periods of 20-50 s. The result shows relatively high wave speeds off Fukushima and Miyagi (Ishigami and Takagi, this meeting). The local earthquake tomography also shows a high P-wave speed in the overlying plate off Miyagi. The study also shows improvement of resolution in the offshore area by adding the S-net data (Toyokuni et al., this meeting). The cross-correlation analysis of ambient seismic noise has successfully extracted Rayleigh and Love waves at a period of as long as 30 s that travels among the S-net stations

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(Takagi et al., this meeting). The anisotropy of velocity in the overlying plate was also examined by shear-wave splitting measurements. The result shows trench parallel fast direction of shear waves, which is similar to the fast directions in the land area (Uchida et al., this meeting).

For the plate boundary, the repeating earthquakes are identified by the S-net which may contribute to a better understandings of the interplate slip and plate geometry (Uchida et al., this meeting). The accelerometer data of S-net also might have potential to detect slow fault slip in the offshore area, because some of the stations seem to responds to the Earth tide (Takagi et al., this meeting).

Acknowledgements: We thank the NIED staff who deployed the S-net, maintained the network and opened the data to the public.

Keywords: S-net, Subduction zone, Ocean bottom observation

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Shallow slow slip event inferred from GNSS-A seafloor geodesy

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In the subduction zone where mega thrust earthquakes occurs, many kind of slow earthquakes in deep plate boundary have been detected by terrestrial dense seismometer and GNSS monitoring networks. On the other hand, in the shallow part of the plate boundary, the investigation of slow earthquakes is limited because of the difficulty of observation at the ocean area. Due to recent development of observation technology, shallow slow earthquakes, such as LFE, VLFE and short-term SSE, have been detected by seafloor seismometers, ocean bottom pressure gauges and submarine borehole strainmeters (e.g., Yamashita et al.,2015; Wallace et al., 2016; Araki et al., 2017, Science).

Deep long-term SSE with duration over a few months is detected by terrestrial GNSS observation which is sensitive to long-term deformation. In this analogy, shallow long-term SSE can be detected by seafloor GNSS-A observation. However it was difficult to detect SSE with the capability of GNSS-A so far. Recently, we have been developing the GNSS-A technology to improve an observation frequency and precision (Yokota et al., 2017; Yokota et al., 2018). Then, the GNSS-A monitoring has a capability to reveals the occurrence situation of undersea SSE which could not be observed by the terrestrial GNSS.

However, because the accuracy is yet poor compared with GNSS, we have been investigating a method for detecting SSE from varying time series data. Nishimura et al. (2013) attempted to detect deep short-term SSE from GNSS data using AIC testing. We modified this method for GNSS-A data and attempted to detect shallow SSE. Then, we detected SSE signals from the GNSS-A data at off the Kii channel, Hyuga-nada and Kumano-nada which locate shallow side around the Nankai Trough historical seismogenic zone and strong coupling regions. There are various statistical method to detect transient variation from time series, and AIC is one example. It is necessary to consider further application of other statistical methods.

We also estimate the rectangle fault model using grid search that can explain displacements obtained from AIC method. Since the current observation sites are installed at 80 to 100 km intervals, displacements are detected only at 1 to 2 sites. Therefore, the estimated fault model has large uncertainty.

Keywords: GNSS-A seafloor geodesy, Slow slip event

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Assessing strike-slip motion at the Shionomisaki Canyon along the Nankai oblique subduction zone using acoustic ranging system

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Nankai trough is known as an oblique subduction zone, and may have trench-parallel strike slip motion along the extent of the outer ridge at least in geological time scale. Tsuji et al. (2014) pointed out that the right-lateral strike slip motion at least in geological timescale is evident from the offset at the Shionomisaki Canyon truncating the trench-parallel linearment. We installed short baseline acoustic ranging system at this site to measure a possible offset to reveal whether such displacement is steady state phenomenon or episodic one. We deployed three acoustic units forming a triangle array with a dimension roughly equal to the depth (~3000m) in 2016 and just have recovered in 2019. The total observation period reached to ~2 years before the batteries were exhausted. The southern baseline of the array is on the same segment, while the northern baseline crossing the trench parallel linearment obliquely. If there were any strike skip motion during our observation period, shortening should be observed only for the northern baseline. All of the three units were recovered in Shinsei-maru cruise (KS19-02), and we confirmed that all data, acoustic traveltimes for ranging, temperature and pressure for sound speed correction, were available properly. Preliminary analysis shows no significant shortening for both the baseline. However scatter is still large to identify the real signal due to large temperature fluctuation beyond the usual correction. More complicated temperature correction considering the time-difference among the three temperature data have to be applied to remove the noise before we conclude the result.

Keywords: Nankai Trough, Oblique subduction, seafloor acoustic ranging

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Development of seafloor realtime observation network for crustal deformation in the Nankai Trough: tiltmeter installation

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Dense ocean-floor network for earthquake and tsunami in the Nankai Trough has been operational since 2010 monitoring earthquake and Tsunami activity in real-time in the seismogenic zone of Tonankai and Nankai earthquakes off Kii peninsula and off Shikoku Island of Japan.

The DONET observation system was designed so that new sensors may be added after deployment of the system, which is first utilized to connect deep borehole observatories deployed by IODP D/V Chikyu. The connection to the DONET enabled us to obtain continuous observation data and this led to discovery of repeating slow slip in the shallow part of the subducting plate (Araki et al., 2017). Currently, three such deep borehole observatories (C0002, C0010, C0006) are operational and providing borehole geodetic data in real-time. The sensitivity of the borehole to such slow slip events is significantly high and only these borehole can detect such repeating small slow slip events in the Nankai Trough. The distribution of the borehole observatories are not very suitable, though, to model area of observed slow slip, due to linear array of these three observatories. Wide spread of observatories sensitive enough to these slow slip events is crucial for such more detailed analysis of slow slip events.

Therefore, in addition to the deep borehole observatories, we plan to establish seafloor observatories that are sensitive to observe slow slip events, which can also be deployed and connected to DONET with lower cost. In our plan, the seafloor observatory (called seafloor observatory for crustal deformation) consists of tiltmeter deployed in shallow hole, fiber optic strainmeter, and seafloor pressure gauge.

We started construction of such seafloor observatories for crustal deformation in 2018. The first observatory is located east of the deep borehole observatory array (C0002, C0010, and C0006) near B-Node of DONET-1. We drilled 8.6 m borehole in October 2018 by R/V Kaimei and seafloor drill called BMS. We installed a Lily tiltmeter in February 2019 and connected the shallow hole tiltmeter to DONET via an interface box which will also be used to connect other sensors (seafloor fiber optic strainmeter and pressure gauge) in the future. The tiltmeter in the shallow hole was packed with sand to the top of the borehole to enhance stability of the tiltmeter in the hole. The initial data from the tiltmeter showed significant drift over 50 microradians a day, but appears to get stable gradually over a week period after the deployment. We analyze initial stabilization history of the shallow hole borehole tiltmeter to improve our installation technique in the future installation of tiltmeters in the seafloor.

We plan to complete installation of the observatory by adding fiber optic strainmeter and pressure gauge this year. Also, another observatory installation is planned in 2019 in DONET-2 area where JHD reported crustal deformation over a year in 2017-2018.

Keywords: the Nankai Trough, slow slip event, seafloor cable observatory

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Calibration of the DONET pressure sensor network in the Nankai trough seismogenic zone using a mobile pressure gauge

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Monitoring of long-time seafloor displacements in a dense and wide area in a seismogenic zone are key to understand strength of plate coupling related to occurrence of large interplate earthquakes. Precise pressure measurements on the seafloor have been thought to be useful tools for detecting long-time vertical seafloor displacements. However a pressure sensor has inherent instrumental drift at a maximum rate of 10 hPa/year. Therefore we need to calibrate each pressure sensor absolutely on the seafloor using high accuracy pressure gauge. Machida et al. (2017) has laboratory evaluated dependencies of temperature and pressure condition of quartz pressure gauge assuming a transport condition between laboratory and seafloor. Based on their results, we have developed a mobile pressure gauge for calibration of the seafloor pressure sensor (Machida et al., 2018, Nishida et al., 2019). The gauge is designed to decrease uncertainties of the quartz pressure sensor proposed by the Machida et al. (2018), and enables us to calibrate seafloor pressure sensor at accuracy of less than 1 hPa. We performed an in situ calibration of the DONET pressure sensor which are installed in the stations of 2C-10 and 1B-8 in October 2018 and February 2019, respectively. And we plan to recalibrate the DONET pressure sensor in May 2019, and estimate each drift component of the DONET pressure sensor. In the presentation, we show a first light of the calibration of the DONET pressure sensors, and a future plan for calibration of the DONET pressure sensors in the Nankai trough seismogenic zone.

Keywords: Mobile pressure gauge, DONET pressure sensor network, Calibration, Crustal deformation, Nankai trough

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-CG56] Ocean Floor Geosciences

convener:Kyoko Okino(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Misae Imano, Tetsuo No

Most of Earth's volcanism and much of its tectonic activity occur on and beneath the seafloor. Various phenomena on the seafloor are closely linked to plate tectonics, Earth and atmosphere. Seafloor rocks and sediments record Earth's evolution and heat and material fluxes on the Earth. Ocean Floor Geosciences session covers a broad range of research on LIPs, crustal movement and structure etc. Any fields of research and approach are welcomed. The session aims to encourage discussion among scientists from different study fields and to integrate our understanding of ocean floor. The session is co-chaired by K. Tadokoro (Nagoya Univ.), O. Ishizuka (AIST), T. Toki (Univ. Ryukyus), and N. Takahashi (JAMSTEC).

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SCG56-19] Analysis of GNSS/Acoustic geodetic data including the period of the transponder replacement

*Ikuta Ryoya[1], Koto Mizuno[1], Horng-Yue Chen[3], Masataka Ando[2], Takeru Komi[1] (1.Faculty of Science, Shizuoka University, 2.Center for Integrated Research and Education of Natural Hazards, Shizuoka University, 3.Institute of Earth Science, Academia Sinica)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SCG56-20] IPR (Indirect Path Ranging): a new approach for long-distance acoustic ranging with a moored relay node

*Ryusuke Yamamoto[1], Ryota Hino[1], Motoyuki Kido[2] (1.Graduate School of Science, Tohoku University, 2.International Research Institute of Disaster Science, Tohoku University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SCG56-21] Development of a kinematic GNSS-A positioning method using the extended Kalman-filter to detect precise vertical displacement

*Fumiaki Tomita[1], Motoyuki Kido[2], Chie Honsho[3], Ryo Matsui[3] (1.Graduate School of Science, Hokkaido University, 2.International Research Institute of Disaster Science, Tohoku University, 3.Graduate School of Science, Tohoku University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SCG56-22] DOP-based accuracy evaluation of GNSS-A positioning on a drifting moored buoy quantified using sea trial observation data

*Misae Imano[1], Motoyuki Kido[2,3], Chie Honsho[3], Yusaku Ohta[3], Ryota Hino[3] (1.Graduate School of Science, Tohoku University, 2.nternational Research Institute for Disaster Science, Tohoku University, 3.Reserch Center for Prediction of Earthquakes and Volcanic Eruptions Graduate School of Science, Tohoku University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SCG56-23] Analysis for GNSS/acoustic ocean bottom crustal deformation considering the heterogeneity of sound speed structure in ocean

*Natsuki Kinugasa[1], Keiichi Tadokoro[1], Yukihiro Terada[2], Teruyuki Kato[3] (1.Graduate School of Environmental Studies, Nagoya University, 2.National Institute of Technology, Kochi College, 3.Hot Springs Research Institute of Kanagawa Prefectural Government)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SCG56-24] Seismic imaging using ocean bottom nodes in the Ishikari Basin, Japan Sea

*Tetsuo No[1], Takeshi Sato[1], Shuichi Kodaira[1], Satoshi Shimizu[2], Tetsuya Yokota[2], Karl Hosgood[3], Masako Robb[3], Tetsuro Tsuru[4] (1.JAMSTEC, 2.Nippon Marine Enterprises, 3.Emerson E&P Software, 4.Tokyo University of Marine Science and Technology)

Analysis of GNSS/Acoustic geodetic data including the period of the transponder replacement

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In this study, we analyzed GNSS/Acoustic geodetic data including the period of the transponder replacement. The data were obtained 60km off Yilan, north eastern coast of Taiwan from May 2009 to May 2016. The site is located just south to the rifting valley in the western end of the Okinawa Trough back-arc basin. The GNSS/Acoustic measurements were conducted for four times from May 2009 to August 2012 and eight times from July 2012 to May 2016. Although the seafloor crustal deformation of the latter eight epochs has been already reported by Chen et al. [2018, GRL], the geodetic data of the former four epochs haven not been analyzed. This is because of a replacement of the seafloor transponders due to the battery depletion between former four epochs and latter eight epochs. Although the last observation of the former four epochs (August 2011) used three transponders, two of them did not reply to the acoustic ranging in July 2012 and then three transponders were newly installed instead. Therefore, the common transponder is only one between the former and the latter epochs. Generally in GNSS/Acoustic measurement, the centroid of the transponder arrays is regarded as a benchmark position which represents the seafloor motion. Because the centroids of the transponder arrays differ greatly between the former and the latter epochs due to the replacement, we cannot recognize these epochs as a continuous series of the observation. Thus We developed a new solution method to deal with the epochs with only a few common transponders as a continuous observation series. The new method solves not the centroid but the motion of the common transponders between different epochs directly. Solving only one configuration of the transponder array from the whole measurement data, the relative motion can be solved more robustly than solving the centroid independently for each epoch. We applied this method to the data and verified the continuity of the estimated benchmark motion comparing with a simulation. The simulation was conducted given an artificial transponder replacement based on the real data. As a result, when enough data are provided in each epochs, we can consider the former and the latter epochs as a continuous series of the observation with an error within 10cm in horizontal component. However, the result of the real data analysis generated about 40cm discrepancy between the former and the latter epochs. From the additional simulation, it was suggested that significantly small number of the acoustic ranging in the observation just before the battery depletion would affect the continuity of the benchmark position as well as the small number of transponders in the former epochs which was three instead of the four in the latter epochs. However, simulation also suggested that the motion of the benchmark within each epoch group before and after the replacement can be solved well. The solved benchmark velocity which is assumed to be same between the former and the latter is identical to the velocity reported in Chen et al. [2018, GRL]. This result suggests that there was no back-arc opening evet during the former epochs.

Keywords: Seafloor crustal deformation, GNSS/Acoustic measurement, Okinawa Trough

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IPR (Indirect Path Ranging): a new approach for long-distance acoustic ranging with a moored relay node

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Seafloor geodetic techniques such as GNSS-Acoustic measurement (GNSS-A), ocean bottom pressure-gauge (OBP) and direct path ranging (DPR) provide in-situ measurement of seafloor deformation. Especially, DPR is a specialized way to preciously measure relative horizontal motion continuously. It measures two-way travel time between a pair of acoustic transducers. The precision of DPR is typically 1–2 mm per 1 km baseline. Observation period is as long as ~3 years so far. However, difficulty in DPR is to ensure direct acoustic paths among transducers not interfered with seafloor as the distance being longer; e.g., an acoustic path bends downward by 142 m for 10 km baseline in a typical sound speed gradient. Unrevealed local topographic bump around the transducer often hinders paths, too.
In extricating such obstacles, we employed a new approach that uses an acoustic relay node, called interrogator, at the halfway of a baseline to reliably pass acoustic paths; we call it “Indirect Path Ranging (IPR)”. Sweeney et al. (2005, *Mar. Geod.*) introduced a ship-hanging interrogator ~500 m above the seafloor and reported that baseline length of 5 km can be measured with several centimeters precision. On the other hand, we moored the interrogator at midwater for long-term continuous observation. A moored interrogator is much advantageous than hanging type, which pumps according to ship's heave; displacement of the interrogator during individual ranging degrades the measuring accuracy.
IPR/DPR observation was conducted during October 2017–August 2018 off Fukushima region, where massive postseismic slip seems to be occurred in the shallow subduction zone (e.g., Iinuma et al., 2016, *Nature Comm.*). We installed five seafloor transponders at trench slope and moored an interrogator at the center of them (i.e., close to the trench axis). All the five baselines for IPR were available, while only one was available for DPR combination due to long distance. We confirmed that rangings were properly carried out over 80% of total period for IPR even the longest beseline of 9180 m.
As the first step, we estimate the 3-D position of the interrogator using four seafloor stations that can be simultaneously called from the interrogator. The interrogator was in motion within the radius of 50 m during most of the period, while it excursed by 300 m at the longest. Traveltime residuals were in order of ~10 cm in terms of distance. Since the acoustic paths were almost horizontal, vertical motion of interrogator may be poorly resolved. Therefore, the vertical motion should be determined form pressure data rather than being solved as an unknown. Anyway, uncertainty of the vertical position of the interrogator has less contribution in total ranging accuracy for its geometry. In the next step, we plan to evaluate interrogated baseline length changes with more precise interrogator position by applying sound velocity correction.

Acknowledgements: This research is supported by JSPS (Japan Society for the Promotion of Science) KAKENHI (JP26000002). The installation and recovery of the instruments were made during the research cruises of R/V Shinsei-maru (KS-16-14; KS-18-13), and R/V Hakuho-maru (KH-17-J02).

Keywords: Seafloor geodesy, Direct path ranging, Indirect path ranging, 2011 Tohoku Earthquake, Postseismic slip

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Development of a kinematic GNSS-A positioning method using the extended Kalman-filter to detect precise vertical displacement

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1. Background

GNSS-Acoustic (GNSS-A) seafloor geodetic observations have provided many observation results from campaign surveys using a research vessel (e.g., Tomita et al., 2017), and continuous surveys using a moored buoy has been tried recently (e.g., Kido et al., 2018). The classic GNSS-A positioning methods (e.g., Spiess et al., 1998; Kido et al., 2006) can provide a position for each ping simultaneously transmitted to all seafloor transponders; therefore, it is possible to perform real-time positioning. However, the classic method has been developed to detect horizontal motions, and it has not been well investigated to detect precise vertical motions. Meanwhile, Tomita et al. (2018) developed a kinematic GNSS-A positioning method using the extended Kalman-filter (EKF-based GNSS-A positioning method), and they demonstrated that vertical solutions could be improved. However, they has not been well investigated its improvement.

2. Numerical tests

We applied the EKF-based GNSS-A positioning method (Tomita et al., 2018) to simulation data. Here, we created simulation data based on three types of synthetic seafloor transponder arrangements, and we then investigated difference of precision of vertical solutions due to the transponder arrangements. As a result, for the transponder arrangements having diversity of shot angles from center of the array (multi-angled transponder arrangement), vertical positions can be solved even by the classic positioning method. Furthermore, the positioning precision can be improved by applying EKF.

3. Application to actual observation data

We applied the EKF-based positioning method to the actual observation data obtained by campaign surveys at sites with the multi-angled transponder arrangement in the off-Tohoku region (Tomita et al., 2017). Although vertical positions should not be changed with time during each campaign, the results showed long-term variation (~10 cm of standard deviation) by both the classic and the EKF-based GNSS-A positioning method. Since such long-term variations were similar to errors of the onboard kinematic GNSS positioning estimated by the means of Fujita & Yabuki (2003), it is expected that the GNSS-A positioning for the vertical component would be improved by improvement of the kinematic GNSS positioning. Meanwhile, we found that short-term temporal variation was improved by EKF. We calculated differential time-series of the solutions to remove the long-term errors, and we then calculated standard deviations of the differential solutions: ~10 cm and ~5 cm for the classic and the EKF-based positioning methods, respectively. Although we still have uncertainty in the long-term variation of the vertical solutions, precision for each acoustic ping can be greatly improved by EKF.

4. Investigation for real-time positioning

In order to implement EKF, we have to provide the appropriate process noise value. As we investigated the optimal process noise based on likelihood using the actual observation data of various campaigns, their values were similar each other; therefore, the appropriate process noise value can be fixed. The computation cost of the EKF-based positioning method is relatively low when the process noise value if

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fixed. Such low computation cost is plausible for the continuous survey using a moored buoy. Meanwhile, for the continuous survey, sampling frequency of the acoustic ranging is limited to save electricity of systems on the moored buoy and battery of the seafloor transponders. Then, we investigated effects of the sampling interval to the precision by re-sampling the observation data, and we found that difference of the precision between the classic and the EKF-based positioning methods was small for the sampling intervals longer than 30 minutes. Thus, to take advantage of the EKF-based positioning method, the sampling interval should be shorter than 30 minutes at least although much shorter sampling interval is plausible for precise positioning.

Keywords: Seafloor geodetic observation, Kalman-filter, Real-time positioning

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DOP-based accuracy evaluation of GNSS-A positioning on a drifting moored buoy quantified using sea trial observation data

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We have developed an offshore monitoring system of seafloor movement using a multi-purpose moored buoy, which realizes regular and on-demand GNSS-Acoustic (GNSS-A) measurements (Takahashi et al., 2014). The target accuracy of horizontal array position was set to 1 m, aiming to detect coseismic displacement accompanied with a huge earthquake (>M8). To endure the strong current around Japan, the system needs a slackly mooring technique for smaller tension (Ishihara et al., 2012) using a much longer tether line than the water depth. Because the moored buoy usually drifts by wind and current around a seafloor array, GNSS-A measurement is likely to be carried out far from the array center. However, the positioning accuracy significantly degrades when the observing point is positioned outside the array, due to a bad geometry between an observing point and transponders (Kido, 2007). Therefore, measurements using a moored buoy are generally carried out under worse conditions than those using a vessel. Our previous studies showed that the horizontal positioning accuracy (2 σ) with a single ranging was 46 cm when the buoy was inside the array, while it degraded to 97 cm when the buoy was outside the array, through a year-long sea trial near Nankai Trough (Imano et al., 2017; Kido et al., 2018). Besides the degradation depending on the distance from an observing point to the array center, we found a directivity of the positioning accuracy depending on the geometry between an observing point and seafloor transponders (Imano et al., 2018). In this study, we propose a method to evaluate the positioning accuracy at an arbitrary observing point based on the above characteristics of GNSS-A positioning using the system.

To interpret the accuracy degradation and directivity in relation to the position of observing points, we introduced Dilution of Precision (DOP: Langley, 1999) for GNSS-A positioning, which represents the degree of propagation of measurement errors to positioning errors. We firstly calculated EDOP/NDOP (the degree of error propagation to the EW/NS components of the array position) from the diagonal elements of the normal equation matrix of the observation equation of array positioning. Next, we computed error ellipses by diagonalizing the normal equation matrix because the nondiagonal elements were significantly large in many cases. The error ellipses clearly exhibit the feature that the estimation error of array positions was large in the direction from an observing point to the array center. Then, we converted the error ellipses to the positioning accuracy by multiplying the standard deviation of traveltime residuals when an array position was estimated using the data of all the 527 pings. The resulting positioning accuracy well explained the array position error and its dependency on the observing position found in the results of the sea trial.

The DOP analysis and its conversion into the positioning accuracy based on the actual observation data enable detailed assessment of the directional accuracy of GNSS-A positioning at arbitrary observing point, which is quite important in interpreting a realtime measurement of seafloor movement upon the occurrence of a huge earthquake. In this presentation, we will explain the above method and discuss its application to realtime GNSS-A positioning using the system assuming the occurrence of a huge earthquake.

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Acknowledgements: This study was supported by MEXT project for Development of GPS/Acoustic Technique, JST Cross-ministerial Strategic Innovation Promotion Program (SIP, Reinforcement of resilient function for preventing and mitigating disasters) and MEXT/JSPS Research Project for compound disaster mitigation on the great earthquakes and tsunamis around the Nankai Trough region.

Keywords: GNSS-A measurement, Moored buoy, DOP

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Analysis for GNSS/acoustic ocean bottom crustal deformation considering the heterogeneity of sound speed structure in ocean

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Observation for ocean bottom crustal deformation by GNSS (global navigation satellite system) acoustic method is monitoring long-term movements of transponders fixed on seafloor by acoustic ranging. We estimate the transponder position for each observation by vessel with the assumption that the relative position between transponders does not change temporally. Thus, precise estimation of the displacement needs having correct array shape.
The main factor of positioning error is temporal and spatial variation of travel time in ocean. Temporal variation is caused by the tide with a cycle of 12-24 hours and by the inertial gravity wave with a cycle of several 10 minutes. With the assumption that the transponder position is fixed during observation, the long-term variation can be estimated easily and the short-term variation cannot be cause of bias positioning error because its effect is included in the observed travel time as noise. The spatial variation is caused by the temperature, pressure, and salinity. The vertical gradient can be obtained by CTD (conductivity, temperature, depth profiler) measuring. Main factor of horizontal gradient is the temperature gradient which is generated significantly in the area near the Kuroshio current. We considered that the horizontal gradient has largest effect on the positioning. Then, we developed new estimation method considering both temporal and spatial variation of sound speed.
New method assumes that the horizontal sound speed structure has constant gradient. We applied this method to the observation point off the coast of Ashizuri and Kumano and compared the array shape estimated by new method and one considering only temporal sound speed variation. The result shows that the transponders where the sound speed is faster is estimated to be shallower. Making theoretical travel time small for the transponder where the sound speed is faster needs to make the propagation distance short. Since the ranging is operated on the circular route around the array, horizontal position cannot be biased to decrease the average of residual of travel time. That is why the position is estimated to be shallower. Thus, the accurate positioning needs considering the horizontal gradient of sound speed. We also discovered that the ship track has effect on its accuracy.

Keywords: Ocean bottom crustal deformation, GNSS/acoustic, Temporal and spatial variation, the Kuroshio current

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Seismic imaging using ocean bottom nodes in the Ishikari Basin, Japan Sea

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In the Japan Sea, damaging earthquakes caused by faults distributed in land–marine transition zones and coastal areas (such as the 2007 Niigata-ken Chuetsu-oki Earthquake and the 1964 Niigata earthquake) have occurred in the past (e.g. Usami et al., 2013). Moreover, according to recent reports, source faults which may cause large earthquakes became apparent in many coastal areas of the Japan Sea (e.g. Committee for Technical Investigation on Large-scale Earthquake in Sea of Japan, 2014). Therefore, data acquisition regarding crustal structures in land–marine transition zones and coastal areas is an important task for increasing the accuracy of the source fault model in the Japan Sea. In previous studies, seismic surveys using ocean bottom cables and two-ship seismic surveys have effectively obtained deep structure imaging in land–marine transition zones and coastal areas of the Japan Sea (e.g. Abe et al., 2010; Sato, 2013). However, owing to budget constraints, such methods and systems may not always be feasible. Therefore, to facilitate future seismic exploration in coastal areas, we attempted a seismic survey using ocean bottom nodes (OBNs), an approach that employs easy-to-handle equipment.

For our seismic survey, we used the JAMSTEC R/V *KAIMEI* to study crustal structures off of the northwestern coast of Hokkaido, Japan (Sato et al., 2018). The OBN system was constructed by Nippon Marine Enterprises, Ltd, comprising 10 nodes at approximately 100-m intervals in the Ishikari Basin. The OBN system was installed at a water depth of 800 m. Each node had a natural frequency of 15 Hz and recorded data for three component omnidirectional geophones and one hydrophone component (Shimizu et al., 2012). The data acquisition specifications were as follows: shot spacing was 25 m; tuned air gun array had a maximum capacity of 2,650 cu in (approximately 43.5 L) and comprised 11 air guns; standard air pressure was approximately 2,000 psi (approximately 14 MPa); and the air gun array was kept 6 m below sea surface throughout the experiment. In this survey line, a normal multi-channel seismic reflection (MCS) survey and a seismic refraction survey using ocean bottom seismographs were also separately performed.

Our data analysis used a method based on mirror imaging. Wave field separation using geophone and hydrophone polarity characteristics and multiple reflection waves was performed together with prestack migration (Dash et al., 2009). Normal reflection imaging was performed using the upgoing wavefield, which reflected on the reflector once. However, mirror imaging was performed using the downgoing wavefield. Using this approach, the imaging range could be extended to several times that of the developed OBN system. Based on a preliminary analysis of the OBN data, we obtained imaging of the sedimentary layer and the basement below the seafloor; the obtained results are consistent with those of the normal MCS profile.

Keywords: Ocean bottom nodes, Seismic imaging, Japan Sea

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | 304 3F

[S-CG62] Potentiality of Machine Learning in Solid Earth Sciences

convener:Takahiko Uchide(Research Institute of Earthquake and Volcano Geology, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Hirokuni Oda(Institute of Geology and Geoinformation, Geological Survey of Japan, AIST), Chairperson:Takahiko Uchide(Geological Survey of Japan, AIST), Hirokuni Oda

The recent development of the machine learning techniques including the deep learning is leading innovations in various fields. The applications of these techniques to solid earth sciences are also expected to develop new frontiers by, for example, the classification, the pattern recognition, and the regression of data. On the other hand, there are concerns on the human-interpretability of the deep learning.
This session will provide an opportunity to share the application studies to various fields in solid earth science and inspire each other. We also look forward to studies addressing the black box issue of the deep learning.

9:00 AM - 9:20 AM JST | 12:00 AM - 12:20 AM UTC

[SCG62-01] The Promise of Machine Learning in Solid Earth Geoscience: Examples from Seismology

★Invited Papers

*Gregory C Beroza[1], Mostafa Mousavi[1], Weiqiang Zhu[1], Karianne J Bergen[2], Paul A Johnson[3], Maarten V De Hoop[4] (1.Stanford University, 2.Harvard University, 3.Los Alamos National Laboratory, 4.Rice University)

9:20 AM - 9:35 AM JST | 12:20 AM - 12:35 AM UTC

[SCG62-02] Automatic Approach to Low-Frequency Earthquakes Detection in Southwest Japan Based on Deep Learning Technique

*Yu Junyu[1], Yuji Yagi[1], Takanori Matsuzawa[2], Ryo Okuwaki[1] (1.Graduate School of Life and Environmental Sciences,University of Tsukuba, Tsukuba, 2.National Research Institute for Earth Science and Disaster Resilience)

9:35 AM - 9:50 AM JST | 12:35 AM - 12:50 AM UTC

[SCG62-03] Broadband ground motion waveform synthesis utilizing AI-based upsampling technique (2)

*Takahiro Maeda[1], Asako Iwaki[1], Hiroyuki Fujiwara[1], Kazutoshi Matsuzaki[2], Hiromitsu Tomozawa[2], Yuji Mori[2], Misato Tsuchiya[2], Naofumi Miyata[2] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Mizuho Information & Research Institute, Inc.)

9:50 AM - 10:05 AM JST | 12:50 AM - 1:05 AM UTC

[SCG62-04] Forecast trial of postseismic deformetion after the 2011 Tohoku-Oki earthquake by recurrent neural network

*Norifumi Yamaga[1], Yuta Mitsui[2] (1.Graduate School of Science and Technology, Shizuoka University, 2.Shizuoka University)

10:05 AM - 10:25 AM JST | 1:05 AM - 1:25 AM UTC

[SCG62-05] Deep Learning Approaches for Eruption Prediction of Sakurajima

★Invited Papers

*Tsuyoshi Murata[1] (1.Tokyo Institute of Technology)

10:25 AM - 10:30 AM JST | 1:25 AM - 1:30 AM UTC

Discussion

The Promise of Machine Learning in Solid Earth Geoscience: Examples from Seismology

*Gregory C Beroza[1], Mostafa Mousavi[1], Weiqiang Zhu[1], Karianne J Bergen[2], Paul A Johnson[3], Maarten V De Hoop[4]

1. Stanford University, 2. Harvard University, 3. Los Alamos National Laboratory, 4. Rice University

Physical, chemical, and biological processes all have substantial influence on the solid Earth. They range over tremendous spatial and temporal scales and can interact in complex ways. Increasingly, humans interact with the shallow reaches of the Earth in ways that are increasingly consequential. The solid Earth presents a variety of natural hazards that are poorly understood, yet increasingly impactful as exposure grows through increasing urbanization in hazard-prone areas. We need to improve our understanding of how the Earth works; however, attempts to understand the solid Earth are challenging because nearly all of the Earth’ s interior is inaccessible to direct observation. Knowledge of the Earth's interior must be based on inference, through interpretation of measurements taken at or near the surface, through controlled laboratory experiments, and through numerical simulations. For this reason solid Earth geoscience is both a data-driven and a model-driven field. Unanticipated discoveries increasingly will come from the analysis of large data sets, novel developments in inverse theory, and procedures enabled by computationally intensive simulations. Increasingly affordable and capable sensors are dramatically increasing the data available to drive this understanding. Moreover, the increasingly realistic character of computer simulations are better able to represent the behavior of the Earth. We are faced with the challenge of gaining new insights from these data and simulations, and techniques from the rapidly evolving field of machine learning (ML) are likely to play a key role in this effort. In this talk we illustrate the promise of machine learning using recent examples from seismology.

Keywords: Seismology, Machine Learning , Earthquakes

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Automatic Approach to Low-Frequency Earthquakes Detection in Southwest Japan Based on Deep Learning Technique

*Yu Junyu[1], Yuji Yagi[1], Takanori Matsuzawa[2], Ryo Okuwaki[1]

1. Graduate School of Life and Environmental Sciences,University of Tsukuba, Tsukuba, 2. National Research Institute for Earth Science and Disaster Resilience

Slow earthquakes have been observed on both shallower and deeper sides of seismogenic zone of megathrust earthquakes and therefore been thought to potentially interact with disastrous megathrust ruptures. A class of slow earthquakes at a dominant frequency of 2–8 Hz, marked as deep low-frequency events (LFEs), are observed continuously along the Nankai Tough from the Southwest Shikoku to the Kii peninsula in Japan. The frequent occurrence of LFEs in this region may suggest an increased probability of impending megathrust earthquakes. Therefore, precise monitoring of the seismic activity of these LFEs may provide a key clue to the quantitative prediction of huge earthquakes and deepen our understanding of diverse earthquake processes. However, traditional approaches to earthquakes detection such as STA/LTA method fails to detect LFEs signal masked by background noise because of the lack of impulsive phase arrivals, which makes it challengeable to detect LFEs from raw seismograms automatically. The matched-filter method leverages the similarity of representative template waveform and continuous seismic waveform and has been used in the Japan Meteorological Agency (JMA) to distinguish and catalog LFEs automatically since July 2014, but it also makes detectability restricted by the limited prior knowledge that refers to available matching templates.

The recent advance in the field of deep learning has shown a robust capability of predictions or discriminations by using general features learned from fitting data, which can potentially be used in tackling LFEs detection. Deep-learning models are basically trained by scanning through large datasets and meanwhile tweaking their parameters gradually toward the direction in which the difference between fed data and the model's predictions descends.

To create training dataset in our study, we prepared a total of 4 years continuous three-component velocity seismograms data recorded by 75 stations of High-sensitivity Seismograph Network Japan (Hi-net) operated by the National Research Institute for Earth Science and Disaster Resilience (NIED) across Southwest Japan from January 2010 to December 2013. We first preprocessed raw data streams without applying bandpass filter and cut them into millions of single-station, 3-channel, 10-seconds event-waveform windows vectorized as 2D arrays at a sampling rate of 100 Hz. We then labeled 3,179,167 windows as noise, 161,930 windows as regular earthquakes, 29,090 windows as LFEs, and 262,209 windows as deep low-frequency tremors, which were considered to be a continuous LFEs signal, according to the JMA's seismic catalog and the World Tremor Database (WTD). Due to the fluctuation of the positions of seismic phases in the waveform windows, we choose to use the Convolution Neural Network (CNN); a deep-learning model that first extracts local features and then integrates them hierarchically so less disturbed by the inhomogeneity of data than the traditional model does. For each data window, the model outputs four probabilities corresponding to the likelihood of each respective class. Event detection is declared when one of four probabilities exceed the threshold we set (50% for general).

We trained the model preliminarily and evaluate the accuracy of the model on a brand-new test dataset generated by the same rules as those of creating training dataset using receiver operating characteristic

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(ROC) analysis. We were given the area under the ROC curve (AUC) score of 0.923, 0.991, 0.981, and 0.914 (naive baseline = 0.5) for noise, regular earthquake, LFEs, and deep low-frequency tremor respectively, which suggests that our model is capable of classifying waveform windows correctly with high confidence. We also noticed that there are a lot of LFEs that are incorrectly identified as tremors in spite of the low ratio of tremors that are incorrectly identified as LFEs. To find a rational explanation for this asymmetric structure and the classifying borderlines of our model, we will do more error analysis and unbox each layer of our model to visualize how they are activated in further research. And we will further tune our model and integrate the single-station classifiers to build local networks that can identify earthquake events coherently.

Keywords: slow earthquakes, LFEs, deep low-frequency tremors, earthquake detection, deep learning

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Broadband ground motion waveform synthesis utilizing AI-based upsampling technique (2)

*Takahiro Maeda[1], Asako Iwaki[1], Hiroyuki Fujiwara[1], Kazutoshi Matsuzaki[2], Hiromitsu Tomozawa[2], Yuji Mori[2], Misato Tsuchiya[2], Naofumi Miyata[2]

1. National Research Institute for Earth Science and Disaster Resilience, 2. Mizuho Information & Research Institute, Inc.

To enhance the reliability of seismic hazard assessment, it is important to improve the accuracy of predicting broadband ground motion. For predicting broadband ground motion, a hybrid method is often used. The hybrid method synthesizes broadband ground motion by summing up long-period and short-period ground motion calculated separately. The long-period ground motion is calculated by a theoretical method such as the finite difference method which can consider the effect of the three-dimensional velocity structure. The short-period ground motion is calculated by empirical or semi-empirical methods such as statistical Green's function method can consider the effect of random heterogeneity of seismic source and propagation path. These methods, however, use different velocity structure models, it is known that problems such as the shift of travel time, discontinuity of spectral amplitude between the period range.

For this problem, Iwaki and Fujiwara (2013) proposed a method of synthesizing broadband ground-motion waveform based on the relationship of ground-motion waveform between long-period and short-period extracted from observation data. We considered this problem of extracting the relationship between long-period and short-period ground motions as a problem of upsampling in artificial intelligence and have studied this problem using the coupling learning method (Nagata et al., 2016) which is one of machine learning methods (Maeda et al., 2018). To construct a prediction model of a short-period ground-motion waveform from long-period ground-motion waveform based on artificial intelligence, we can utilize a vast amount of strong ground motion data recorded by K-NET and KiK-net.

The performance of the prediction model is evaluated based on the similarity of observed and predicted broadband ground motion. In the previous study, we evaluated the similarity based on the time series data of the broadband waveform. However, in this study, we used an envelope shape of waveforms for narrowband of 0.5-1.0 Hz, 1-2 Hz, 2-4 Hz, 4-8 Hz, 8-16 Hz, and a Fourier amplitude spectrum for evaluating similarity. The data sets used for learning and testing of artificial intelligence were (1) records of a single observation site, (2) records of multiple observation sites with similar ground conditions, (3) records of multiple observation sites due to earthquakes of the similar magnitude, (4) records of multiple observation sites due to earthquake occurring same region, and (5) a whole records from (1) to (4). We found a tendency that the prediction performance is somewhat higher in the case (1). Qualitatively, it is expected that the prediction performance in the case (1) that can take into consideration the site-specific characteristic of ground motion will be significantly higher and the result of this study suggests that there is room for improvement in the similarity evaluation.

Acknowledgments: This work was partially supported by the Council for Science, Technology and Innovation (CSTI) through the Cross-ministerial Strategic Innovation Promotion Program (SIP), titled “Enhancement of societal resiliency against natural disasters” (Funding agency: JST). This study was conducted as part of joint research with RIKEN.

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Keywords: broadband ground motion waveform synthesis, coupled learning method, artificial intelligence

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Forecast trial of postseismic deformetion after the 2011 Tohoku-Oki earthquake by recurrent neural network

*Norifumi Yamaga[1], Yuta Mitsui[2]

1. Graduate School of Science and Technology, Shizuoka University, 2. Shizuoka University

The 2011 Tohoku-Oki earthquake caused large postseismic deformation, hiding possible small signals, such as slow slips and volcanic events. In general, postseismic deformation is fitted by a logarithmic, exponential or their combined function. To forecast postseismic deformation more accurately, we introduce a recurrent neural network method which is one of the machine learning approaches. This method autonomously learns relation between input and output data. We use 700-days sequence of GNSS time-series data of 191 stations (GEONET) as input data and the following data as output data for training the neural network. The results of the neural network better forecast the time-series data than those of regression analyses in an E-W direction. However, in an N-S direction, the neural network does not work better than regression analyses. These facts indicate that data with a sufficiently small signal to noise ratio is needed for the neural network. In the results of the E-W direction, we find several regions with low precision of the forecast, partly corresponding to the Niigata-Kobe strain concentration zone, as well as along the coast of Sea of Japan in northern Tohoku.

Keywords: neural network, postseismic deformation

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Deep Learning Approaches for Eruption Prediction of Sakurajima

*Tsuyoshi Murata[1]

1. Tokyo Institute of Technology

In this research, we take advantages of deep learning into time series data and apply this technique to sensor data acquired from volcanic monitors.
We focus on two problems: (1) volcanic eruption classification and (2) early prediction of volcanic eruption. The goal of (1) is to recognize the current status of the volcano, while the goal of (2) is to predict the future eruption by detecting the time series prior to the eruption which is the early signal of the upcoming eruption. For (1), the proposed method VolNet based on convolutional neural network achieves an average F-score of 90%. For (2), the proposed method based on Stacked 2-Layer LSTM achieves promising results of 66.1% accuracy. And the accuracy of 4-stage warning system is 51% in the critical stage. We demonstrate the effectiveness of our methods with the largest and the most comprehensive set of volcano sensor time series data.

Keywords: Eruption Prediction, Sakurajima, Deep Learning

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[J] Oral | G (General)：General

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | 104 1F

[G-01] Disaster prevention education

convener:Hitoshi Nakai(Kobuchisawa Research Institute for Nature and Education), Jiro Komori(Teikyo Heisei University), Shintaro Hayashi(Akita University Graduate School of Education), Chairperson:Jiro Komori(Teikyo Heisei University)

Each time a serious disaster occurs, there are calls for better disaster prevention education in and around the stricken area, and such education is actually implemented. However, it is not extended to other parts of the nation. Although disaster prevention education really is needed across Japan, it tends to be implemented only in the directly affected locality of a catastrophic disaster. Moreover, even in affected areas, when 10 to 20 years have elapsed from a major event, with a decline in the number of survivors, there is less motivation to pass experiences and learning on to the next generation, despite the potential for such disasters to recur, tens or hundreds of years into the future. It is not easy to maintain conversations about disaster experiences through several generations. Consequently, effective disaster prevention education is provided only in the region stricken by a particular event, and it is practiced only for up to 20 years following the last disaster. As a result, provision of disaster prevention education has become less effective in many areas of Japan. This session focuses on the following two questions: (1) What kind of disaster prevention education can be practiced continuously nationwide? (2) How can such disaster prevention education be implemented in schools and educational sessions? We encourage anyone who wishes to help develop new disaster prevention education based on awareness of these issues to make a presentation in this session. Participation is not restricted to geoscientists; any person or group engaged in any domain of disaster prevention is welcome to submit a paper.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[G01-01] New high school compulsory subjects"Chiri-sougou(Comprehensive geography)"! : Possibility to promote disaster education

*Shintaro Hayashi[1] (1.Akita University Graduate School of Education)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[G01-02] Kyushu University's multidisciplinary disaster prevention education for students near nuclear power plants after 2016 Kumamoto earthquake

*Megumi Sugimoto[1,2], Silvia Peppoloni[2] (1.Kyushu University, 2.International Association for Promoting Geoethics)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[G01-03] The cases of the limit of dam impoundment during floods and necessity of information sharing at local disaster prevention

*Jiro Komori[1], Yuuri Masuhara[1] (1.Teikyo Heisei University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[G01-04] Disaster Tradition and Disaster Education of 2008 Sichuan Earthquake

★Invited Papers

*FU SIQI[1], Shiroshita Hideyuki[1] (1.Kansai University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[G01-05] Preparedness for Nankai Trough Earthquake: Incorporating Understandings of Uncertainties in Disaster Prevention Education Schemes

*Manabu Hashimoto[1], Mika Shimizu[2] (1.Disaster Prevention Research Institute, Kyoto University, 2.Center for the Promotion of Interdisciplinary Education and Research, Kyoto University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[G01-06] Importance of issuing evacuation for individual family
★Invited Papers

*Suzuki Shigeyuki[1] (1.Okayama University)

New high school compulsory subjects"Chiri-sougou(Comprehensive geography)"! : Possibility to promote disaster education

*Shintaro Hayashi[1]

1. Akita University Graduate School of Education

A new subject "Comprehensive geography(Chiri-sougou)" is implemented in high school from 2022. "Comprehensive geography" may be a powerful tailwind for promotion of disaster education education. Because
1) "Comprehensive geography" is a compulsory course to be taken by most high school students.
2) Learning about disasters is a big part.

Disaster-related officials, such as related organizations and departments of the country and the prefecture, researchers involved in disaster prevention education, NPO corporations, Geopark, etc., need to make sufficient preparations, such as contacting the high school side and discussing. If you do so, there is a possibility that you can greatly contribute to the dissemination of disaster prevention education by taking advantage of this new subject.
"Comprehensive geography" is a compulsory subject: High school "Geography comprehensive" is a compulsory subject to be implemented from 2022. It is indicated in the curriculum guidelines published by the Ministry of Education, Culture, Sports, Science and Technology in 2018, and the textbook preparation work is ongoing. Almost all high school students will be taking classes from 2022.
Since the 1970's, geography subjects have been taken as non-compulsory courses. The revision of this time has resulted in a great increase in the weight of geography subjects.
Learning about disasters is the main contents of "Comprehensive geography": contents of "Comprehensive geography" can be roughly divided into three - "contemporary world thought in maps and geographical information systems" "international understanding and international cooperation" "sustainable regional creation ".
"Sustainable community development" is further divided into "natural environment and disaster prevention", "research on living area and regional perspective". "Natural environment and disaster prevention" is to acquire knowledge about preparation and response to natural disasters, to undertake task exploration activities, and to acquire skills to read hazard maps and topographic maps.
However, the high school does not have enough resources to conduct the lesson of the natural disaster part of the new subject "Comprehensive geography". In high school there is a shortage of teaching materials and lessons for compulsory conversion of "Comprehensive geography". Educational materials necessary for implementation of "Comprehensive geography" are knowledge of various disasters, knowledge about disasters in the area, learning materials such as hazard maps, and so on. In addition, disaster prevention personnel can also be involved in "Comprehensive geography" as a lesson. Both materials can be provided to the high school side by disaster prevention related institutions.
Teaching Materials Required for "Comprehensive geography" Implementation: "Comprehensive geography"requires two kinds of teaching materials.
1) Materials concerning disasters in the region: Natural disasters occurred in the area in the past and materials on preparation for disaster are necessary. Materials on historical disasters are particularly important. Also, hazard maps and topographic maps are essential learning materials. Also, in "comprehensive geography", high school students will learn about either earthquakes, tsunami, weather disasters, or volcanic disasters.
2) Exploratory learning on disasters is based on "Regarding disaster prevention based on regional

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characteristics, pay attention to relationships with nature and social conditions, common points and differences in areas, creating a sustainable community, It is multifaceted and multilateral consideration and expression for preparation and response to natural disasters (literal translation) ". Disaster prevention related organizations can provide materials for exploration. Disaster prevention related institutions themselves are also materials of explorative learning.
In this way, the new subject "Comprehensive geography" opened in high school from 2022 is highly likely to be a powerful tailwind for promoting disaster education education, People involved in disaster prevention need to participate in "comprehensive geography" classes.

Keywords: Comprehensive geography, Disaster education, Curriculum guidelines published by the Ministry of Education, Culture, Sports, Science and Technology in 2018

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Kyushu University's multidisciplinary disaster prevention education for students near nuclear power plants after 2016 Kumamoto earthquake

*Megumi Sugimoto[1,2], Silvia Peppoloni[2]

1. Kyushu University, 2. International Association for Promoting Geoethics

Kyushu University start disaster prevention education program 2017 Kumamoto earthquake. This multidisciplinary disaster prevention education program me was requested to professors by students after the 2016 Kumamoto earthquake. Kyushu University is located at 32 km from Nuclear power plant Genkai has restarted already. Medical doctors, oceanographers, meteorologists, seismologists, volcanologists, hydologists natural hazard management specialists, artists and designers join this program too. We would like to introduce this program in our presentation.

Keywords: Risk mangement, Urgent Protective action planning Zone, Geoethics, specialization, Disaster prevention education for students, evacuation from nuclear accidents

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The cases of the limit of dam impoundment during floods and necessity of information sharing at local disaster prevention

*Jiro Komori[1], Yuuri Masuhara[1]

1. Teikyo Heisei University

Two major flood of the 2018 Japan floods (heavy rain and flood disaster in the western Japan), Takahashi River in Okayama and Hiji River in Ehime had emergency discharge from managed dams in upper streams. The interpretation, especially the decision of success or failure of dam management is difficult. However, there are some concerns of local residents, and the fact of worsening of terms of natural condition due to global warning and sand accumulation in dam lakes.
Thus, we listed the similar cases of the 2018 floods, which occurred with emergency discharge at the upstream from a dam. Total 65 cases are compiled from web databases for the previous 60 years newspaper articles in Yomiuri, Asahi and Mainichi (Japanese 3 major dailies). The list shows recurrence cases of flood with discharge from same dam and tendency of “the limit of dam” of decrepit structure. While, educational effect are appear by information sharing between dam management and residents.

Keywords: 2018 Japan floods, dam management, emergency discharge, artificial calamity, information sharing, case study

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洪水した河川の上流でダムの緊急放流があった事例

ver.20190118

	発生年	ダム名	河川名	所在地	建設着工/完成年	降雨の原因
1	1958年8月1日	殿山ダム	日置川	和歌山県田辺市	1955/1957	台風17号
2	1961年6月28日	美和ダム	三峰川	長野県伊那市	1952/1959	梅雨前線
3	1962年7月27日	風屋ダム	十津川	奈良県吉野郡十津川村	1954/1960	台風7号
4	1962年7月27日	二津野ダム	十津川	奈良県吉野郡十津川村	1959/1962	台風7号
5	1962年7月27日	殿山ダム	日置川	和歌山県田辺市	1955/1957	台風7号
6	1962年8月26日	相模ダム	相模川	神奈川県相模原市	1937/1947	台風14号
7	1965年7月1日	市房ダム	球磨川	熊本県球磨郡水上村	1953/1959	梅雨前線
8	1965年9月17日	佐久間ダム	天竜川	静岡県浜松市	1954/1958	台風24号
9	1965年9月17日	秋葉ダム	天竜川	静岡県浜松市	1953/1956	
10	1971年8月1日	長安口ダム	那賀川	徳島県那賀郡那賀町	1950/1955	台風23号
11	1972年7月6日	鶴田ダム	川内川	鹿児島県薩摩郡さつま町	1959/1965	梅雨前線
12	1972年7月11日	新成羽川ダム	成羽川	岡山県高梁市	? /1968	梅雨前線
13	1972年7月12日	立岩ダム	太田川	広島県広島市	? /1939	
14	1975年8月17日	早明浦ダム	吉野川	高知県長岡郡本山町	1965/1978	台風5号
15	1981年8月5日	大夕張ダム	夕張川	北海道夕張市	1954/1961	台風12号
16	1982年8月1日	大迫ダム	吉野川	奈良県吉野郡川上村	1954/1973	台風10号
17	1990年9月19日	永源寺ダム	愛知川	滋賀県東近江市	1952/1972	台風19号
18	1990年9月19日	殿山ダム	日置川	和歌山県田辺市	1955/1957	
19	1994年9月22日	樽水ダム	増田川	宮城県名取市	1965/1976	寒冷低気圧
20	1994年9月22日	釜房ダム	名取川	宮城県柴田郡川崎町	1964/1970	
21	1994年9月23日	七北田ダム	七北田川	宮城県仙台市	1972/1984	
22	1994年9月23日	大倉ダム	大倉川	宮城県仙台市	1956/1961	
23	1995年7月1日	裾花ダム	裾花川	長野県長野市	1962/1969	梅雨前線
24	1995年7月1日	鹿野川ダム	肱川	愛媛県大洲市・西予市	1953/1958	梅雨前線
25	1997年7月26日	殿山ダム	日置川	和歌山県田辺市	1955/1957	台風9号
26	1997年9月16日	北川ダム	北川	大分県佐伯市	1958/1962	台風19号
27	1998年10月17日	旭川ダム	旭川	岡山県岡山市	1949/1954	台風10号
28	1999年9月15日	鹿森ダム	足谷川	愛媛県新居浜市	1958/1962	台風16号/秋雨前線
29	1999年8月14日	玄倉ダム	玄倉川	神奈川県上足柄郡山北町	1957/1958	熱帯低気圧
30	2000年9月12日	矢作ダム	矢作川	愛知県豊田市	1962/1970	台風14号/秋雨前線
31	2001年8月21日	七川ダム	古座川	和歌山県東牟婁郡古座川町	1951/1956	台風11号
32	2001年8月21日	小匠ダム	小匠川	和歌山県東牟婁郡那智勝浦町	? /1959	台風11号
33	2003年8月9日	二風谷ダム	沙流川	北海道沙流群平取町	1973/1997	台風10号と前線
34	2004年7月13日	刈谷田川ダム	刈谷田川	新潟県長岡市	1968/1980	梅雨前線
35	2004年7月13日	笠堀ダム	笠堀川	新潟県三条市	1959/1964	
36	2004年7月13日	大谷ダム	五十嵐川	新潟県三条市	1971/1993	
37	2004年8月30日	鹿野川ダム	肱川	愛媛県大洲市・西予市	1953/1958	台風16号
38	2004年8月30日	池田ダム	吉野川	徳島県三好市	1968/1974	台風16号
39	2004年9月29日	宮川ダム	宮川	三重県大台町	1951/1956	台風21号
40	2004年9月30日	萩形ダム	小阿仁川	秋田県北秋田郡上小阿仁村	1961/1966	
41	2004年10月20日	鮎屋川ダム	鮎屋川	兵庫県洲本市鮎屋	? /1970	台風23号
42	2004年10月20日	前山ダム	鴨部川	香川県さぬき市	1968/1974	
43	2004年10月20日	大川ダム	津田川	香川県さぬき市	1959/1963	
44	2004年10月20日	五名ダム	湊川	香川県東かがわ市	1952/1962	
45	2005年9月6日	菅野ダム	錦川	山口県周南市・岩国市	1959/1965	台風14号
46	2005年9月6日	温井ダム	滝山川	広島県山県郡安芸太田町	1974/2001	
47	2005年9月6日	鹿野川ダム	肱川	愛媛県大洲市	1953/1958	
48	2006年7月22日	鶴田ダム	川内川	鹿児島県薩摩郡さつま町	1959/1965	梅雨前線
49	2006年8月16日	三保ダム	酒匂川	神奈川県足柄上郡山北町	1969/1978	台風10号
50	2007年9月17日	森吉ダム	小又川	秋田県北秋田市	1951/1952	温帯低気圧（台風11号）
51	2010年7月15日	木屋川ダム	木屋川	山口県下関市	1940/1955	梅雨前線
52	2011年7月29日	本名ダム	只見川	福島県大沼郡金山町	1952/1954	梅雨前線
53	2011年7月30日	笠堀ダム	笠堀川	新潟県三条市	1959/1964	
54	2011年7月30日	大谷ダム	五十嵐川	新潟県三条市	1971/1993	
55	2011年9月4日	七色ダム	北山川	三重県熊野市	1963/1965	台風12号
56	2011年9月4日	七川ダム	古座川町	和歌山県東牟婁郡古座川町	1951/1956	
57	2011年9月4日	椿山ダム	日高川	和歌山県日高川町	1966/1988	
58	2013年9月16日	日吉ダム	桂川	京都府南丹市	1972/1997	台風18号
59	2014年8月10日	長安口ダム	那賀川	徳島県那賀郡那賀町	1950/1955	台風11号
60	2014年8月3日	鏡ダム	鏡川	高知県高知市	1960/1966	台風12号
61	2018年7月7日	野呂川ダム	野呂川	高知県高知市	1969/1975	台風7号・梅雨前線
62	2018年7月7日	野村ダム	肱川	愛媛県西予市	1971/1981	
63	2018年7月7日	鹿野川ダム		愛媛県大洲市	1953/1958	
64	2018年7月7日	河本ダム	西川	岡山県新見市	1958/1964	
65	2018年7月7日	新成羽川ダム	成羽川	岡山県高梁市	/1968	

注意：上記は洪水が発生し，同じ降雨によりダムが特例操作，またはそれに類似する放水を行った事例であり，放水が洪水の起因であるか否かの判断はここでは行っていない．

主な情報源：読売新聞，朝日新聞，毎日新聞の各オンラインデータベース，ダムの河川名，所在地，着工/竣工年はDamMaps(http://www.dammaps.jp/)ほかを参考にした．

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Disaster Tradition and Disaster Education of 2008 Sichuan Earthquake

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1. Kansai University

When human beings try to do "disaster prevention", first of all, we are trying to prevent or reduce the assumed damage by clarifying disaster related things, especially the cause and mechanism of its occurrence, assuming the damage caused by the disaster . When realizing such a process that can be considered as "disaster prevention" in general, so-called disaster prevention experts such as researchers targeting natural disasters and administrative staff who formulate and implement laws and policies are the protagonists It plays a leading role as. In order to systematically study the prevention and reduction of damage in an objective way systematically, we will call such disaster prevention activities "disaster prevention science" in this research. It is believed that promoting "disaster prevention science", clearly informing its necessity, and surely implementing disaster prevention measures is the goal of "disaster prevention" now. One typical example is evacuation drills at school. Because it is clear that it is possible to reduce damage by carrying out evacuation drills, evacuation drills are actually spreading to schools throughout Japan. Currently, the majority of "disaster prevention" is putting power to such a goal. In other words, it can be said that equal signs are drawn between "disaster prevention" and "disaster prevention science". It is generally considered that "disaster prevention" education is to make things already evident as the necessity of disaster prevention, and to make things not done possible. Disaster prevention experts and general citizens are considered to be "disaster prevention" success if they can work together to achieve this situation. But what about the reality? Humans understand, but there are many things that they do not do. Even if we tell the citizens that decided measures based on "disaster prevention science" are decidedly effective as it is, they are often procrastinated or ignored. For example, according to a survey conducted by the Cabinet Office in Heisei 29, regarding "measures taken in preparation for a major earthquake," I fixed furniture, home appliances, etc. and did not mention falling, falling, and moving " People are 49.4% of respondents. And as a reason for not doing that, reasons such as "I'm trying to do but postpone it" or "It's awkward" are high ranked. On the other hand, human beings, as higher animals in the natural world, have been associating with nature for many years, touching important matters without knowing, and continuing to do it accidentally over the long term. No, it may not be a coincidence. Even if it is not scientific, it sometimes has the effect of calling disaster against disasters. It is a lifestyle habit useful for disasters even if people in Nepal always place water storage tanks on the roof for daily water cutoff measures. Even in Japan, after the Niigata Prefecture Chuetsu Earthquake occurred, the avalanche broke the road and could not transport necessary food and goods for evacuation. The ingredients that were useful at that time were the ingredients and firewood that the local residents had prepared before entering the winter. Neither bother to go for disaster prevention, but as a result it leads to disaster prevention. There are other things that wisdom that has already been implemented in the life like this "can actually do such a view from the viewpoint of disaster prevention" or "there is surprising effect when used in this way". Discovery, protection and dissemination of these are also considered to be a kind of disaster prevention education. Therefore, in this research the above idea also applies to disaster dragging. In other words, its approach differs depending on the country and region in disaster transmission, and aims to learn about the new approach of disaster transfer from the difference. Specifically, the case of "Sichuan Earthquake" that hit China's Sichuan Province on May 12, 2008 is taken as a case. About 11 years after the earthquake, we investigate how the disaster is recorded in the affected area and how we are trying to communicate it to posterity people in that way and compare it during the day. Based on the results of the hearing survey conducted by Youth in Chengdu and the future disaster prevention experience hall,

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several disaster prevention education facilities, disaster transmission facility, we report on the new approach and disadvantage of disaster trading in Japan.

Keywords: Disaster Education, Disaster Tradition , 2008 Sichuan Earthquake

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Preparedness for Nankai Trough Earthquake: Incorporating Understandings of Uncertainties in Disaster Prevention Education Schemes

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1. Disaster Prevention Research Institute, Kyoto University, 2. Center for the Promotion of Interdisciplinary Education and Research, Kyoto University

For better disaster prevention education schemes to prepare for disasters, it is essential to examine how we address large-scale disasters with uncertainties which we have never experienced before, such as Nankai Trough earthquake. Specifically, how to incorporate “uncertainty” aspect into disaster prevention education and how to link the learnings into practices for better disaster preparedness is a critical challenge we are facing. The “uncertainty” is not a small component for disaster prevention. Rather, understandings of the reality of “uncertainty” at both scientific and social levels in terms of when, where, and how earthquakes may occur, affect the overall practical level of preparedness for disasters.

Given the above, addressing uncertainties is a challenge which multi-stakeholders need to work together, including natural and social scientists, policy communities, emergency practitioners, local governments, businesses, schools, and the public through collaborative learnings during normal times. For these learnings, it is critical for disaster prevention education to play a role. Especially the education schemes need to take into consideration: 1) how to make a common ground for understandings of uncertainties among multi-stakeholders based on available scientific information, 2) how to incorporate the understandings of uncertainties into learning process, and 3) how to direct the learnings into practices for better disaster prevention.

Based the above, a study group in Kyoto University where natural and social scientists collaboratively work together, have been seeking for the ways for addressing the reality of earthquake risks and uncertainties for different stakeholders through a series of workshops for the past three years. The presentation will report on the findings and insights drawn from the workshops targeted at education community (March, 2017), business community (June, 2017), civil disaster prevention community (March, 2018), and multi-stakeholders (January, 2019).

Specifically, the series of workshops were designed collaboratively by natural and social scientists with the focus on 1) scenario-based, 2) stakeholder-based, 3) site-based, and 4) dialogue-based or interactive-learning- based contexts. Especially, to optimize the learnings of earthquake risks and uncertainties, the workshops created processes for each participant to understand the uncertainties through themselves by applying it to their own daily lives or work settings.

Based on the workshops, overall, we have seen:

On the same table, different people with different backgrounds share their responses, awareness, and insights, which led to strengthen each understandings of the reality of uncertainties. Before and after the workshop, almost all participants changed their literacy and mindsets for addressing uncertainties. For examples, participants responded to workshops with comments: “earthquake risks have uncertainties

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and it is important to act flexibly against the unexpected events”, “even as a person in charge in a company did not understand it before workshop”, and “I realized it is important to address “uncertainties” even if it is incomplete information.” As a collective knowledge from the workshop, as examples, from the one targeted for business, the following points were drawn:

- To provide any earthquake risk information is important even if the probability is low and uncertainty high. For this, information recipients’ literacy is necessary too.

- Providing information from authoritative institution is critical; since when we think about the real scenarios, information from SNS or other sources will be flooded.

- We need to think about not only BCP but also disaster risk management from daily basis, covering not only response, but also recovery.

Thus, based on the results drawn from the workshops, we will provide policy implications in terms of how to incorporate understandings of uncertainties in disaster prevention education schemes.

Keywords: Disaster Prevention Education, Nankai Trough Earthquake, Uncertainty, Forecast, Scenario-based Workshop

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Importance of issuing evacuation for individual family

*Suzuki Shigeyuki[1]

1. Okayama University

Japan is a disaster-prone country and there are many variety of natural hazards. The hazards and degree of the risk are quite different in individual small area depend on geography and the site of disaster source. Disaster management for individual family is necessary to protect citizens from disasters. Recent examples of disaster reduction activities in local community and school will be presented.

Keywords: disaster management, natural hazard, disaster reduction activity

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[J] Oral | G (General) : General

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | 103 1F

[G-02] Geoscinece Outreach

convener:Takeyuki Ueki(Faculty of Risk and Crisis Management, Chiba Institute of Science), Jiro Komori(Teikyo Heisei University), Naoko HASEGAWA(Ochanomizu University), Satoko Oki(Faculty of Environment and information Studies), Chairperson:Satoko Oki

The aims of Outreach and geoscience education are to encourage developments that raise public awareness of geosciences through schools and/or public outreach by not only educators but also researchers. Therefore, any presentation related with these aims will be welcomed to this session. Depending on schedule and venue,some presentation will be changed to Poster presentations.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[G02-01] Outreach of geography on general books

*Naoko HASEGAWA[1], Yuuki NAKAGAWA[1] (1.Ochanomizu University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[G02-02] **Dissemination of geographical and archaeological thinking by museum exhibitions: Practical approaches using three-dimensional models**

*Yuichi S. Hayakawa[1,2], Sahoko Aki[2] (1.Faculty of Environmental Earth Science, Hokkaido University, 2.Center for Spatial Information Science, The University of Tokyo)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[G02-03] Introduction of Guide Skill Up Course and Its Effect in the Izu Peninsula Geopark

*Tsuda Kazuhide[1], Hiroshi Ono[1], Hiroshi Yamazaki[1], Akifumi Matsuo[1], Hideki Ono[2] (1.NPO Whole Earth Institute, 2.Izu Peninsula Geopark Promotion Conucil Bureau)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[G02-04] Testcase of Science Cafe with Confrontation Axis Considerd to Complex of Earth and Space Science

*Harufumi Tamazawa[1,2], Yuko Ikkatai[3] (1. Disaster Prevention Research Institute, Kyoto University, 2.Faculty of Fine Arts, Kyoto City University of Arts, 3.kabli Institute for the Physics and Mathematics of the Universe, University of Tokyo)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[G02-05] Literacy for Rumors of Earthquake Occurrence

*Yoshiaki Orihara[1], Masashi Kamogawa[2], Toshiyasu Nagao[1] (1.Institute of Oceanic Research and Development, Tokai University, 2.Department of Physics, Tokyo Gakugei University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[G02-06] **Regional crustal movements and gigantic tsunami traces recorded by ghost forests: Importance of outreach activities and education for disaster prevention**

★Invited Papers

*Kiyoyuki Shigeno[1], Futoshi Nanayama[2,6], Kazuaki Watanabe[2], Masayuki Ishii[3], Kazuhito Ishiwata[4], Shigeto Inokuma[5], Keita Fukatsu[7] (1.Meiji consultant co.,Ltd., 2.Geological Survey of Japan, AIST, 3.Ishii Professional Engineer Office, 4.Betsukai municipal museum, 5.Nemuro City museum history and nature, 6.CWMD, Kumamoto Univ., 7.Notsuke Peninsula Nature Center)

Outreach of geography on general books

*Naoko HASEGAWA[1], Yuuki NAKAGAWA[1]

1. Ochanomizu University

Publication of general books (books for general readers) is a way of outreach. We analysed recent general books of geography, on the point of writer’ s profession (researchers, teachers, others, etc.), their’ s contents, and those relationships.

Reserchers write geoscience, including physical geography. Middle and high school teachers, write whole contents of geography (general geography), which they learn in middle and high school. Writers as side business didn’ t write geoscience and general geography, they wrote especially on excursion.

Keywords: outreach, geography, general books

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Dissemination of geographical and archaeological thinking by museum exhibitions: Practical approaches using three-dimensional models

*Yuichi S. Hayakawa[1,2], Sahoko Aki[2]

1. Faculty of Environmental Earth Science, Hokkaido University, 2. Center for Spatial Information Science, The University of Tokyo

The way of thinking in geography and archaeology are sometimes similar to each other in that they comprise both the spatial and temporal contexts. Geography is more spatial-oriented, while archaeology is more temporal-oriented. The outreaching collaboration of geography and archaeology would, therefore, be effective in developing the ability of thinking in a spatiotemporal context. Such the collaboration of geography and archaeology can be presented in a museum exhibition. Although the number of museums specifically designed for geography is limited in Japan, there are numerous archeological museums in which geographical contents can also be included. Here we discuss the effects of a museum exhibition on the dissemination of geographical and archaeological thinking by their collaborative works. In particular, three-dimensional models of landforms and landscapes are utilized to promote the geographical and archaeological thinking for the visitors. The case studies include several museum exhibitions in Aomori, Fukushima, Nagano, and Kyoto Prefectures, each of which showed different appearances of the exhibitions. The approaches using 3D models were supposed to be informative directly letting the visitors feel and think the geographical and archaeological contexts behind the models.

Keywords: art, museum, children, geographical thinking, three dimensional

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Introduction of Guide Skill Up Course and Its Effect in the Izu Peninsula Geopark

*Tsuda Kazuhide[1], Hiroshi Ono[1], Hiroshi Yamazaki[1], Akifumi Matsuo[1], Hideki Ono[2]

1. NPO Whole Earth Institute, 2. Izu Peninsula Geopark Promotion Conucil Bureau

[Introduction]
Generally, the material (volcano, mineral, topography, etc.) picked up at the geopark has an impression that it is professional and difficult to understand. The significance of existence of "attractive and meaningable geo guide" is great.
This report examined the lecture focusing on "transmitted technology" against the certified geo guide at the Izu Peninsula Geopark. We designed a lecture aimed at aiming to be able to express "exactly more easily" the expert knowledge that students have accumulated through various training etc. so far.

[Method]
The subjects were conducted on 30 Izu Peninsula certified geo guides in November to December 2018 once a week from 10:00 to 16:00 as shown below, with five contents.
As the 5th monitoring tour, we distributed a leaflet at the 1st lecture and started recruiting.
In addition, we conducted a questionnaire after each lecture, and tabulated the evaluation and effect of the course.

1. Guidance, How to make a place, Mental attitude of the guide
After confirming the flow of 5 times and treating it as a guidance of the course, learn how to start a program smoothly with the participants. Learn how to relate the guide to visitors and the mental attitude required to face the guide.

2. Transmission technology, Field tour, Lecture
The instructor carried out a simple geo tour for students. In the afternoon, we will give lectures and discussions on the "transmitted technology" that the instructor has taken in.

3. Program design, Sharing of guide methods
Learn the flow and composition of the program to effectively "transmit".Also, set up time to share daily guidance techniques and tools you are using among participating guides.

4. Program planning, Rehearsal
Organize 4 to 5 teams. Incorporate the techniques and ideas learned in the past three courses, and prepare a program for elementary school upper grades (about 15 minutes). Also suppose it will be rainy on that day.

5. Practice, Program execution
Provide programs created for primary school students , upper grades. While doing questionnaire and retrospect, notice what you got in the whole and take it their lifestyle.

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[Results]
According to the results of the questionnaire, almost everyone was satisfied with the contents in each lecture. For students that answered that they could leverage what we learned in this course to their own program and were able to say the direction of how to communicate to geo tour.
Towards the actual implementation of the program created by the team to elementary school students, sometimes from lecturers and talks between students, the trick to assembling tips and programs, the process of discovering each other's potential , As the number of times repeated, the students became robust.
In addition, there were few students who gave a problem point, many positive opinions were received. Hospitality of drinks and music, etc. that create a relaxing space, group activities, drawing out the voluntariness of students, cooperativeness There are many opinions that we would like to continue, etc., and a constructive opinion went up to make it better.

Keywords: Geo guide, Skill up course, Transmissing techniques

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Testcase of Science Cafe with Confrontation Axis Considerd to Complex of Earth and Space Science

*Harufumi Tamazawa[1,2], Yuko Ikkatai[3]

1. Disaster Prevention Research Institute, Kyoto University, 2. Faculty of Fine Arts, Kyoto City University of Arts, 3. kabli Institute for the Physics and Mathematics of the Universe, University of Tokyo

Science policies related to earth and planetary science include those with large scale, especially in connection with space science, and it is not clearly shown what kind of consciousness the public has due to high expertise, and as a result experts is the field. On the other hand, as far as the development of science and technology (ST)as well as space development, dialogue about science and technology with the public is shown as a goal from the government, and it is one thing to grasp what the public think about the policy Department. In the social survey on the space policy conducted on the Internet in 2014, the difference of images between space development and other ST policies, etc. are also being investigated, but on the other hand, regarding the specific budget allocation, It is difficult to judge whether or not you have a concrete image, such as answering to do (Fujita &Taromaru 2015). In 2017, we conducted an interview survey on why I responded to respondents after asking about the same contents, but some anserwed that it is difficult to consider space development compared to ST related to daily life (Tamazawa et al. 2018). Town meetings and public comments are being held as concrete attempts to foster opinions while encouraging citizens to feel familiar. It is a question to be examined including knowing how citizens think and thinking about how to reflect it in policy and effective method development.

Assuming to examine individual policy issues, it is necessary to share the process of grasping the background of the problem and organizing the problems, and how to visualize the problem and to discuss it is a challenge. is there. Especially, event formats such as those provided by a single science cafe, such as those provided by a regular science cafe, can deviate from the purpose of "gathering opinions" due to the information transmission and reception between participants and host. What type of format is effective to encourage participants to have their own opinions and think subjectively.

In January 2018, in a science café in a science café at the wine bar, a discussion on ST and society at the university, two topic donors were discussed and opinions of the participants were chronologically aligned We made a test case of a science cafe in a controversial style, taking the approach of visualizing. Under either theme "Setting the environmental change of Mars is allowed", from the topic provider, after giving representative opinions from the standpoint of favor and opposition, after agreeing and opposing axes on the white board , And asked the magnet to indicate the position of the participant's opinion. In order to see the transition of opinion after discussion among the participants, they asked for the position of opinion again after the discussion.

In the case of doing it in a university class, after the initial opinion, we had a discussion by the group including approval and opposition for each group, asked for suggested criteria and presented the opinions of the individual again There were participants who changed opinions on the other side from the viewpoint of environmental ethics, generation ethics, diversity. On the other hand, participants who strongly agreed or opposed from the beginning did not see much change.

In the event held at the wine bar, the agreement side agreed more, the other side moved the opinion to the other side more. There was an opinion that the opinion after the end of the science cafe considered

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taking care of participants into consideration. In both cases, it turned out that the position of the participants varied to some extent through the visualization of opinions, and that there were constant layers of standing position changes with the discussion. In general events related to ST such as science cafe, there is a tendency for people with a high level of interest in science and technology to participate (Kano, Mizumachi et al.), And such layers include a place of opinion such as question and answer at the event If there is, there is a possibility that the speaking participant may stand behaving apart from its own opinion transition, contributing to facilitation and activation of the discussion, on the other hand, excessive role consciousness is said to be a citizen's awareness From the point of view it may be possible that it is separate from the person's own opinion.

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Keywords: Public Engagement of Science, Science Policy, Scinece Cafe, Active Learning

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Literacy for Rumors of Earthquake Occurrence

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1. Institute of Oceanic Research and Development, Tokai University, 2. Department of Physics, Tokyo Gakugei University

A rumor of earthquake occurrence has often emerged after the most of large earthquakes (EQs), such as the 2016 Kumamoto EQ (Magnitude: M7.3) and the 2018 Hokkaido Eastern Iburi EQ (M 6.7). In the Kumamoto EQ, one of the hotels in Kochi prefecture was temporally closed due to the rumor. After the large EQs, the other false rumors such as animal escaping from the zoo and stop the supply of public water also emerged. In addition, the rumor of EQ occurrence often emerges not only after the large EQs but also during the aseismic period. In this study, we introduce features of the rumors of EQ occurrences and discuss literacy for them to identify the false rumors.

Keywords: rumor of earthquake occurrence, literacy

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Regional crustal movements and gigantic tsunami traces recorded by ghost forests: Importance of outreach activities and education for disaster prevention

*Kiyoyuki Shigeno[1], Futoshi Nanayama[2,6], Kazuaki Watanabe[2], Masayuki Ishii[3], Kazuhito Ishiwata[4], Shigeto Inokuma[5], Keita Fukatsu[7]

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Coastal topography and tsunami deposits caused by trench type earthquakes can be clearly observed around the Kuril subduction zone, eastern Hokkaido. We conducted a geological excursion on the theme of geological phenomena caused by giant earthquakes, which can be participated by local citizens on September 3-4, 2018 as a related event of the 125th annual scientific congress of the Geological Society of Japan in Sapporo. In this excursion, we taught that future disasters can be predicted based on the past information from strata and topography recorded during the past several thousand years. And these are useful for teaching materials for students. We also hope that local citizens will consider future giant earthquake and tsunamis and disaster prevention using peel specimens of tsunami deposits for local museums, etc.

Keywords: outreach activities, awareness activities, tsunami deposits, related regional crustal movements, giant earthquake

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[G-02] Geoscinece Outreach

convener:Takeyuki Ueki(Faculty of Risk and Crisis Management, Chiba Institute of Science), Jiro Komori(Teikyo Heisei University), Naoko HASEGAWA(Ochanomizu University), Satoko Oki(Faculty of Environment and information Studies), Chairperson:Naoko HASEGAWA

The aims of Outreach and geoscience education are to encourage developments that raise public awareness of geosciences through schools and/or public outreach by not only educators but also researchers. Therefore, any presentation related with these aims will be welcomed to this session. Depending on schedule and venue,some presentation will be changed to Poster presentations.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[G02-07] **Constructing quaking model in the geological club activity and discussion activities around crack investigation**

*Ryo S Nakamura[1] (1.Miyagi Rifu high school)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[G02-08] The Impact of Middle School Students' "BOSAI Narratives" on the Community of Tosashimizu City

*Risako Tokoro[1], Kei Usui[1], Ayana Kawasaki[2], Tosei Nagamatsu[3], Satoko Oki[2] (1.Keio University, Faculty of Policy Management, 2.Keio University, Faculty of Environment and Information Studies, 3.Keio Research Institute at SFC)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[G02-09] **Disaster Prevention Education Programs to Increase Risk Perception**

*Erina Hyuga[1], Hitomi Sasaki[1], Satoko Oki[1] (1.Keio University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[G02-10] Geoscience education for infants using geological specimen

*Naoki Morita[1,2], Mana Yasui[2,3], Hiroshi Hagiya[2,4] (1.Meisei University, 2.Non-Profit Organization Science and Art, 3.Waseda research institute for science and engineering, 4.Tokyo City University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[G02-11] Introducing Narrative Approach to Earthquake Disaster Prevention (BOSAI) Teacher Training: Practice in Saitama Prefecture

*Ami Pareek[1], Satoko Oki[1], Kohei Yamaguchi[1], Mirei Toba[1] (1.Keio University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[G02-12] Practice of Disaster Education in Mexico: "Cultural Tuning" Based on Comparative Study of Public Educational Curriculum Between Japan and Mexico

*Takuya Iwahori[1], Genta Nakano[1], Katsuya Yamori[1] (1.Disaster Prevention Research Insutitute, Kyoto University)

Constructing quaking model in the geological club activity and discussion activities around crack investigation

*Ryo S Nakamura[1]

1. Miyagi Rifu high school

Our school region is standing on the field of active-fault "Nagamachi-Rifu" line.
Our school region is standing on the field of active-fault "Nagamachi-Rifu" line.
We have had activities upon the surrounding research, for the fault's activity and sediments research.
Therefore, we seeked leading method to make experimental motion in the class and science club activity.
I will talk about daily geological activities, also concern to against disaster education as follows;

(1) Leading method of sediment materials research
Students tried to find some geological faults on the ground. They found boling core samples above the faults and succeed to analyze sediments and mentioned volcanic ash contains.

(2)Constructed motor-controlled quaking apparatus
The quaking model plays much important rolls to mention real breaking phenomena. Our students discussed the several soil model made by corn and chocolate-flakes, and constructed quake mechanics. Firstly they quaked by the hand-quaked, but the reproducibility was lower level. Then they planned motor-controlled and made by steel cans and rubber plugs which everything found surroundings. Reproducibility and easy constructing is much valuable model to make leading geological methods.

(3)Discussed cracks on the building by the stress
Students found the cracks on the building to specific direction, they mentioned about ground stress characteristic. Essentially, our region is located the border between ocean and continental plates. They also discussed the effects made by flat-constructed grounds.

Keywords: Seismic experiments, Sediments, Crack investigation

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The Impact of Middle School Students' "BOSAI Narratives" on the Community of Tosashimizu City

*Risako Tokoro[1], Kei Usui[1], Ayana Kawasaki[2], Tosei Nagamatsu[3], Satoko Oki[2]

1. Keio University, Faculty of Policy Management, 2. Keio University, Faculty of Environment and Information Studies, 3. Keio Research Institute at SFC

Students of Shimizu Middle School, located in Tosashimizu City (Kochi Prefecture) has been writing short stories called “BOSAI Narratives” since 2016. In JpGU 2018, Nagamatsu presented on how the students themselves were influenced by writing them (Nagamatsu, 2018). This year, we will discuss the results of our study on how the narratives affected the students’ parents and other people in the community.

About Tosashimizu City and the “BOSAI Narratives”

Tosashimizu City is a provincial city with a population of 14,000 people; 47% of it being over 65 years of age. In 2012, the Japanese government announced that in the Nankai Trough Earthquake, the tsunami height estimation of the city can be as high as 34 meters (Cabinet Office, 2012). The announcement was meant to increase people’s awareness, but it resulted in leading some people to lose hope in surviving the earthquake (Sun, 2014 and Oki, 2017). However, the “BOSAI Narratives” seem to be changing the situation.

We developed the “BOSAI Narrative” with the teachers of Shimizu Middle School in 2016. It is a short story written by individual students imagining their own situation in the event of the Nankai Trough Earthquake. They could write about anything that they imagine to be happening at the time of the disaster, under the condition that they must end in hope.

Research Method

At the end of the school year 2017, we conducted a survey on all the parents of the community, who had read the “BOSAI Narratives” written by the students of that year. Out of the respondents, we selected 10 parents to interview individually in order to conduct further qualitative research on how they were impacted by reading the students’ narratives.

Results

Through careful analysis of the survey and interview results, we discovered the following: 1) readers obtained and understood information concerning the occurrence of earthquakes, despite its uncertainty. In other words, the students played the role of “translating” scientific language into a daily context; 2) moreover, readers began to reconsider their everyday lives; 3) readers have trust in the disaster preparedness education program itself; 4) how the readers are impacted relies heavily on their individual backgrounds; 5) the narratives do not necessarily induce readers in perceiving earthquakes subjectively; 6) some readers learned to seek value in living the moment; 7) the narratives exposed the readers to other worlds and situations (term in Japanese: “guuyusei”) (Yamori, 2007); 8) the narratives’ setting to “end in hope” led some readers to imagine the opposite situation; thus 9) empowering readers to contemplate disaster (Yamori, 2007); and lastly 10) as for the interviewees in this study, most of them had already taken preventive measures prior to reading the narratives. Thus, only a few cases of behavioral changes were recognized in the narratives’ readers.

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Keywords: Education, Earthquake, Narrative

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Disaster Prevention Education Programs to Increase Risk Perception

*Erina Hyuga[1], Hitomi Sasaki[1], Satoko Oki[1]

1. Keio University

1. Introduction

The 2011 Great East Japan Earthquake raised awareness of the importance of disaster prevention education. Japan's Ministry of Education, Culture, Sports, Science, and Technology (2013) has emphasized the importance of developing education programs that nourish children's independence. However, a survey we conducted in 2015 revealed that it is difficult for school teachers to develop such programs for disaster prevention by themselves (Nagamatsu and Oki, 2015).

2. The "*Finding Risks in the Photo (FRP)* Class" and Photovoice method

This research will discuss a teaching material that we developed mainly for elementary school students. In it, named the "*FRP* Class", students are to look at photographs of themselves in certain situations and find items that may be dangerous when a large earthquake occurs. Since the students themselves are in the photos, they can perceive earthquakes as their own problems. In fact, we have been receiving reports that students became more proactive in learning about disaster prevention, and also became faster at reacting to earthquakes and drills (Oki, 2016).

The Photovoice method, established in public health studies, resembles the "*FRP* Class" in that it uses photos. By explaining to others about the pictures that they took, people find problems of themselves or their community. Originally in the "*FRP* Class", the students were pictured in the photos. This time, by applying the Photovoice method to the "*FRP* Class", each student became the photographer, rather than the subject. We investigated how their awareness of disaster risk management would change throughout the process.

3. Research methodology

We held a workshop on disaster prevention in Tsuruoka City, Yamagata prefecture, targeting students from Grades 2 to 4 in Tsuruoka and nearby cities. Participants took two pictures of their favorite places and sent them to us by e-mail in advance. During the workshop, the students learned about disaster prevention through various activities. Later in the workshop, we had the students introduce their favorite places to each other and explain its dangerous points. In the end, we assigned them to take pictures of the same place that they had taken beforehand, and to rethink about what they like, and what they think is dangerous about the place. We found that some took photos from different angles, to capture the dangers that had not been pictured in their previous photos. This suggests their ability to evaluate risks in actual earthquakes.

4. Results

We conducted a follow-up survey on some participants. As a result, almost all of them spoke of what they learned to their friends or family in addition to re-considering dangerous points. Furthermore, some reviewed their emergency bags and others discussed about evacuation sites. This corresponds to the three elements of study in the theory of "community of practice" (Lave and Wenger, 1991), that is 1)internalization of knowledge, 2)change of identity, and 3)expansion of learning community.

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disaster prevention to promote the ability to live.
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Geoscience education for infants using geological specimen

*Naoki Morita[1,2], Mana Yasui[2,3], Hiroshi Hagiya[2,4]

1. Meisei University, 2. Non-Profit Organization Science and Art, 3. Waseda research institute for science and engineering, 4. Tokyo City University

NPO Science and Art has developed natural science education in kindergarten since 2016.
The classroom runs a natural science class of 9 classes (60 infants and 8 elementary school students) every week. In this presentation we will introduce the following three programs and their educational effects.
1 ·Fossil Excavation Experience
2 ·Mineral Kaleidoscope
3 ·Dinosaurs Card Game
In the fossil excavation experience, the real ammonoid is embedded in the mixture material of gypsum plaster and sand. Children feel the excavation sensation with wooden sticks and rubber hammers. Let the fossils found by the children are made labels, and let them manage themselves as children's own collection.
Mineral Kaleidoscope program uses small stones such as quartz(purple/pink) and olivine to make a kaleidoscope. While observing the stone, develop a story to its origin and the topic of the production area.
In Dinosaur Card Game, while playing ordinary game, let children show and touch fossils (replicas, real fossils) of dinosaurs and marine
reptiles that appeared in Card.Teach children how to get dinosaurs information by using an picture books.
By introducing the feedback of this program, not only can infants earth science, but also includes the role of extending the interest afterwards. This program is proposed to be an excellent program in earth science education from early childhood.

Keywords: Early childhood education, Earth science education, Geological specimen

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Introducing Narrative Approach to Earthquake Disaster Prevention (BOSAI) Teacher Training: Practice in Saitama Prefecture

*Ami Pareek[1], Satoko Oki[1], Kohei Yamaguchi[1], Mirei Toba[1]

1. Keio University

1. Introduction

Since the March 11th, 2011 Great East Japan Earthquake occurred during the daytime when students were in class, the importance of disaster education again became the focal point of society. However, educators have expressed concerns regarding the topic (Nagamatsu, Oki, 2015). Although the effectiveness of disaster prevention education is well known, there are still numerous challenges to it. For example, working hours of school teachers greatly exceed “Karoshi level,” which is over 80 hours per month. Furthermore, the curriculum in public schools is widespread, in addition to fundamental subjects. In a curriculum where there is very little space for additional implementations, it is very difficult to teach disaster prevention education that the teachers themselves have never learned before. There are no teaching materials prepared, and at school, the teachers already have their hands full guiding their students and parents. In most schools, there is only one faculty member assigned to be in charge of school safety including disaster prevention, and in essence, that faculty member has to formulate an annual safety plan and a disaster prevention manual prescribed by the School Health and Safety Law by his/herself. Based on this manual, he/she is responsible for implementing disaster prevention education for that school. With the lack of time, experience, and budget, it is unreasonable to think that the faculty is capable of making improvements from the previous year's plan. As a result, only the continuation of evacuation exercises that have become a mere micromachining and a slight modification of the manual remains.

This presentation will report more efficient and effective ways of conducting earthquake disaster prevention teacher training, and also its achievements.

2. Research Methodology

This study was carried out to alleviate such confusion of the school site. We focused on teacher training, especially for disaster prevention education that is aimed to resolve problems mentioned before by introducing a narrative approach. Teachers are introduced to a hypothetical case in which a large earthquake occurs under school management - the expression and behavior of a child, anxiety, and frustration of a teacher is described in detail from a teacher 's perspective. Teachers are then asked to write out the risks inspired by reading this, participate in group work with other teachers in charge of the same grade, and to share thoughts in front of other teachers in that school. As a result of the training, it is made possible to raise awareness of tackling disaster safety within the entire faculty, and to visualize risks and reevaluate current evacuation methods. This program is 50 minutes in total. We also made handouts which support teachers to improve the evacuation drills after the training.

3. Activities in Saitama Prefecture and Progress

We have been working with two model schools (one public elementary school, and one public junior high school) in Saitama. First, we have done the teacher training, and after that we have done the follow-ups. Teacher training was a good opportunity for the teachers to think about disaster prevention. As a result, there were many activities done positively by school. For example, autonomously revising the evacuation drill, actively making a new plan for it and practicing it, etc. We have also conducted the follow-up surveys in the end of the year.

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Other than the activities of two model schools, all of the school principals in the city gathered for a meeting on July 2018. After the meeting there were positive reactions from some principals, that they were willing to do some activities of disaster prevention.

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Keywords: Disaster prevention, Education

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Practice of Disaster Education in Mexico: "Cultural Tuning" Based on Comparative Study of Public Educational Curriculum Between Japan and Mexico

*Takuya Iwahori[1], Genta Nakano[1], Katsuya Yamori[1]

1. Disaster Prevention Research Insutitute, Kyoto University

The purpose of this research is to compare curriculum of public education between Japan and Mexico with specific focus on knowledge of seismology. The authors at first review the public compulsory educational curriculum in each country, and secondly, carried out practice of disaster education in a university in Mexico City and analyzed the questioner survey of the class. As the result, the authors found that "plate tectonics" is the key to compare the system of the knowledge constructed in the course of public education in each country.

Keywords: Disaster education, Seismology, Mexico

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[J] Oral | G (General)：General

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | 104 1F

[G-03] Geoscience education from elementary school to university students

convener:Masatsune Hatakeyama(Seiko Gakuin High School), Chairperson:Toshihiro Niwa

We will provide and discuss various educational practices (teachings and procedures) for elementary, junior high school, high school and university students. We also welcome outreach reports for all grades. In addition, especially for liberal arts level geoscience education of undergraduate, we will consider the problems and future prospects of our current situation.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[G03-01] "Science reading" in the Oki Island Library Let's science reading! The story of Light deliver "science reading and demonstration experiments in the Oki Island Library

*Kunihiro Abe[1] (1.Shimane Penunsula Shinjiko Narumi, Kuibiki Geopark Promotion Committee)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[G03-02] Difference in elementary students' understanding of a solar eclipse by using different ICT devices

*Koji Imai[1], Yasuhiro Murayama[1], Takahiro Yamanishi[2] (1.National Institute of Information and Communications Technology, 2.MITSUBISHI MINATOMIRAI INDUSTRIAL MUSEUM)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[G03-03] Let's learn landform and disaster risk

*Yuki Kurisu[1] (1.Geospatial Information Authority of Japan)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[G03-04] Demonstration of the serpentinite dehydration at a laboratory in school

*Soichi Omori[1], Yukinobu Katsumata[2] (1.The Faculty of Liberal Arts, The Open University of Japan, 2.Natural and Environmental Sciences Program, The Open University of Japan)

10:00 AM - 10:20 AM JST | 1:00 AM - 1:20 AM UTC

[G03-05] Educational activities of the Earth and planetary science in the collaboration of schools, science museums, and scientists using digital globe

*Akinori Saito[1], Takuya Tsugawa[2] (1.Department of Geophysics, Graduate School of Science, Kyoto University, 2.National Institute of Information and Communications Technology)

10:20 AM - 10:30 AM JST | 1:20 AM - 1:30 AM UTC

Discussion

"Science reading" in the Oki Island Library Let's science reading! The story of Light deliver "science reading and demonstration experiments in the Oki Island Library

*Kunihiro Abe[1]

1. Shimane Penunsula Shinjiko Narumi, Kuibiki Geopark Promotion Committee

Concept The phenomenon of the light seen on the island of Oki is stared again, and how the phenomenon might happen, and the light is learnt through the science reading and the demonstration experiment, and it hopes that the inquiring mind which tries to pursue it will grow up, and this course was done.

Basic content Need

light to see things Because there is a certain character in light, the shape of the one is seen and the color is seen. The nature of Light •light goes straight without any obstruction. Light goes straight while diffusing from the light source. •natural light source and artificial light source for light source -Reflection and reflection of light... In an object where light cannot pass, it reflects at the boundary surface, and the angle of incidence and reflection angle of the normal of the reflected surface of light are equally reflected. (Positive reflections and irregular reflection) The light has a color. (It leads to spectrum, wave, and interference in the future.) Three primary colors of light, rainbow The difference and shadow of black and white
The demonstration experiment was performed in such an idea.

Keywords: Visible light, straight, diffusion, light source, light and color, reflection

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Difference in elementary students' understanding of a solar eclipse by using different ICT devices

*Koji Imai[1], Yasuhiro Murayama[1], Takahiro Yamanishi[2]

1. National Institute of Information and Communications Technology, 2. MITSUBISHI MINATOMIRAI INDUSTRIAL MUSEUM

To progress active learning by effective utilization of ICT devices, we studied three different learning methods of a solar eclipse for elementary school students: a passive learning method providing materials by a projector, an active learning method with a tablet, and a virtual experience learning method with a stereoscopic model. According to the results of the questionnaire survey about the degree of ease in understanding, the students answered that it was easy to understand using a tablet or model, and all students showed increased motivation for learning.

Keywords: solar eclipse, ICT, elementary student, active learning

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Let’s learn landform and disaster risk

*Yuki Kurisu[1]

1. Geospatial Information Authority of Japan

Education for disaster prevention is internationally attached importance as is the case with Sendai Framework for Disaster Risk Reduction 2015 - 2030. In Japan, course of study is promoted substantial education for disaster prevention and safety. Geospatial Information Authority of Japan (GSI) released education contents for learning landform and the disaster risk, provides the contents through toolbox for geography education (http://www.gsi.go.jp/CHIRIKYOUIKU/index.html). We would like to report about this contents. We devised three points in order to learner’s interest.

The first point is learning landform and the disaster risk with character. From geography point of view, they can learn disaster of mountainous areas, plain areas and coastal areas with resident. Finally, they can study disaster risk in familiar region using Hazard Map Portal Site.

The second point is interactive development of story. The introduction part leads them to think the relationship between landform and disaster with proverb. The development part has them considered disaster risk with cases and land condition. The conclusion part prompt them to reconfirm inseparable relationships with landform and the disaster risk.

The last point is easy representation of technical terms. They have to understand characteristics of river

in order to grasp flood. In the contents, we compare river a valley to a funnel.

GSI will continuously provide useful information about disaster risk such as this content and support geography education.

Keywords: Education for disaster prevention, landform, disaster risk

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Demonstration of the serpentinite dehydration at a laboratory in school

*Soichi Omori[1], Yukinobu Katsumata[2]

1. The Faculty of Liberal Arts, The Open University of Japan, 2. Natural and Environmental Sciences Program, The Open University of Japan

We report an experimental method to demonstrate the serpentine dehydration reaction at a laboratory in school. The aim of this study is illustrating the H_2O cycle between the surface environment and the mantle via hydrous minerals.

Keywords: hydrous mineral, serpentinite, dehydration reaction, labo experiment

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Educational activities of the Earth and planetary science in the collaboration of schools, science museums, and scientists using digital globe

*Akinori Saito[1], Takuya Tsugawa[2]

1. Department of Geophysics, Graduate School of Science, Kyoto University, 2. National Institute of Information and Communications Technology

Educational activities of the Earth and planetary science using Dagik Earth, a digital globe, have been carried out in the collaboration of schools, science museums, and scientists. Dagik Earth has been developed by Earth and planetary scientists in Kyoto University, NICT and others. Many scientists join the project to develop the contents using the Earth and planetary data. It is presented as permanent and temporal exhibitions in science museums. Some science museums have training seminars of Dagik Earth for school teachers. Because it is simple and easy to use, it is designed to use regular classrooms. The manual for teachers is developed for science and social class in elementary schools, junior high schools, and high schools in Japan. As the usage of Dagik Earth expands in the collaboration of schools, science museums, and scientists, the difficulties to use it in classrooms become clear. For example, the whole Earth is rarely taught in the science class in the elementary school because the study of the country-scale is more focused. In the presentation, current status of the project, its difficulties in schools, and the future plan will be reported.

Keywords: Digital globe, Dagik Earth, 3D presentation

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[J] Oral | G (General)：General

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | 104 1F

[G-03] Geoscience education from elementary school to university students

convener:Masatsune Hatakeyama(Seiko Gakuin High School), Chairperson:Masatsune Hatakeyama(Seikogakuin High school)

We will provide and discuss various educational practices (teachings and procedures) for elementary, junior high school, high school and university students. We also welcome outreach reports for all grades. In addition, especially for liberal arts level geoscience education of undergraduate, we will consider the problems and future prospects of our current situation.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[G03-06] **Improving Awareness of Marine Conservation and Sustainability among Taiwanese Middle School Students by Teaching Slow Fish Movement**

*Ya-Yin Liao[1], Liang-Ting Tsai[2], Ting-Kuang Yeh[3], Cheng-Chieh Chang[1] (1.National Taiwan Ocean University Institute of Education , 2.Taiwan Marine Education Center, 3.National Taiwan Normal University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[G03-07] Prototyping of the teachable moment presetation for recent earthquakes in Japan (2) - - -The case of the 3 January 2019 Kumamoto earthquake (M5.1) on and improvement from the previous prototype- - -

*Reiji Kobayashi[1] (1.Graduate School of Science and Engineering, Kagoshima University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[G03-08] Development of web application for polarizing microscope observation

*Fumitoshi Morisato[1] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[G03-09] Usage and Utilization of 3D display function on GSI Maps

*Ryoichi Kojiroi[1] (1.Geospatial Information Authority of Japan)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[G03-10] Bringing field- and laboratory work into the classroom by using online modules in the edX platform

*Alejandra Quintanilla-Terminel[1], Matej Pec[1], Oliver Jagoutz[1] (1.Massachusetts Institute of Technology)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

Discussion

Improving Awareness of Marine Conservation and Sustainability among Taiwanese Middle School Students by Teaching Slow Fish Movement

*Ya-Yin Liao[1], Liang-Ting Tsai[2], Ting-Kuang Yeh[3], Cheng-Chieh Chang[1]

1. National Taiwan Ocean University Institute of Education , 2. Taiwan Marine Education Center, 3. National Taiwan Normal University

The ocean is the largest life support system on Earth. Through long-lasting evolution, an enriched variety of ocean specimens have been produced, thereby fulfilling human needs such as those of food, medicine, and marine recreation. Numerous marine products contain health-beneficial compounds; for example, oils obtained from multiple types of fish are enriched with Eicosapentaenoic acid (EPA) and Docosahexaenoic acid (DHA), which are beneficial to human eyes and brain development, respectively. Additionally, these components are immensely beneficial for controlling inflammation, lowering cholesterol, and replenishing calcium. Therefore, usage of marine products is closely related to the growth and development of the human body and regulation of its physiological functions; seafood is thus a key element of a healthy diet. However, human behavior and activities over the preceding ten years have posed the threat of damage to the health of ocean environments and productivity of marine resources. Hence, marine conservation and generating awareness of it is a pivotal task.

The study aimed at measuring the impacts of Slow Fish Movement curriculum on students' marine purchasing and eating habits along with determining the changes in student's understanding level regarding marine awareness and sustainability. For the same, a questionnaire designed for Slow Fish Movement (SFM) curriculum map with core values derived from Sustainable Development Goal 14 (SDG 14) in the United Nations, Slow Fish promotion in Italy, as well as Principles for Seafood Consumption Recommended by Taiwan Seafood Guide. The study objects were seventh and eighth-grade students of Er-Xin Middle School in Keelung city. The experiment lasted for three weeks. The experimental group contained 1,007 students and compared their performance difference with pre-test & post-test. Of the 1,070 questionnaires distributed, Invalid questionnaires were 63 and thus eliminated—resulting in 1,007 valid responses, the overall response rate was 94.11%. Before the SFM course, a pre-test was conducted to understand students' original knowledge, attitudes and behaviors in life about marine conservation and sustainability. After SFM course for three weeks, a post-test was conducted to understand if students improve understanding levels on ocean conservation and sustainability. After retrieval and sorting of the responses, the statistics software SPSS 20.0 for Windows was used to calculate the mean and standard deviation and conduct paired sample *t*-test. The result revealed:
The most common consumption seafood by mistake in Taiwan Seafood Guide "SAY NO" criterion is Cuttlefish which usually caught by methods that destroy marine habitats. Slow fish movement curriculum map significantly impacted students' judgments on selection environment-friendly of seafood consumption ($t = -46.229$, $p < .001$) After taking the course of Slow Fish Movement that students exhibited significantly increased understanding of marine conservation and sustainability ($t = -19.064$, $p < .001$).

Sustainable development is the core target of Global growth. Teaching SFM curriculum map to promote awareness of environmentally friendly seafood-purchasing methods can enable consumers to eat more

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healthily and ocean ecology to be protected, thereby helping ocean ecology to recover its bioenergy.

Keywords: Slow Fish Movement, Sustainability, Marine Conservation, Taiwan Seafood Guide, Sustainable Development Goals (SDGs)

Keywords: Slow Fish Movement, Sustainability, Marine Conservation, Taiwan Seafood Guide, Sustainable Development Goals (SDGs),

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Prototyping of the teachable moment presetation for recent earthquakes in Japan (2) ---The case of the 3 January 2019 Kumamoto earthquake (M5.1) on and improvement from the previous prototype---

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Several news topics can be a good sources of teaching materials. Relation between news and contents of textbooks can interest students.

The Incorporated Research Institutes for Seismology (IRIS) have provided us with slides of teachable moment presentation on recent earthquakes in the world. Teachable moment means a good opportunity for teaching. I sometimes use the presentation slides in my lectures. However, the IRIS does not create the slides on moderate magnitude earthquakes, which cause moderate damages.

Therefore, I plan to prepare teachable moment presentation for recent earthquakes in Japan. I discussed the preparation guidelines based on that of the Incorporated Research Institutes for Seismology.

The guidelines are that the presentation 1) is prepared for high school and university students in Japan learning geoscience, 2) is created on recent earthquakes occurred in Japan, which may appear in a front page of a newspaper, 3) can be interpreted in about 10 minutes, 4) contains information of hypocenter, magnitude, seismic intensities, damages, tectonic background, historic seismicity, focal mechanism solution, aftershock distribution, seismograms, and other event-specific information, 5) is uploaded within 12 hours after the earthquake, 6) is created in a few hours by using the template, 7) is a classroom-ready product that can be customized, 8) contains open information, which sources are clearly given in slides, and 9) contains only information which may be agreed by most seismologist.

I created a prototype presentation on the 2018 Hokkaido Eastern Iburi earthquake, and uploaded it on the webpage (http://reijikan.my.coocan.jp/RETMJ/retmj-index.html) (Kobayashi, 2018a, b). Kobayashi (2018b) also discussed issues on the contents and the future project system.

On 3 January 2019, a M5.1 earthquake in Kumamoto prefecture. The JMA seismic intensity scale is up to 6 lower. I also created the presentation. I modified expression of the geometry of the fault plane including roughly approximate extent of the fault plane, and adopted a movie on the propagation of the seismic waves created by the National Research Institute for Earth Science and Disaster Resilience (NIED).

I hope that such developments of teachable moment presentation on volcanic eruptions, typhoons, and so on, are carried out to increase number of students learning geoscience.

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Eastern Iburi earthquake).

Kobayashi, R. (2018b): Development of teachable moment presentation for recent earthquakes in Japan, Reports of the Faculty of Science, Kagoshima University, 51, 43-51. (in Japanese with English abstract)

Keywords: teachable moment, the 3 January 2019 Kumamoto earthquake

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Development of web application for polarizing microscope observation

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It is essential to handle actual natural phenomena and natural samples to cultivate the scientific view of nature through geoscience education. At the same time, from the viewpoint of assisting and promoting achievement of the purpose, good quality geoscience materials that anyone can access anytime, anywhere is also necessary. For example, rocks and minerals show various diversity, so to acquire these appraisal methods it is necessary to observe while comparing multiple samples. Among them, concerning the appraisal using a polarization microscope, the cost, and labor required to prepare microscopes and rock slices can be a barrier, especially in self-study. To solve this problem, the speaker has developed a web application that can interactively observe the observation of rocks and minerals by polarizing microscope (“SCOPin rock,” URL is https://microscope.fumipo-theta.com). At the present stage, I have implemented sample selection, rotation, and enlargement of the field of view, switching between open Nicol and cross Nicol, and displaying variable scale.

This application's unique attempt as a polarizing microscope simulator is to deal with various devices including smartphones and tablets and to reduce the amount of data transfer. First of all, you can use this application regardless of the machine as long as you install a modern browser (such as Google Chrome, Safari, and Microsoft Edge), and you can use it in the excellent layout according to the screen size of the device. Second, while maintaining the smooth rotation of the visual field image, the number of images required for one sample is limited to 12 to 24 images. As a result, when using JPEG images of 1280 ×1280 px, the data size is about 2 to 3.5 MB, and the number of requests to the server is only one.

I assume the following use cases for this application.

1. In class, teachers can project polarized microscope images on the screen if there is a projector.

2. In the class, all the students can view and operate the same rock slice picture at hand.

3. In the geological excursion, you can share rock slice photos at the time of guidance.

In the future, I would like to realize content expansion and response to various use cases by publishing the upload function of polarization microscope image data by users and providing private repository creation service of image data.

Keywords: polarizing microscope, Web application, teaching materials

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Link to SCOPin rock



https://microscope.fumipo-theta.com

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Usage and Utilization of 3D display function on GSI Maps

*Ryoichi Kojiroi[1]

1. Geospatial Information Authority of Japan

GSI Maps which is a web map system operated by the Geospatial Information Authority of Japan (GSI), have a 3D display function, the so-called GSI Maps 3D. With the GSI Maps 3D, it is possible to visually grasp various topographies. The GSI Maps 3D can be used by Internet browsers, and it is also supported in smartphones. So the GSI Maps 3D will be useful for teaching material development. To create teaching materials, we encourage to make and enjoy various virtual terrain with the GSI Maps 3D.

First of all in my presentation, I will touch on how to use the GSI Maps 3D. In the latter part of my presentation, I will introduce examples of the topographical representation in 3D. I would like to take up as many things as possible, such as volcanic landform, rock-controlled landform, terrace, fault topography.

GSI Maps can represent various topographies in various ways, and new functions are added as needed. I will continue to consider useful examples for Geoscience education.

Keywords: GSI Maps, topography, 3D, Geoscience education, teaching materials

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Bringing field- and laboratory work into the classroom by using online modules in the edX platform

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1. Massachusetts Institute of Technology

We present two projects that aim at enhancing geoscience education in the classroom through the use of online modules in the edX platform. “Deform the earth” and “Virtual field trip” are two online modules that the department of Earth, Planetary, and Atmospheric sciences is developing in collaboration with MITx . These two modules will be used residentially at MIT, and by being freely accessible through the edX platform, also aim at expanding access to geoscience education worldwide. Each module addresses different challenges in geoscience education. How to teach laboratory skills in the classroom, particularly in a field that is both dangerous and difficult to access? How to teach field skills in a dynamic and effective way and how to make sure the students make the most out of their field experience?

Experimental rock deformation studies allow us to acquire data by measuring mechanical properties of rocks and minerals under a broad range of conditions. This data is essential for geodynamical models and tectonic interpretations. However, because the experimental protocols are difficult to explain in a classroom, and only few rock deformation laboratories exist world-wide, students overlook this component of Earth Sciences and often lack the knowledge to critically evaluate experimental results. Through “Deform the Earth” we want to introduce students to experimental rock deformation. An online module will allow us to both build and assess an experimentalist skill-set without ever needing to enter a real laboratory. The module is built on how-to videos explaining each step in the experimental procedure and analytical explanations of the data analysis. This module will allow us to experiment on ideal methods on how to teach a skill-set by scaffolding the experience for students. In addition, we plan to use pre- and post-testing to find out the most common misconceptions and worked and faded examples to teach how to interpret experimental data. The module will be freely accessible online and could be used by teaching institutions that do not have access to experimental rock deformation facilities.

An essential part of the geology training is learning how to make reliable field observations. This skill, however, is extremely difficult to teach in a traditional classroom setting. It is usually taught through field trips and it is a fundamental part of the curriculum that motivates and excites students into pursuing further studies in geology and earth sciences in general. In introductory classes, students are still learning to distinguish important characteristics in outcrops and may not be able to make important connections during the field trip. “Virtual field trip” aims at recreating the learning experience of the Introduction to geology class in the edX platform. It will be used residentially to provide the students access to the information learned in the field at different stages of the semester-long class, and allow them to consolidate their learning by strengthening connections between concepts they learned in the field and in the classroom. We plan to use pre- and post-testing and compare them with previous runs of the class that did not have access to the online module in order to evaluate its effectivity. The broader audience will benefit from a curated field experience that can be replicated by going to the sites.

Keywords: online learning, field trip, laboratory skills, blended learning

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | 301B 3F

[M-IS24] Integrated Analysis of Geoscience Observations from the Floor to Surface of the Ocean

convener:Keisuke Ariyoshi(Japan Agency for Marine-Earth Science and Technology), Motoyuki Kido(International Research Institute for Disaster Science, Tohoku University), Daisuke Inazu(Tokyo University of Marine Science and Technology), Narumi Takahashi(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Keisuke Ariyoshi, Motoyuki Kido

Sea bottom pressure data contains various components such as crustal deformation, ocean oscillation, tidal variability, atmospheric change, and instrumental drift. So far, seismologists have treated the ocean oscillation as noise, and ocean physicists have done vice versa (considering crustal deformation as noise). Such problems apply to ongoing undersea acoustic distance measuring and other types of ocean observations. In this session, we welcome contribution on various topics focusing on the complementary relationship between seismology, ocean physics, meteorology, tsunami technology, and other related fields.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[MIS24-01] Meteorological Observations at Shionomisaki in cooperation with “Chikyu”, Shinsei-maru and Seisui-maru

*Akira Kuwano-Yoshida[1], Keisuke Ariyoshi[2], Kosei Komatsu[3], Yoshihiro Tachibana[4], Mikiko Fujita[2], Masato I. Nodzu[5], Hatsumi Nishikawa[10], Yoshimi Kawai[2], Naoki Kishita[6], Lyndon Mark Olaguera[5], MIHARU KUBO[8], Kentaro Hase[7], Yuya Matsuyama[6], Minami Masuda[9], Kenta Irie[11], Tetsuji Yoshida[10], Yusuke Watanabe[7], Kosuke Matsuda[12], Syunsuke Aoki[7], Shingo Watanabe[2], Akira Kurisu[13], Shota Yamasaki[7], Hidetaka Hirata[14], Shizuka Akiyama[7], Yoshinori Shigeta[15], Akira Miyata[15], Kai Matsubara[15], Yoshitaka Tada[15], Yasushi Watarai[16], Yusuke Nakamura[16] (1.Disaster Prevention Research Institute, Kyoto University, 2.Japan Agency for Marine-Earth Science and Technology, 3.Graduate School of Frontier Sciences, The University of Tokyo, 4.Faculty of Bioresources, Mie University,, 5.Tokyo Metropolitan University, 6.Kyushu University, 7.Kyoto University, 8.University of The Ryukyus, 9.Hirosaki University, 10.Hokkaido University, 11.Tokyo Gakugei University, 12.Tokyo University of Marine Science and Technology, 13.Okayama University, 14.Nagoya University, 15.Tottori University of Environmental Studies, 16.Rissho University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[MIS24-02] GNSS-A data analysis to estimate the sound speed profile

*Tadashi Ishikawa[1], Yusuke Yokota[2], Shun-ichi Watanabe[1] (1.Hydrographic and Oceanographic Department, Japan Coast Guard, 2.Institute of Industrial Science, the University of Tokyo)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[MIS24-03] Comparison of Ocean Bottom Pressure Observation Timeseries with Result of Real Ocean Estimating Models around the Pacific Rim Earthquake Zone

*Yoichiro Dobashi[1], Daisuke Inazu[2] (1.Tokyo University of Marine Science and Technology, 2.Tokyo University of Marine Science and Technology department of marine resouces and energy)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[MIS24-04] Experimental challenges for interpretation of in-situ observation of bottom pressure recorders (BPRs) at the seafloor

★Invited Papers

*Hiroyuki Matsumoto[1], Toshinori Kimura[1], Shuhei Nishida[1], Yuya Machida[1], Eiichiro Araki[1] (1.Japan Agency for Marine-Earth Science and Technology (JAMSTEC))

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[MIS24-05] Continuous bottom pressure observation by real-time buoy system for tsunami and crustal displacement

*Narumi Takahashi[1], Kentaro Imai[2], Motoyuki Kido[3], Yusaku Ohta[3], Tatsuya Fukuda[2], Yasuhisa Ishihara[2], Hiroshi OCHI[2], Kensuke Suzuki[2], Ryota Hino[3] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Japan Agency for Marine-Earth Science and Technology, 3.Tohoku Univerisity)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[MIS24-06] Looking into the ocean and Earth's interior from their boundary

★Invited Papers

*Yoshio Fukao[1] (1.CEAT / Japan Agency for Marine-Earth Science & Technology)

Meteorological Observations at Shionomisaki in cooperation with “Chikyu”, Shinsei-maru and Seisui-maru

*Akira Kuwano-Yoshida[1], Keisuke Ariyoshi[2], Kosei Komatsu[3], Yoshihiro Tachibana[4], Mikiko Fujita[2], Masato I. Nodzu[5], Hatsumi Nishikawa[10], Yoshimi Kawai[2], Naoki Kishita[6], Lyndon Mark Olaguera[5], MIHARU KUBO[8], Kentaro Hase[7], Yuya Matsuyama[6], Minami Masuda[9], Kenta Irie[11], Tetsuji Yoshida[10], Yusuke Watanabe[7], Kosuke Matsuda[12], Syunsuke Aoki[7], Shingo Watanabe[2], Akira Kurisu[13], Shota Yamasaki[7], Hidetaka Hirata[14], Shizuka Akiyama[7], Yoshinori Shigeta[15], Akira Miyata[15], Kai Matsubara[15], Yoshitaka Tada[15], Yasushi Watarai[16], Yusuke Nakamura[16]

1. Disaster Prevention Research Institute, Kyoto University, 2. Japan Agency for Marine-Earth Science and Technology, 3. Graduate School of Frontier Sciences, The University of Tokyo, 4. Faculty of Bioresources, Mie University,, 5. Tokyo Metropolitan University, 6. Kyushu University, 7. Kyoto University, 8. University of The Ryukyus, 9. Hirosaki University, 10. Hokkaido University, 11. Tokyo Gakugei University, 12. Tokyo University of Marine Science and Technology, 13. Okayama University, 14. Nagoya University, 15. Tottori University of Environmental Studies, 16. Rissho University

Off Kii Peninsula, DONET is distributed to monitor earthquake and tsunami at seafloor in real time. Because observed pressure change at seafloor includes atmospheric and oceanic oscillation as well as crustal deformation, it is important to observe atmosphere and ocean over DONET. On the other hand, Kuroshio affects atmosphere due to heat and moisture fluxes. To observe atmosphere and ocean processes around Kuroshio, meteorological observations at Shionomisaki Wind Effect Laboratory have been conducted in parallel with “Chikyu”, Shinsei-maru, Seisui-maru during 11-20 October (Obs1), 5-9 November (Obs2) and 12-16 November (Obs 3) in 2018. Through the observation period, upper-air observation using GPS sonde has been conducted twice a day at 03 JST and 15 JST. In addition, atmospheric boundary layer has been observed using a drone, a doppler lidar and pilot barons.

Acknowledgement
This study was supported by Kinki Kensetsu Kyokai Research Grant, Kyoto University DPRI Collaborative Research, JSPS KAKENHI Grant Number 17K19093.

Keywords: Kuroshio, DONET, air-sea interaction

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GNSS-A data analysis to estimate the sound speed profile

*Tadashi Ishikawa[1], Yusuke Yokota[2], Shun-ichi Watanabe[1]

1. Hydrographic and Oceanographic Department, Japan Coast Guard, 2. Institute of Industrial Science, the University of Tokyo

Seafloor geodetic observation based on GNSS - Acoustic ranging combination (GNSS-A) is a technique for estimating the absolute position consistent with International Terrestrial Reference Frame. For that reason, it may be called “seafloor GNSS”.

In this observation technique, the distance between the sea-surface ship and seafloor acoustic transponder is measured by acoustic wave. Therefore, the accuracy of sound speed affects the accuracy of position of transponder. For positioning at the centimeter level, it is necessary to have a sound speed with an accuracy of 0.1 m/s. It is not difficult for the current observation instruments to measure within this accuracy. However, it is needed the values at the place and time through which acoustic ray path passed. Because of the complex spatial and temporal variations of the sound speed, it is impossible in practice to make enough observations to cover all these variations in detail. Thus, for centimeter-level positioning, it is not sufficient to use an observed sound speed data only. On the other hand, the observed travel-time data include not only information about the range but also about the sound speed along the ray path. Taking advantage of this fact, we estimate a sound speed correction function. This idea is similar to estimating the atmospheric delay in a precise GNSS data analysis.

To improve an accuracy of positioning, it is important to improve the method to extract the information of sound speed. In this observation, the vessel is moving for about 6 to 20 hours in a region of about 2 to 5 km square. Temporal and spatial variations of sound speed are estimated from the fluctuation of spatial-temporally distributed acoustic data. In this analysis, the geometrical distribution of acoustic data greatly affects the accuracy of sound speed estimation. Therefore, it is necessary to set track line of the ship properly to accurate observation. We investigate the effect of track line on estimation of sound speed. This evaluation is expected to lead to the design of an appropriate observation system.

Keywords: GNSS-A seafloor geodesy, Sound speed profile

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Comparison of Ocean Bottom Pressure Observation Timeseries with Result of Real Ocean Estimating Models around the Pacific Rim Earthquake Zone

*Yoichiro Dobashi[1], Daisuke Inazu[2]

1. Tokyo University of Marine Science and Technology, 2. Tokyo University of Marine Science and Technology department of marine resouces and energy

Ocean Bottom Pressure gauge observation (OBP) has an ability to detect centimeter scale seafloor vertical deformations near the plate boundaries. However, timeseries of OBP contain not only crustal deformation signal but also ocean tide or other oceanic variations, so detection of vertical displacements from OBP variation is not easy task. Especially, non-tidal oceanic variations have common timescale (several days to weeks) with seafloor deformations related to slow earthquakes which have different features from usual earthquake we know. Therefore, removing non-tidal oceanic variations is demanded and one possibility to solve this question is estimating the non-tidal oceanic variations by real ocean estimation model simulations. Actually, this method has already applied to some observation areas.

In this research, we used two realistic ocean estimation models and evaluated how these can reduce the amplitude of non-tidal oceanic variations by applying to multiple ocean area around the Pacific Rim Earthquake Zone.
We introduced a data assimilated product, ECCO (Estimating the Circulation of the Ocean assimilated by JPL) in addition to the single layer-barotropic ocean model (Inazu et al, 2012) and compared these two calculation result with observed OBP time series. In this comparison, we collected OBP timeseries mainly from IRIS Data Management Center and Ocean Networks Canada including Hikurangi Subduction Zone, Cascadia Subduction Zone and Chile Trench.

As a result, we can see the different characteristics of two models and timeseries variation of each sites and evaluate the variation amplitude because 1hPa change means 1cm change in seawater height and seafloor vertical displacement. In case of Hikurangi subduction zone, ECCO can reduce OBP amplitude about 15-25% and standard deviation of after correction is 1.5-2.5 (hPa), and single layer-barotropic ocean model can reduce OBP amplitude about 30%-40% and standard deviation after correction is 1.1-1.8 (hPa). In case of south area of Cascadia subduction zone, the reducing rate is common to each model about 5-15% which isn't so high as Hikurangi subduction zone however standard deviation after correction is 0.9-2.0 (hPa) which is almost same as after correction of Hikurangi subduction zone but in north area of Cascadia subduction zone, standard deviation after correction is 1.6-2.6 (hPa) though two model can reduce amplitude10-20%.
This implies that using model is effective at Hikurangi site and also Cascadia subduction zone is suitable site to detect centimeter scale seafloor vertical deformation from the viewpoint of simple amplitude variation analysis.

Keywords: Crustal deformation, Ocean Bottom Pressure , Physical ocean modeling

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Experimental challenges for interpretation of in-situ observation of bottom pressure recorders (BPRs) at the seafloor

*Hiroyuki Matsumoto[1], Toshinori Kimura[1], Shuhei Nishida[1], Yuya Machida[1], Eiichiro Araki[1]

1. Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

The Japan Marine-Earth Science and Technology (JAMSTEC) involves various underwater technologies related to long-term seafloor or borehole observatories in the seismogenic zone, by which real-time measurement by BPRs (Bottom Pressure Recorders) can contribute to early tsunami detection, slow-slip seismic event monitoring, or possibly crustal deformation’ s measurement etc. JAMSTEC has used the ocean-bottom borehole temperature and pressure simulator for the recent one decade in order to promote our knowledges taking place in the in-situ BPRs’ observations. In the presentation, we present the recent experiment which characterize the hydro-dynamic pressure at the seafloor during an earthquake. A moderately strong earthquake occurred while the authors were evaluating the long-term stabilities of bottom pressure recorders (BPRs) in conjunction with a broadband seismometer in JAMSTEC. In this experiment, a hydro-static pressure simulating that at the seafloor with a depth of 1000 m was applied by using a pressure standard (i.e., a piston gauge). Consequently, the pressurized BPRs were able to completely record the pressure fluctuations induced by the vibrations of a dead weight on the piston-cylinder during the earthquake. The experiment effectively demonstrated the aspects of the hydro-dynamic pressure data obtained through in situ observations during the same earthquake. We were also able to simultaneously obtain records from unpressurized BPRs; these data suggest that the internal mechanics of the BPRs were unaffected by the earthquake. This experimental evidence that BPRs can record true in situ pressure changes without instrumentally induced contamination may be useful for more thorough interpretations of in situ BPR observations by those communities that utilize BPRs.

Keywords: Bottom pressure recorder (BPR), Pressure standard, Broadband seismometer

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Continuous bottom pressure observation by real-time buoy system for tsunami and crustal displacement

*Narumi Takahashi[1], Kentaro Imai[2], Motoyuki Kido[3], Yusaku Ohta[3], Tatsuya Fukuda[2], Yasuhisa Ishihara[2], Hiroshi OCHI[2], Kensuke Suzuki[2], Ryota Hino[3]

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We have developed real-time observation buoy system for tsunami and crustal displacements and carried out one-year continuous observation around eastern Nankai Trough area. Already we reported a part of the records, for example, tsunami signals brought by Off Southeastern Mie prefecture at 1st April 2016. In general, seafloor pressure observation includes many types of signals, which are crustal displacement, long-term seismic signals, tsunamis, density variation brought by sea current, ocean tide, atmospheric pressure and so on. Therefore, we attached many sensors on the buoy system. Atmospheric sensors to measure pressure, wind speed, wind direction were attached on the buoy, and their data was collected with a sampling of 10 minutes. Precise point positioning, a navigation system using four antennas, and gyro compass were also set on the buoy, and we collected navigation data including buoy position with 2 Hz sampling. Sea floor pressure data using low pass filtered of 0.023 Hz was collected with a sampling of 15 seconds and they were sent to the buoy via the wire end station using acoustic data transmission (Takahashi et al., 2015). The crustal displacement data was also collected, and the buoy has a transducer to communicate with seafloor transponders (Imano et al., 2017; Kido et al., 2018). Many types of observation were succeeded, and next step of our actions is to distinguish these signals. We applied bandpass filter changing the frequencies to the seafloor pressure data. As the results, we found that various signals with relative low frequency were recorded. Although these amplitudes were approximately 0.5 hPa, there were cases with signals with a low frequency of a few minutes, or that from approximately one hour to two hours and with relative short duration. It is possible that slow slip events with various frequencies distribute around off Enshu-nada. In addition, much disturbance was recorded on the pressure sensor during low atmospheric pressure. Such phenomena were recorded by Dense Oceanfloor Network system for Earthquakes and Tsunamis (DONET; Kaneda et al., 2015; Kawaguchi et al., 2015), it is possible that micro tsunami produced by sea surface fluctuation due to variation of atmospheric pressure. In order to clarify the cause of such phenomena, it is essential to observe from seafloor to sea surface. We have successfully observed various physical data both seafloor and sea level in this observatory system. In this presentation, we will introduce various signals recorded by many types of sensors on the real-time buoy system.

Keywords: Tsunami and crustal displacement, real-time observaion, buoy

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Looking into the ocean and Earth’s interior from their boundary

*Yoshio Fukao[1]

1. CEAT / Japan Agency for Marine-Earth Science & Technology

Introduction

Table 1 summarizes the recent ocean bottom observations in which I have been involved. Although these observations were made solely by seismologists, more than half of the published papers were on the oceanic disturbances, including tsunamis, infragravity (IG) waves, internal tides and frontal bores. Less than half were reports on the solid Earth disturbances including VLF earthquakes and slow seafloor deformation. This fact indicates importance of collaboration of oceanographers and seismologists to analyze and interpret the ocean bottom records. I will pick up several topics from Table 1 to explain what may be required to reach a correct interpretation of the records.

Example studies

No. 2. Dispersive IG waves incoming to the off-Aogashima pressure gauge array (A-array), south of Japan, were backprojected by the method conventionally used in seismology. The results were combined with oceanographic information about the spatiotemporal variation of significant wave heights of IR waves provided by WAVEWATCH III. This combination made it possible to locate the excitation sources of the observed IR waves.

No. 3. Off Miyagi, Japan, 42 tilt events dipping landward in a direction perpendicular to the trench axis were detected by a triaxial accelerometer and a tilt-output from BBOBS through an observational period of 10 months. The possibility of seafloor tilting was precluded by a parallel oceanographic observation using a current-meter operated in a limited period. The current record showed that each tilt event was associated with landward flow of cold water. The thermometer inside the accelerometer confirmed that a tilt event was always associated with temperature drop. Clearly, the recorded tilt events were consequences of the frontal passages of advancing bores (solitary waves characterized by an upsloping surging front followed by cold waters). It would be essential for a single station observation to deploy multiple seismological and oceanographic instruments on the seafloor

No. 6. Using the A-array records, we detected the first-mode M2 internal tidal waves propagating with a horizontal phase speed of ~1 m/s in the onshore and offshore directions over the array along the eastern slope of Aogashima Island. The PSD of the internal tide was ~3000 times smaller than that of the M2 external tide. A tide-resolving ocean circulation model (JCOPE-T) was used to simulate the bottom pressure variations at the array. The analysis of the simulated records well reproduced the observed onshore and offshore internal tidal waves. This work represents a good example of collaborations of seismologists and oceanographers.

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No. 11. Slow deformation of the seafloor with a time scale of hours was detected on the records from the far-off Torishima pressure gauge array (B-array) deployed near the Izu-Bonin Trench. Retrieval of signal of this time scale is in general challenging because of the overlaps of tidal disturbances of larger amplitudes and air-pressure disturbances of possibly comparable amplitudes. I developed a method to remove effects of these oceanic and atmospheric disturbances to detect seafloor displacement including its permanent component.

Discussion

Based on these limited experiences, I suggest several possible collaborative works between oceanographers and seismologists. Suggestion includes (No.2) monitoring of the IG wavefield in the Pacific Ocean using data from the seafloor networks such as DONET, S-net and NEPTUNE, (No.3) quantification of internal bores generated in the deep ocean by long-term oceanographic observations at the sea bottom, (No.6) update of a tide-resolving ocean circulation model such as JCOPE-T by assimilating data from the seafloor networks, and (No.11) use of the tide-resolving ocean circulation model to remove “noises” of oceanic and atmospheric origins to retrieve “signals” from the Earth’s interior.

Keywords: ocean bottom observation, pressure gauge, array observation

Table 1. Recent results from our ocean bottom observations

Phenomenon	No	Observation target	Instrument	Sytem	Authors	Year	Journal	Other tools
Ocean	1	Infragravity waves	OBP	DONET	Tono et al.	2014	EPS	
	2	Infragravity waves	OBP	A-array	Tonegawa et al.	2016	JGR-Oceans	HINDCAST/ GLOBAL_IG
	3	Frontal bores	OBA+OBT	Off-Miyagi	Fukao et al.	2016	JGR-Oceans	Currentmeter+ Thermometers
	4	Tsunamis	OBP	A- array	Fukao et al.	2018	Sci. Adv.	JAGURS code
	5	Tsunamis	OBP	A- array	Sandanbata et al.	2018	PAGEOPH	
	6	Internal tide	OBP	A-array	Fukao et al.	2019	JGR-Oceans under review	JCOPE-T
Ocean/ Solid Earth	7	Island deformation by tsunamis	OBP	A-array	Nishida et al.	2019	JGR	BBS on Aogashima Is.
Solid Earth	8	VLF earthquakes	BBOBS	Off-Kii array	Sugioka et al.	2014	Nature Geo.	
	9	VLF earthquakes	BBOBS	DONET	To et al.	2015	PEPI	
	10	Ambient HF seafloor noise	OBS	Off Shikoku array	Tonegawa et al.	2015	Nature Com.	
	11	Slow seafloor uplift	OBP+ BBOBS	B-array	Fukao et al.	2019	in progress	

OBP: Ocean Bottom Pressure Gauge BBS: BroadBand Seismometer on land (3-components)
OBS: Short-period Ocean Bottom Seismometer (3-components)
BBOBS: BroadBand Ocean Bottom Seismometer (3-components)
OBT: Tilt-outputs from BBOBS (2-components)
A-array: Off Aogashima array of OBPs with BBOBS at one site
B-array: Far-off Torishima array of OBPs with BBOBS at one site

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | 301A 3F

[M-IS25] Recent weather disasters: factors and impact on the atmosphere, hydrosphere, and human beings

convener:Kazuaki Nishii(Graduate School of Bioresources, Mie University), Chairperson:Kazuaki Nishii(三重大学)

A record heavy rain event occurred in July 2018 around western Japan, which caused lots of flood and sediment disasters. The toll of dead and missing was more than 200. The heavy rain was followed by a record heat wave. The highest temperature in a day reached 41.1 degrees Celsius in Kumagaya, which is an all-time high in Japan. This year also suffered from typhoons over and over again. In July 2017, there was another heavy rain event in northern Kyushu area, which also caused tremendous damage. The aims of this session are to discuss factors that caused weather disasters in recent years, and to clarify those impact on the atmosphere and hydrosphere as well as on human beings.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MIS25-01] Heavy Rainfall Event in Middle Viet Nam on 8-9 December 2018 and current QPE/QPF at VNMHA

★Invited Papers

*Kazuo Saito[1,2,3], Le Duc[4,3], Du Duc Tien[5], Mai Khanh Hung[5] (1.Japan Meteorological Business Suport Center, 2.Atmosphere and Ocean Research Institute, the University of Tokyo, 3.Meteorological Research Institute, 4.Japan Agency for Marine-Earth Science and Technology, 5.National Center for Hydro-Meteorological Forecasting, Viet Nam Meteorological and Hydrological Administration)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MIS25-02] High-resolution flow-simulation in Typhoon 21, 2018: tremendous loss of water plants in South Lake Biwa

★Invited Papers

*Satoshi Nakada[1], Hiroki Haga[2], Maho Iwaki[1], Keisuke Hatano[3], Koji Mabuchi[1], Noriko Takamura[1] (1.National Institute for Environmental Studies, 2.Lake Biwa Museum, 3.Japan Water Agency)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MIS25-03] Northern mid-latitude warming prolonged for more than 6 months in 2018 well-predicted by the JMA's operational seasonal prediction system

*Chiaki Kobayashi[1], Ichiro Ishikawa[1] (1.Meteorological Research Institute)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MIS25-04] Synoptic-scale Predictability of Heavy Rain over Western Japan in July 2018

*Akira Kuwano-Yoshida[1] (1.Disaster Prevention Research Institute, Kyoto University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MIS25-05] Anomalous Moisture Transport and Oceanic Evaporation during a Torrential Rainfall Event over Western Japan in Early July 2018

*Shion Sekizawa[1], Takafumi Miyasaka[1,2], Hisashi Nakamura[1], Akihiko Shinpo[3], Kazuto Takemura[3], Shuhei Maeda[3] (1.Research Center for Advanced Science and Technology, University of Tokyo, 2.Meteorological Research Institute, 3.Japan Meteorological Agency)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[MIS25-06] Leading modes of atmospheric circulation variability during the heavy rain event in July 2018

*Kazuaki Nishii[1], Bunmei Taguchi[2], Hisashi Nakamura[2] (1.Graduate School of Bioresources, Mie University, 2.Research Center for Advanced Science and Technology, The University of Tokyo)

Heavy Rainfall Event in Middle Viet Nam on 8-9 December 2018 and current QPE/QPF at VNMHA

*Kazuo Saito[1,2,3], Le Duc[4,3], Du Duc Tien[5], Mai Khanh Hung[5]

1. Japan Meteorological Business Suport Center, 2. Atmosphere and Ocean Research Institute, the University of Tokyo, 3. Meteorological Research Institute, 4. Japan Agency for Marine-Earth Science and Technology, 5. National Center for Hydro-Meteorological Forecasting, Viet Nam Meteorological and Hydrological Administration

On 8-9 December 2018, a heavy rainfall event occurred in Middle Viet Nam, and at Da Nang, a record-breaking rainfall 635 mm was observed in 24 hours from 19 LST (12 UTC) 8 December. This heavy rainfall was relating to the strong cold surge from the north and eastern wind, a typical heavy rainfall situation in Viet Nam.
Since June 2018, a bilateral cooperative project between the Japan International Cooperation Agency (JICA) and the Viet Nam Meteorological and Hydrological Administration (VNMHA) for strengthening capacity in weather forecasting and flood early warning system in Viet Nam has been conducted. This project is relating to S-band radars that installed in Hai Phong (Phu Lien) and Vinh by another grant aid project in September 2017, and the Japan Meteorological Business Support Center (JMBSC) is contributing to four scopes of the project on surface meteorological observation, radar maintenance and products, weather forecasting, and regional weather dissemination.
In the presentation, we introduce the ongoing JICA project, and refer to the heavy rainfall event on 8-9 Decemebr 2018, and the quantitative precipitation estimation (QPE) system based on automatic weather station (AWS) and radar networks and satellite data and the quantitative precipitation forecast (QPF) system based on numerical weather prediction (NWP) at VNMHA. Current and future subjects of the project on the two systems will be discussed.

Acknowledgments: The authors thank to JICA project team members including Kenji Akaeda, Michihiko Tonouchi, Masao Mikami, Kiichi-Sasaki, Hiroyuki Ichijo, Chiho Kimpara, and staff of VNMHA including Nguyen Vinh Thu, Nguyen Dang Quang, and Nguyen Thu Hang. Generation of the precipitation analysis map at VNMHA is partly supported by the national research project “Developing an operational heavy rainfall forecast system for Bac Bo area - Vietnam” (code KC.08.06/16-20; project manager Hoang Duc Cuong).

Keywords: heavy rainfall, JICA project, QPE/QPF, numerical weather prediction, Viet Nam

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High-resolution flow-simulation in Typhoon 21, 2018: tremendous loss of water plants in South Lake Biwa

*Satoshi Nakada[1], Hiroki Haga[2], Maho Iwaki[1], Keisuke Hatano[3], Koji Mabuchi[1], Noriko Takamura[1]

1. National Institute for Environmental Studies, 2. Lake Biwa Museum, 3. Japan Water Agency

The typhoon 21 (Jebi) of Category 5 landed in Japanese main island on September 4 in last year (2018) and catastrophically damaged in mainly west Japan. The typhoon generated the extreme fluctuation of the water level observed in the south basin of Lake Biwa and induced the massive loss of aquatic plants, especially submerged macrophytes in the whole basin. The similar water level fluctuation was first observed in 2nd Muroto Typhoon in September 16, 1961. In recent years, the widespread exuberance of the aquatic macrophytes was often emergent in the south basin, which can severely affect water quality and biota in the lake bed. On the positive side of the aquatic macrophytes, they can absorb the nutrients dissolved in the lake to purify water and spawning ground for freshwater fishes such as carp and crucian. The massive loss of aquatic macrophytes can greatly impact the water environment in the south basin. It is anticipated that the climate change can induce the intense typhoons, understanding the massive loss mechanism of water macrophytes is essential to manage the lake water quality in the near future. This study investigates the physical processes of massive loss of aquatic macrophytes in the south basin based on the high-resolution flow simulation in Lake Biwa to reproduce the extreme fluctuation of the water level in the period of the typhoon 21 attack. We employed the prognostic, three-dimensional, unstructured-grid Finite-Volume Community Ocean Model (FVCOM). This model uses an unstructured triangular grid and provides better flexibility to fit the irregular coastal geometry and bathymetry in the Lake Biwa. The finite-volume approach ensures the conservation of mass necessary to reproduce water level fluctuation in the lake under conditions of a strong atmospheric disturbance. Reanalysis meteorological Grid Point Value datasets of the Meso-Scale Model datasets produced by the Japan Meteorological Agency were input into the FVCOM as mean hourly air temperature, precipitation, cloud cover, relative humidity, dew-point temperature, and wind speed. Hourly-mean data of river inflow to the lake and outflow from the Seta weir located in the south basin were input to the simulation. The initial conditions of water temperature used in the lake simulation were produced by the observational data obtained in August 2018. The simulations began from an initial state of rest, starting 28 August 2018 and was conducted for 2 weeks. Water level data to validate the simulated water level were downloaded from the Water Information System operated by the Ministry of Land, Infrastructure, Transport and Tourism of Japan. The simulation reproduced the extreme fluctuation of the water level, indicating that correlation coefficient between simulated and observed data was more than 0.9. When the water level pronouncedly decreased approximately 1 meter in the typhoon approach near the Lake Biwa, the northward current stronger than 1 m/s was formed in the whole south basin. The bottom shear stress and the drag force on the aquatic submerged macrophytes were calculated based on the simulated data. The bottom shear stress was smaller than critical shear stress suggesting little scouring in the basin bed. On the other hand, the drag force was larger in the areas of the higher vegetation height of submerged macrophytes, indicating that the map of the drag force was similar to the horizontal distribution of the macrophytes loss. These results suggested that the stronger horizontal flow induced by the typhoon wind formed the large drag force on the higher submerged macrophytes leading to uprooting and washout over the speed limit. The south wind over the 20 m/s blowing above the lake surface can induced the flow stronger than 1 m/s to uproot the submerged macrophytes.

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Keywords: Lake Biwa, water plants, flow-simulation, Typhoon

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Northern mid-latitude warming prolonged for more than 6 months in 2018 well-predicted by the JMA's operational seasonal prediction system

*Chiaki Kobayashi[1], Ichiro Ishikawa[1]

1. Meteorological Research Institute

In Japan, record-breaking heavy rains were observed in various places, mainly in western Japan in early July 2018 (Tsuguchi et al, 2018). Thereafter, an extremely high temperature continued mainly in eastern and western Japan (JMA, 2018). East Japan's summer average temperature recorded the highest since the statistical records began in 1946 (JMA, 2018). One of the background factors that brought such a hot summer is that the zonally averaged tropospheric temperature anomaly was high in the northern mid-latitudes (JMA, 2018). Here, we conduct re-forecast and sensitivity experiments by the JMA Seasonal Prediction System (JMA/MRI-CPS2; Takaya et al., 2018) and discuss factors of the formation of the prolonged high temperature anomaly in the Northern mid-latitude.
The seasonal mean 200 hPa height shows positive anomaly in almost all areas of the northern mid-latitudes. This indicates tropospheric warming in the northern mid-latitudes. In particular, the positive anomalies were large in the area from Mongolia to northern China, the vicinity of Alaska Bay, the vicinity of the Labrador Peninsula and in the southern part of the Scandinavian Peninsula. The positive anomalies of the northern mid-latitudes were remarkable in the zonally averaged field, and in the time series, the positive anomalies of the northern mid-latitudes had been continuing from around autumn of 2017.
This prolonged northern mid-latitude positive anomalies were well predicted in re-forecast experiments using a coupled model with initial date at October 28, 2017, despite the fact that the initial date is more than six months ago.
From the end of 2017 to the spring of 2018, the sea surface temperature in the Pacific equator shows anomaly pattern of the La Niña type, then ENSO became neutral during the summer of 2018. From spring to summer, the SSTs over the northern side of the equator showed positive anomalies and the SSTs over the southern side of the equator showed negative anomalies. This SST anomaly pattern continued during spring and summer 2018. This pattern was also well predicted by the model.
In order to investigate the influence of this SST anomaly pattern on the atmospheric anomaly field, we conducted an experiment in which the SST of the tropical Pacific region was nudged to climate SST. The northern mid-latitude height in this experiment (referred to as 'sensitivity experiment' hereafter) was lower than that of re-forecast experiment during the period from the end of 2017 to the summer of 2018. The positive anomalies of convective activity on the north side of the equator were well predicted in the re-forecast experiment, but in the sensitivity experiment, the convective activity anomalies in the same region were weak. This suggests that the SST anomalies in the tropical Pacific has played an important role through the anomalies of convective activity to the formation of the prolonged Northern midlatitude positive height anomalies.

Keywords: summer of 2018, northern mid-latitudes tropospheric warming, AO

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Synoptic-scale Predictability of Heavy Rain over Western Japan in July 2018

*Akira Kuwano-Yoshida[1]

1. Disaster Prevention Research Institute, Kyoto University

Heavy rain event occurred between 5 and 8 July 2018 over western Japan. Japan Meteorological Agency (JMA) had published a press release about the event at 1400 JST 5 July before the event began. Using week ensemble prediction data and reanalysis data by JMA, predictability of westerly jet at middle troposphere and moisture flux at lower troposphere, which are main factors of heavy rain by Baiu front, are analyzed. The ensemble prediction initialized after 12 UTC 30 June well predicted meridional position of westerly jet at middle troposphere. However, horizontal moisture flux maximum at lower troposphere was predicted over the East China Sea at that time. The moisture flux flowing to western Japan was firstly predicted at 00 UTC 1 July. An upper trough developing over Eurasia Continent affected the westerly jet prediction. On the other hand, formation position of Typhoon 1807 (Prapiroon) east of Taiwan determined the zonal position of moisture flux. Predictability of rain continuance is affected by an upper ridge propagated from Eurasia Continent which is well predicted after 3 July.

Keywords: Baiu front, Predictability, Ensemble prediction

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Anomalous Moisture Transport and Oceanic Evaporation during a Torrential Rainfall Event over Western Japan in Early July 2018

*Shion Sekizawa[1], Takafumi Miyasaka[1,2], Hisashi Nakamura[1], Akihiko Shinpo[3], Kazuto Takemura[3], Shuhei Maeda[3]

1. Research Center for Advanced Science and Technology, University of Tokyo, 2. Meteorological Research Institute, 3. Japan Meteorological Agency

Western Japan experienced torrential rainfall in early July 2018, which caused severe floods and landslides especially over western Japan. Japan Meteorological Agency (JMA) reported that this extreme event was associated with extreme enhancement of northward moisture flux and its convergence over western Japan. Some recent studies have pointed out an essential role of surrounding oceans for extreme rainfall events through the anomalous heat and moisture supply to the warm, moist monsoonal airflow. This study investigates anomalous oceanic evaporation during the torrential rainfall event over western Japan based on the objective analysis data from the JMA Meso-Scale Model. We have found that the heavy rainfall was associated with enhanced oceanic evaporation extensively around Japan, especially along the Kuroshio and entirely over the Japan Sea. We then conducted a linear decomposition of local surface latent heat flux anomalies based on the bulk formula to determine factors for the enhanced evaporation. Our results show that the enhanced evaporation under the pronounced southerly inflow toward the extreme rainfall region was mainly due to increase in the surface wind speed along the Kuroshio south of Japan, with an additional contribution from warm SST anomalies to the enhanced moisture inflow into central Japan. In order to quantitatively assess contribution of the enhanced evaporation to anomalous moisture transport in the mixed layer, we also performed a backward trajectory analysis for moist air parcels. It reveals that anomalous moisture supply from the ocean to air parcels along trajectories is dominated by enhanced evaporation due to the stronger surface wind speed, which corresponds to about 20 % of the column water vapor anomaly and about 5 % of the total column water vapor.

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Leading modes of atmospheric circulation variability during the heavy rain event in July 2018

*Kazuaki Nishii[1], Bunmei Taguchi[2], Hisashi Nakamura[2]

1. Graduate School of Bioresources, Mie University, 2. Research Center for Advanced Science and Technology, The University of Tokyo

A continuous heavy rain was observed in western Japan in early July 2018. The aim of this study is to investigate the atmospheric circulation from a view point of leading modes of atmospheric circulation variability and its relationship to external forcings. The first mode of the EOF analysis, applying to interannual variability of 300-hPa westerlies around Japan in early July, represents variability of intensity of the westerlies and precipitation associated with the Baiu front. The score of this mode in 2018 suggests that this mode contributed to the weakening of the westerlies and reduction of precipitation at the climatological position of the Baiu precipitation. The second mode represents meridional shifts of westerly jet axis and position of precipitation. The score of the second mode in 2018 suggests that this mode contributed to northward shift of westerlies and Baiu precipitation. A series of ensemble experiments of an atmospheric general circulation model (AGCM) was conducted under five boundary conditions. The emergence of the first (second) mode is often observed in an experiment in which observed sea surface temperatures are prescribed in the extratropics (tropics), while climatological-mean SST is prescribed in the tropics (extratropics). The score of the second mode is, however, not as large as observed in 2018, which may be one of reasons why the AGCM experiment can not reproduce the heavy rain event in July 2018.

Keywords: modes of atmospheric circulation variability, heavy rain

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | 301B 3F

[M-GI37] Earth and planetary informatics with huge data management

convener:Ken T. Murata(National Institute of Information and Communications Technology), Rie Honda(Department of Science and Technology, System of Natual Science, Kochi University), Susumu Nonogaki(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Takeshi Horinouchi(Faculty of Environmental Earth Science, Hokkaido University), Chairperson:Susumu Nonogaki, Ken Murata(National Institute of Information and Communications Technology)

Increasingly large and complex data are produced by observations and numerical simulations in earth and planetary sciences. The target of this session is to discuss a broad range of practices and new knowledge of informatics, international standard and modelling, including techniques for large-scale data processing and numerical simulation, data preservation and publication, data transfer and collection and other data technologies with a vision to advance an emerging data-intensive science, namely "geoplanetary informatics".

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MGI37-01] Exploration of the earth environment using meteorological satellite "Himawari"

*ryuta ando[1], Shigeto Watanabe[1], Ken T. Murata[2] (1.Hokkaido Information University, 2.National Institute of Information and Communications Technology)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MGI37-02] Kochi radar network composed of compact X-band radars

*Koji Sassa[1], Toshiaki Takaki[2], Ken T Murata[3] (1.Natural Science Cluster, Kochi University, 2.Furuno Electric Co.,Ltd., 3.National Institute of Information and Communication Technology)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MGI37-03] Rain Echo Classification by Deep Learning Using Observation Big Data of Phased Array Weather Radar

*Shinsuke Satoh[1], Hiroshi HANADO[1], Seiji Kawamura[1], Tomohiko Konno[1], Michiaki Iwazume[1], Shigenori Otsuka[2], Takemasa Miyoshi[2] (1.National Institute of Information and Communications Technology, 2.RIKEN Center for Computational Science)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MGI37-04] Communication area map of LoRa in Chikuma city using community bus services

*Kohei Mizuani[1], Ken T. Murata[1], Yoshiaki Muroyama[1], Kazunori Yamamoto[1], Kazuya Muranaga[2], Takamichi Mizuhara[3], Praphan Pavarangkoon[1] (1.National Institute of Information and Communications Technology, 2.Systems Engineering Consultants Co., LTD., 3.CLEALINK TECHNOLOGY Co.,Ltd.)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MGI37-05] Development of an inexpensive and small balloon observation device, and its application in observing the Earth's upper atmosphere

*Taku Takada[1], Yui Sasaoka[1], Shiya Ueta[1], Ken T. Murata[2], Hidehiko Suzuki[3] (1.National Institute of Technology, Kochi College, 2.National Institute of Information and Communications Technology, 3.Meiji University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

Discussion

Exploration of the earth environment using meteorological satellite "Himawari"

*ryuta ando[1], Shigeto Watanabe[1], Ken T. Murata[2]

1. Hokkaido Information University, 2. National Institute of Information and Communications Technology

We investigated the earth environment using the meteorological satellite "Himawari 8" and artificial intelligence (AI). Generally, AI needs images more than tens of thousands for the recognition of image. However, we used spectral data extracted for each pixel of spectral image at 16 wavelengths (visible to infrared) from "Himawari 8" for AI learning in this research. By characterizing the spectral data and the earth environment, we developed an AI system to recognize the earth environment and the environmental changes. This study is the first time to learn the spectral data of 16 wavelengths for each pixel in AI and to investigate the earth environment. Moreover, this AI model uses only hundreds of data sets of 16 wavelength for learning the earth environment in all space and time such as latitude / longitude, day / night, season. Our developed AI using spectral data of the meteorological satellite "Himawari" is useful for predicting typhoons and drift ice, etc. The AI is also useful to investigate planetary environment as well as the earth environment.

Keywords: Meteorological Satellite Himawari-8, Spectral Data, 16 wavelengths, Artificial intelligence

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Kochi radar network composed of compact X-band radars

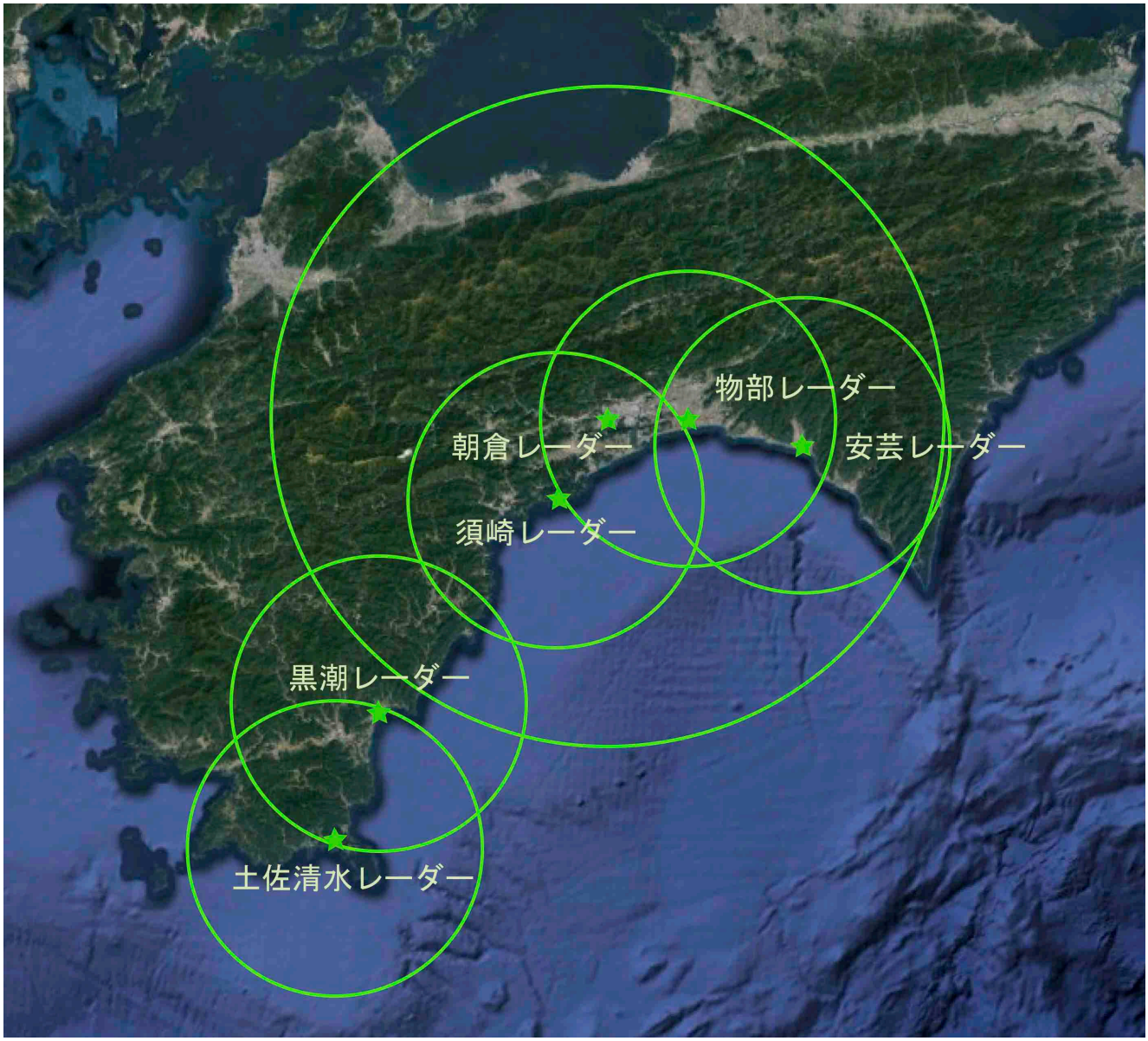
*Koji Sassa[1], Toshiaki Takaki[2], Ken T Murata[3]

1. Natural Science Cluster, Kochi University, 2. Furuno Electric Co.,Ltd., 3. National Institute of Information and Communication Technology

Kochi Prefecture is the heaveist rain area in Japan. Heavy rain events and hazardous winds causing disaster frequently occur there. But, only one C-band Doppler radar of JMA and two C-band polarymetric radars in high mountains cover the area and warm rain near ground cannot be observed by these radars well.
Then we constructed high resolution radar network composed of 6 compact X-band polarymetric radars settled in Kochi Prefecture and started continuous observation. These radars are solid state type. The observation range and beam width of one radar is 80 km and 2 deg., respectively. The other 5 radar observes within 30 km and these beam width is 2.7 deg. They make volume scan at relatively low elevation angles every 1 minute and 1 km CAPPI data are obtained from them. These big data are corrected in science cloud in NICT via wonms settled at each radar sights. We can show the 1km CAPPI network data about 4minutes after the observation.
We succeeded to observe the organised convection systems, such as linear rain bands by 5 radars when torrential rain occurred in the west Japan in early July, 2018. We also observed the vortices in parent clouds causing tornadoes in detail.

Keywords: radar network, compact radar, cloud

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Rain Echo Classification by Deep Learning Using Observation Big Data of Phased Array Weather Radar

*Shinsuke Satoh[1], Hiroshi HANADO[1], Seiji Kawamura[1], Tomohiko Konno[1], Michiaki Iwazume[1], Shigenori Otsuka[2], Takemasa Miyoshi[2]

1. National Institute of Information and Communications Technology, 2. RIKEN Center for Computational Science

The phased array weather radar (PAWR) was developed with the goal of early detection and prediction of sudden weather disasters caused by torrential rain and tornados and gusts. The PAWRs installed in Suita, Kobe, Okinawa, are operated regularly and generate three-dimensional data every 30 seconds. The observation big data exceeding 2 PB has been accumulated. The real-time observation data is used by the smartphone app "3D Rain Watch" and "RIKEN 3D Nowcast" and the research results of data analysis and data assimilation have been published, but the accurate prediction of torrential rain could not be realized. Also, many of archived past data cannot be used effectively. In recent years, it has become an era when a computer can realize judgment using a deep learning which has developed rapidly. Although deep learning needs to be learned using a large amount of data, new results which cannot obtain by human data analysis, are expected. In this study, we aim to automatic extraction of the precursor phenomena leading to torrential rain prediction by using deep learning technology called convolutional neural network (CNN). As the first attempt, we try to classify rain echoes from two-dimensional image data of rainfall distribution observed by PAWR. In terms of rain echo classification, the difference in rainfall type, convective or stratiform, is also important, but in addition to that, we attempt to classify rainfall distribution patterns such as isolated, linear, and mass.
The original data of PAWR observation is archived as binary data of polar coordinates, but for this deep learning we use a quick look (QL) image showing the horizontal distribution of the radar echo intensity of the altitude of 2 km which is published in real time on the Web Page. The number of accumulated QL images of Kobe PAWR reaches 4 million in total, but more than half are QL images without rain in the radar observation range of 120 km in diameter and cannot be used for rain echo classification. In order to perform deep learning, it is necessary to label the QL images, but it is not easy for a man to manually label 10000 images. Fortunately, in order to create a rain summary graph on the Web, numerical information of the average rainfall amount, maximum rainfall amount, and rainfall area corresponding to each QL image is saved as a text file. After rough labeling using the information, eventually it is judged by human eyes. Finally, we classify into eight categories of strong / weak isolated convective, linear convective, mass convective, stratified, and no rainfall. Using more than 900 samples in each category from 50 days observation data in June, July, August 2016, we repeatedly learned them about 1000 times using a simple 7-layer CNN, and as a result it was able to perform rain echo classification with an accuracy of 72%. We believe it is possible to increase accuracy by removing ambiguous labeling samples or using a more complicated CNN network. In the future, we want to advance research that leads to heavy rain prediction by using three-dimensional data and time-series data.

Keywords: Phased Array Weather Radar, Observation Big Data, Deep Learning, Rain Echo Classification

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Communication area map of LoRa in Chikuma city using community bus services

*Kohei Mizuani[1], Ken T. Murata[1], Yoshiaki Muroyama[1], Kazunori Yamamoto[1], Kazuya Muranaga[2], Takamichi Mizuhara[3], Praphan Pavarangkoon[1]

1. National Institute of Information and Communications Technology, 2. Systems Engineering Consultants Co., LTD., 3. CLEALINK TECHNOLOGY Co.,Ltd.

Internet of Things (IoT) where data of many sensors are collected through the Internet is one of important social infrastructure technologies. Various sorts of regional IoT technologies were developed and expected to be tools for the enhancement of public services and the resolution of public issues in the community thorough use and application of the collected data. We conducted communication environment measurement of private LoRa (Long Range), which is one of the low-power wide area (LPWA) communication technologies in Chikuma city, Nagano prefecture, Japan, using community bus services. In this experiment, we set up LoRa relay stations at three locations in the city: the Koshoku governmental building (the northern part of the city), the Togura governmental building (the southern part of the city), and the Amenomiya drainage plant (the eastern part of the city). In addition, beacon transmitters were installed in the community buses (nine routes in all). The location and time information were transferred from the routes of the buses to the NICT Science Cloud servers in real time through the relay stations. Experimental results are summarized in an area map, indicating that we succeeded in communicating in most of the bus routes and confirmed the possibility of covering the entire city by the LPWA. Even in the insensitive area of this experiment, the communication will become possible by adding several relay stations.

Keywords: IoT, LPWA, LoRa, area map

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Development of an inexpensive and small balloon observation device, and its application in observing the Earth's upper atmosphere

*Taku Takada[1], Yui Sasaoka[1], Shiya Ueta[1], Ken T. Murata[2], Hidehiko Suzuki[3]

1. National Institute of Technology, Kochi College, 2. National Institute of Information and Communications Technology, 3. Meiji University

In this presentation we will outline the development of an inexpensive and small balloon observation device and its use in observing the Earth's atmosphere, from the troposphere to the stratosphere. By enclosing helium in a rubber balloon used for meteorological observation, it is possible to make the observation device fly in a region extending beyond the troposphere to the stratosphere. We have been developing balloon observation devices and carrying out balloon-based observation experiments with students since 2014. In 2018, we aimed to develop an observation system capable of monitoring the flight path of the balloon devices, by installing three to four ground stations (including mobile stations) and using communication equipment based on Long Range (LoRa) modulation of the 920 MHz band. We conducted experiments with LoRa communication equipment with a line-of-sight of up to 28 km, which confirmed that communication via LoRa modulation can be successfully applied in balloon monitoring. Furthermore, we are currently developing a balloon detachment system and, by separating the balloon near the designated altitude, we can shorten the distance traveled in the horizontal direction and lengthen the observation time at the optimum altitude. In the current balloon observation system, we aim to develop its use for various atmospheric observations, mainly for classifying the following three observation sequences: (1) when reaching the stratosphere (about 25 km altitude), the balloon bursts and deploys a parachute; (2) when reaching an altitude of about 15 km, when air density becomes sufficiently low, the balloon detaches and deploys a parachute, (3) when reaching an altitude of between 7 and 10 km, after completely passing through the tropospheric cloud layer, the balloon detaches and deploys a parachute. We hope to develop a balloon observation system suitable for use with various observation targets.

Keywords: Balloon observation, small balloon, upper atmosphere, stratosphere, troposphere, LoRa communication

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | 301B 3F

[M-GI37] Earth and planetary informatics with huge data management

convener:Ken T. Murata(National Institute of Information and Communications Technology), Rie Honda(Department of Science and Technology, System of Natual Science, Kochi University), Susumu Nonogaki(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Takeshi Horinouchi(Faculty of Environmental Earth Science, Hokkaido University), Chairperson:Rie Honda, Ken Murata(National Institute of Information and Communications Technology)

Increasingly large and complex data are produced by observations and numerical simulations in earth and planetary sciences. The target of this session is to discuss a broad range of practices and new knowledge of informatics, international standard and modelling, including techniques for large-scale data processing and numerical simulation, data preservation and publication, data transfer and collection and other data technologies with a vision to advance an emerging data-intensive science, namely "geoplanetary informatics".

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MGI37-06] Introduction of “ChOWDER”: A tiled display driver that augment large scale visualization of geoscience.

*Tomohiro Kawanabe[1], Kenji Ono[2], Atsushi Higuchi[3], Koichi Toyoshima[3], Kazunori Yamamoto[4], Kazuya Muranaga[5], Ken T. Murata[4] (1.RIKEN , 2.Kyushu Univ., 3.Chiba Univ., 4.NICT, 5.Systems Engineering Consultants Co.,LTD.)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MGI37-07] Data archive and integrated data analysis tools developed by ERG Science Center

*Tomoaki Hori[1], Yoshizumi Miyoshi[1], Masafumi Shoji[1], Mariko Teramoto[1], Tzu-Fang Chang[1], Satoshi Kurita[1], Shoya Matsuda[2], Yasunori Tsugawa[1], Tomonori Segawa[1], Norio Umemura[1], Nozomu Nishitani[1], Takako Kondo[1], Hiroyasu Yonaha[1], Yukinaga Miyashita[3], Kunihiro Keika[4], Kanako Seki[4], Yoshimasa Tanaka[5], Iku Shinohara[2] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Japan Aerospace Exploration Agency / Institute of Space and Astronautical Science, 3.Korea Astronomy and Space Science Institute, 4.Graduate School of Science, The University of Tokyo, 5.National Institute of Polar Research)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MGI37-08] KOSEN-1 CubeSat mission for Jupiter's radio science

*Kazumasa Imai[1], Nobuto Hirakoso[2], Taku Takada[1], Kentarou Kitamura[3], Masafumi Imai[4], KOSEN-1 Team[5], Charles A. Higgins[6], James R. Thieman[7], NASA Radio JOVE Team[8] (1.Department of Social Design Engineering, National Institute of Technology, Kochi College, 2.Department of Mechanical Engineering, National Institute of Technology, Gunma College, 3.Department of Mechanical and Electrical Engineering, National Institute of Technology, Tokuyama College, 4.University of Iowa, 5.KOSEN-1 Team, 6.Middle Tennessee State University, 7.University of Maryland Baltimore County, 8.NASA Radio JOVE Team)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MGI37-09] Problems of acquisition of auroral image data and data processing

*Ryuho Kataoka[1], Ken T. Murata[2], Yoshizumi Miyoshi[3], Herbert Akihito Uchida[1], Yoko Fukuda[4], Atsushi Yamashita[5], Masayuki Tanaka[6] (1.National Institute of Polar Research, 2.National Institute of Information and Communication Technology, 3.Nagoya University, 4.National Institute for Environmental Studies, 5.The University of Tokyo, 6.Tokyo Institute of Techonology)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MGI37-10] Innovative progress in ground observation of snow crystals and weather conditions by citizen science

★Invited Papers

*Kentaro Araki[1] (1.Meteorological Research Institute)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MGI37-11] Efforts of landslide susceptibility mapping for slope disaster risk evaluation

*Kazunori Hayashi[1], Akihiko Wakai[2], Go Sato[3], Takashi Kimura[4], Ken T. Murata[5], Akino Watanabe [2] (1.Okuyama Boring Co., Ltd., 2.Gunma University, 3.Teikyo Heisei University, 4.National Research Institute for Earth Science and Disaster, 5.National Institute of Information and Communications Technology)

Introduction of “ChOWDER”: A tiled display driver that augment large scale visualization of geoscience.

*Tomohiro Kawanabe[1], Kenji Ono[2], Atsushi Higuchi[3], Koichi Toyoshima[3], Kazunori Yamamoto[4], Kazuya Muranaga[5], Ken T. Murata[4]

1. RIKEN , 2. Kyushu Univ., 3. Chiba Univ., 4. NICT, 5. Systems Engineering Consultants Co.,LTD.

1. Introduction
The Tiled display is a method that tiles multiple physical displays to provide large pixel space. Demand for tiled displays is expected to increase in the research fields that deal with data requiring large-scale, high-resolution visualization such as geoscience. In this paper, we first describe the outline of "ChOWDER", a system that realizes tiled display in software, and then introduce example applications in geoscience. Finally, we will explain how to obtain ChOWDER software.

2. ChOWDER
ChOWDER is an open source tiled display driver which is jointly conducting research and development between RIKEN and Kyushu University, running on Windows, Linux, and macOS. It has a unique feature called "Virtual Display Area "(Hereinafter referred to as" VDA ") which is not available in other tiled display drivers.
The VDA is a logical two-dimensional space managed by the ChOWDER server, and the display contents can be arranged at arbitrary positions and magnification ratios here. In addition, since the display device which is the content display destination can also be placed on the VDA at an arbitrary position/magnification ratio, by using this, it is possible to build a tiled display with high flexibility such as mixed displays with different resolutions and aspect ratios.
Since the necessary software for the display device is only an ordinary Web browser such as Firefox, Chrome, there is no need to install special software or expensive graphics board corresponding to multiple display connection. When the Web browser connects to the ChOWDER server, it is in the full-screen display mode, and the whole pixels of the physical display is used as the display area of ChOWDER. In other words, it functions as (a part of) the ChOWDER tiled display as long as it is a device on which the ordinary web browser runs.
Also, the device of the display content sending side needs only the Web browser. Static content such as text file, image file, PDF file and streaming contents such as movie file, the desktop screen of sending side device, web camera can be displayed on ChOWDER tiled display.
In addition, ChOWDER can mirror tiled displays of multiple sites. By lay over the display device positions of each site on the above VDA, it is possible to share and display contents between multiple sites.
With these features, we believe ChOWDER is a flexible software that can build a tiled display with a relatively small investment.

3. Use cases
Fig.2 shows a 16K resolution image by visualization software HIVE developed by RIKEN and display it to a tiled display consisting of twelve 4K display (15,360 ×6,480 total pixel resolution) through ChOWDER. It is parallel computation result of climate simulator NICAM used the whole system(88,128CPU) of "K computer". HIVE has the function of directly transmitting the rendering result image to ChOWDER, hence it is possible to simultaneously observe the entire overview and detailed parts without thinning out the high-resolution data generated by the large-scale simulation using the supercomputer.
Fig.3 shows a tiled display (17,280 ×5,120 total pixels) composed of 36 full HD displays owned by the

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Center for Environmental Remote Sensing, Chiba University. It displays two of AMATERASS (http://amaterass.nict.go/ index.html) screens and an image from Himawari 8 provided by the National Institute of Information and Communications Technology. The screen of AMATERASS is streamed from the users PC screen to ChOWDER, and when AMATERASS is operated on the PC, it also follows the display on the tiled display at the same time. Since PCs of multiple users can be displayed as contents sending sources and respective information can be displayed side by side on one tiled display, bird's-eye view-ish collaborative work can be performed.

4. Software distribution

ChOWDER is an open source software distributed under the BSD 2 clause license and can be used free of charge for academic and commercial use. You can download software and user documentation from GitHub. (https://github.com/SIPupstreamDesign/ChOWDER)

Keywords: Tiled Display, Visualization, Web Browser, Collaborative work

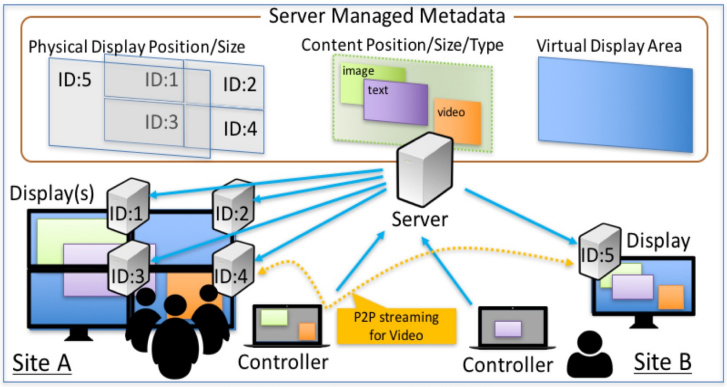


Fig.1 System Diagram of ChOWDER



Fig.2 A Displaying Example of a 16K Resolution Image



Fig.3 A Displaying Example of Multiple Application Windows Streaming from Multiple Users PC.

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Data archive and integrated data analysis tools developed by ERG Science Center

*Tomoaki Hori[1], Yoshizumi Miyoshi[1], Masafumi Shoji[1], Mariko Teramoto[1], Tzu-Fang Chang[1], Satoshi Kurita[1], Shoya Matsuda[2], Yasunori Tsugawa[1], Tomonori Segawa[1], Norio Umemura[1], Nozomu Nishitani[1], Takako Kondo[1], Hiroyasu Yonaha[1], Yukinaga Miyashita[3], Kunihiro Keika[4], Kanako Seki[4], Yoshimasa Tanaka[5], Iku Shinohara[2]

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The ERG (Exploration of energization and Radiation in Geospace) is a Japanese geospace exploration project. Its core component is the ERG satellite, also known as Arase, an inner magnetosphere satellite with the full set of particle and field instruments launched on December, 2016. The ERG project consists of the satellite observation team, the ground-based network observation team, and the integrated data analysis/simulation team. Besides these research teams, ERG Science Center (ERG-SC) has been organized and operated by ISAS/JAXA and ISEE/Nagoya University from the very beginning of the ERG project. Since then, ERG-SC has been playing an essential role in managing the data center for all kinds of scientific data as well as promoting close collaborations of the three teams and other research projects, maximizing scientific output from the ERG project. For studies of Geospace, where different plasma populations are interacted with each other via cross-energy and cross-regional coupling processes, the integrated data analysis combining various kinds of data sets is key to comprehensive understanding of multiscale dynamical processes. For these purposes, the level-2 (calibrated, in physical unit) science data and higher level data products of the Arase satellite as well as the ground observation network data are archived in the Common Data format (CDF), which was developed by NASA, and are basically open freely to the international science community from the ERG-SC data repository. The integrated data analysis tool is also developed on the basis of the Space Physics Environment Data Analysis Software (SPEDAS), which is de facto standard software of the space physics community, enabling the data users to combine Arase data with the other satellite, ground, modeling data seamlessly in plotting and manipulating them.

Keywords: Arase satellite, Radiation belt, Space plasma

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KOSEN-1 CubeSat mission for Jupiter's radio science

*Kazumasa Imai[1], Nobuto Hirakoso[2], Taku Takada[1], Kentarou Kitamura[3], Masafumi Imai[4], KOSEN-1 Team[5], Charles A. Higgins[6], James R. Thieman[7], NASA Radio JOVE Team[8]

1. Department of Social Design Engineering, National Institute of Technology, Kochi College, 2. Department of Mechanical Engineering, National Institute of Technology, Gunma College, 3. Department of Mechanical and Electrical Engineering, National Institute of Technology, Tokuyama College, 4. University of Iowa, 5. KOSEN-1 Team, 6. Middle Tennessee State University, 7. University of Maryland Baltimore County, 8. NASA Radio JOVE Team

Since the discovery of Jupiter's decametric radio emissions in 1955, important details of its radiation mechanism have not yet been elucidated. In order to investigate the beaming structure of Jupiter's radio emission to clarify aspects of the emission mechanism, we plan to launch a 2U-size CubeSat for observation of Jupiter's radio waves and observe simultaneously in outer space and on the ground. The purpose of this project is to measure the emission delay time by using a correlation analysis method. The delay time can be measured by the correlation analysis of waveform data obtained by simultaneous observations of Jupiter's radio S-bursts between this satellite and the ground. If the beam of Jupiter's radio S-bursts is moving together with the rotation of Jupiter, we can calculate a time difference of about 70 milliseconds at the baseline length of 8000 km. Using the proposed simultaneous observations, it is possible to test whether the Jovian S-bursts are emitted like a 'beacon', rotating with Jupiter's magnetic field and sweeping by the Earth, or like a 'flashlight', an instantaneous emission with a 0 millisecond time delay. This information is very important to determine the nature of the Jupiter's radio emission mechanism.

Our application for the launch of a 2U-CubeSat named KOSEN-1 by a JAXA Epsilon rocket was selected on Dec. 12, 2018, as a CubeSat candidate for JAXA's innovative satellite technology demonstration program. This rocket launch including our KOSEN-1 project is scheduled at the end of 2020. The worldwide ground-based observations together with the KOSEN-1 satellite will be supported by the NASA Radio JOVE project, an education and outreach program for planetary radio astronomy.

The KOSEN-1 project is supported by the Coordination Funds for Promoting AeroSpace Utilization of the Ministry of Education, Culture, Sports, Science and Technology (MEXT), JAPAN.

Keywords: CubeSat, Jupiter radio, decametric wave, beam structures

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Problems of acquisition of auroral image data and data processing

*Ryuho Kataoka[1], Ken T. Murata[2], Yoshizumi Miyoshi[3], Herbert Akihito Uchida[1], Yoko Fukuda[4], Atsushi Yamashita[5], Masayuki Tanaka[6]

1. National Institute of Polar Research, 2. National Institute of Information and Communication Technology, 3. Nagoya University, 4. National Institute for Environmental Studies, 5. The University of Tokyo, 6. Tokyo Institute of Techonology

We have obtained various types of auroral image data in various shooting styles around the world. In this lecture, we will report on several problems of data processing. Experiments currently undertaken include real-time image processing of aurora with possibility of 4K / 8K streaming, acquisition of continuous image data of 100 fps by the EMCCD camera and the data release, and photographing of aurora from unmanned aircraft using a small infrared camera. In the past attempts using commercially available digital cameras, outreach-purpose experiments include 4K-3D dome-master time-lapse images and 20K-VR shooting, scientific-purpose experiments include automatic detection of auroras to control high-speed imaging of aurora.

Keywords: aurora, image processing, high-speed imaging

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Innovative progress in ground observation of snow crystals and weather conditions by citizen science

*Kentaro Araki[1]

1. Meteorological Research Institute

To improve forecasts of snowfall events, a better understanding of the horizontal distribution of precipitation types and the microphysical properties of snow clouds is required. Observations of cloud microphysical properties, however, has been limited because of the sparse observation network. Recently, ground observations of precipitation types are performed by citizen science approaches especially in United States. In this study, ground observations of snow crystals and weather conditions are conducted by citizen science in Japan, and we would like to introduce recent progress in ground observation study and discuss the potentialities and challenges of citizen science big data.

The Meteorological Research Institute (MRI) has conducted the "#KantoSnowCrystal Project" to collect images of snow crystals from citizens during snowfall events in the Kanto and Koshin regions in Japan from November 2016. Smartphone cameras were used to capture the images, which were mainly collected through social networking services. Through the project, we were able to establish an easy method for snow crystal observation and data collection. More than 10,000 snow crystal images were gathered throughout the 2016-2017 winter, of which 73% were analyzable. In the case of heavy snowfall event in the Kanto plain on 22 January 2018, more than 40,000 snow crystal images were gathered in only a day. The #KantoSnowCrystal Project thereby realized spatiotemporally ultra-dense observations of snow crystals in these metropolitan areas, and the observation dataset should contribute to investigations of snowfall mechanisms in these areas and the verification and improvement of numerical weather models, etc. The amount of data, however, varied considerably between heavily populated central urban areas and less-populated inland areas. As the number of the data became enormous, it was also a challenge to efficiently collect and analyze the big data.

To investigate the characteristics of citizen science data, an existing dataset obtained from citizens of the "10-minute weather report" provided by Weathernews Inc. was examined. In this data, weather types are classified into 15 categories based on citizens' experiences. From the result of the examination of about 60 million weather reports from 2012 to 2017, it was found that the number of citizen science data and the population were proportional and the number of the data highly depended on human activity. The number of the data tended to increase in the case of rare and severe storm events in the metropolitan areas, such as heavy snowfall events in Tokyo in winter. From the comparison of the data between citizen science and the Japan Meteorological Agency, about 90 % of the weather types of rain and snow agreed in each data. The coincidence rate of weather type, however, declined for graupel and mixed rain and snow. These results indicate that citizen science data is effective in the snowfall study in the metropolitan areas and greatly contributes to the snowfall study if there is objective information such as photographs of precipitation.

Based on the results of these studies, the #KantoSnowCrystal Project of the MRI has started to use the App "SoraWatch by 3D AmagumoWatch" (https://sora-watch.3d-amagumo.com/) for smartphone and tablet devices and to gather the information of weather type and snow depth images in addition to snow crystals from all over Japan from February 2019. Citizen scientists are able to select 16 weather types (sunny, cloudy, rain, mixed rain and snow, snow, ice pellet, hail, thunder, tornado, fog, frost, burnt sky,

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rainbow, cloud iridescence, halo and arc, and the other), 11 snow crystal types, and snow depth with these photographs on the App. The database is also available for the purpose of scientific research and education. Big data obtained from citizen scientists through the App has possibility to contribute to not only the snowfall study but also various meteorological research fields, educations, commercials, etc.

Keywords: citizen science, big data, meteorological observation

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Efforts of landslide susceptibility mapping for slope disaster risk evaluation

*Kazunori Hayashi[1], Akihiko Wakai[2], Go Sato[3], Takashi Kimura[4], Ken T. Murata[5], Akino Watanabe[2]

1. Okuyama Boring Co., Ltd., 2. Gunma University, 3. Teikyo Heisei University, 4. National Research Institute for Earth Science and Disaster, 5. National Institute of Information and Communications Technology

We introduce the current situation and efforts of the landslide susceptibility mapping method required for risk evaluation of slope disasters in this presentation.

The type of ladnslide movement is controlled by the geological and geomorphological factors. For example, shallow-seated landslides and highly fluidized landslides frequently occur on slope covered by unconsolidated volcanic sediments. Moreover, in Sedimentary rock regions with continuously bedding plane structure, large translational slides prone to occur on dip slope, while shallow-seated landslides prone to occur on steep cliffs of the anti-dip slope. In other words, the factors of data used for landslide susceptibility mapping and their weighting depend to the type of landslide movement at each slope, and on the geological and geomorphological conditions at each region.

On the other hand, rainfall indices such as effective rainfall and soil water index are used for announcement of the landslide disaster alert in Japan, but it does not sufficiently consider geographical and geomorphological conditions. For this reason, the spatial resolution as an evaluation unit is only 5 km square, and issues are still remained for landslide risk evaluation on each slope units and classification of landslide susceptibility areas. In addition, it is generally difficult to evaluate large-scale, deep-seated landslides, which are caused by complicated geological structures and underground hydrological conditions.

In this presentation, as a case study of the landslide susceptibility mapping considering geological and geomorphological factors, the activity evaluation of the landslide slopes using the AHP method, development of susceptibility mapping method for earthquake-induced landslides, and heavy rainfall-induced landsides in the volcanic regions will be introduced. A new slope stability evaluation method using a simple prediction model for shallow groundwater level rising will be introduced as well.

Keywords: landslide, slope, heavy rainfall, earthquake, disaster, susceptibility mapping

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-AG Applied Geosciences

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | 302 3F

[M-AG41] Dynamics of radionuclides emitted from Fukuchima Dai-ichi Nuclear Power Plant in the environment

convener:Yoshio Takahashi(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Kazuyuki Kita(Faculty of Science, Ibaraki University), Yuichi Onda(Center for Research on Isotopes and Environmental Dynamics, University of Tsukuba), Daisuke Tsumune(Central Research Institute of Electric Power Industry), Chairperson:Yoshio Takahashi(東京大学), Yuichi Onda(Center for Research on Isotopes and Environmental Dynamics, University of Tsukuba)

The Great East Japan Earthquake caused the severe accident in TEPCO Fukushima dai-ichi nuclear power plant (FDNPP), leading to emission of huge amount of radionuclides to the environment. They have been transported and diffused by atmospheric motion, depositing them to soil and vegetation. Deposited radionuclides are dynamically shifted in the earth environment; atmosphere, soil, inland water, ocean, and ecosystem. To understand this dynamic shift in the environment and for the long-term prediction of the disaster by the radionuclides, investigation and discussion based on not only the earth sciences including ecology but also on the radiochemistry and other related sciences. In this session, various efforts to understand the dynamic behavior of radionuclides emitted from FDNPP accident in the earth system as well as to predict their influences on the environment. It is expected that this session will offer a good opportunity to discuss radionuclides in the earth environment from wide aspect and to exchange information in various research fields.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MAG41-01] Investigation on basic physical and chemical properties of radio-Cs micro particles

*Yasuhito Igarashi[1], Kazuyuki Kita[2], Yukihiko Satou[3], Tomoaki Okuda[4], Yoshinari Abe[5], Keisuke Sueki[6], SHINOHARA ATSUSHI[7], Kazuhiko Ninomiya[7], Tsutomu Ohtshuki[1], Koichi Takamiya[1] (1.Institute for Integrated Radiation and Nuclear Science, Kyoto University, 2.Graduate School of Science and Engineering, Ibaraki University, 3.Collaborative Laboratories for Advanced Decommissioning Science, Japan Atomic Energy Agency, 4.Department of Applied Chemistry, Keio University, 5.Faculty of Science,Tokyo University of Science, 6.Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba, 7.Graduate School of Science, Osaka University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MAG41-02] Dynamics of radioactive microparticles released from the Fukushima nuclear plant: heating and dissolution characteristics

★Invited Papers

*Taiga Okumura[1], Noriko Yamaguchi[2], Terumi Dohi[3], Kenso Fujiwara[3], Kazuki Iijima[3], Toshihiro Kogure[1] (1.The University of Tokyo, 2.National Agriculture and Food Research Organization, 3.Japan Atomic Energy Agency)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MAG41-03] Dynamics of atmospheric ^{131}I just after the Fukushima accident related to ^{137}Cs by analysis of published data

*Haruo Tsuruta[1], Yuichi Moriguchi[2], Teruyuki Nakajima[3] (1.Remote Sensing Technology Center of Japan, 2.The University of Tokyo, 3.Japan Aerospace Exploration Agency)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MAG41-04] Distribution of ^{237}Np and Plutonium isotope in terrestrial environment in Fukushima Prefecture

*Miho Fukuda[1], Zheng Jian[1], yamazaki Shinnnosuke[1], Tatsuo Aono[1] (1.National Institute for Quantum and Radiological Science and Technology, National Institute of Radiological Science)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MAG41-05] Study on deposition of ^{134}Cs and ^{137}Cs from atmosphere to freshwater environment using a mountainous lake, Lake Haruna in Gunma Prefecture, Japan

*Seiya Nagao[1], Shouhei Miyasaka[2], Shun Watanabe[3], Kyuma Suzuki[3], Shinya Ochiai[1] (1.Institute of Nature and Environmental Technology, Kanazawa University, 2.Graduate School of Natural Science and Technology, Kanazawa University, 3.Gunma Prefectural Fisheries Experimental Station)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MAG41-06] Spatial variability of radiocesium deposition through the tree canopy via branchflow and stemflow

*Zul Hilmi Saidin[1], Yuichi Onda[2], Hiroaki Kato[2], Momo Kurihara[2], Kazuki Nanko[3], Delphis F. Levia[4] (1.Graduate School of Life and Environmental Sciences, University of Tsukuba, Tsukuba, Ibaraki, Japan, 2.Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba, Tsukuba, Ibaraki, Japan, 3.Department of Disaster Prevention, Meteorology and Hydrology, Forestry and Forest Products Research Institute, Tsukuba, Ibaraki, Japan, 4.Departments of Geography, University of Delaware, Newark, Delaware, USA)

Investigation on basic physical and chemical properties of radio-Cs micro particles

*Yasuhito Igarashi[1], Kazuyuki Kita[2], Yukihiko Satou[3], Tomoaki Okuda[4], Yoshinari Abe[5], Keisuke Sueki[6], SHINOHARA ATSUSHI[7], Kazuhiko Ninomiya[7], Tsutomu Ohtshuki[1], Koichi Takamiya[1]

1. Institute for Integrated Radiation and Nuclear Science, Kyoto University, 2. Graduate School of Science and Engineering, Ibaraki University, 3. Collaborative Laboratories for Advanced Decommissioning Science, Japan Atomic Energy Agency, 4. Department of Applied Chemistry, Keio University, 5. Faculty of Science,Tokyo University of Science, 6. Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba, 7. Graduate School of Science, Osaka University

The 2011 Fukushima Daiichi Nuclear Power Plant (F1NPP) accident caused several significant releases of radioactive particulates into the environment.The physical and chemical properties of these particles, which have not been known before,have been an area of significant study. It is suggested that these fine particulates could also remain,in significant amounts,inside the nuclear reactor cores where the accidents occurred. Though appropriate samples cannot currently be obtained from the inside of the stricken reactor cores, radioactive particles collected near to the site serve as a valuable evidence for elucidation of the accident events for each reactor unit explosion and as micro-scale samples of the residual fuel debris inside the reactors. Study of these particles can help to better establish an acceptable procedure for decommissioning (collection of molten fuel, etc., decontamination inside the reactor, safety of workers, etc.). Thus, it is necessary to investigate the physical and chemical properties using advanced micro-scale analytical methods, at the same time as examining effective separation and collection methods for the radioactive particles based on the obtained property information. This will all contribute to risk reduction of the whole "decommissioning" plan. Thus, we started the analysis of such radioactive particles by using the state-of-the-art technologies such as micro-X-ray analysis, Kelvin force microscopy, induced flourescent microscopy, etc. along with radiochemical analysis.

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Dynamics of radioactive microparticles released from the Fukushima nuclear plant: heating and dissolution characteristics

*Taiga Okumura[1], Noriko Yamaguchi[2], Terumi Dohi[3], Kenso Fujiwara[3], Kazuki Iijima[3], Toshihiro Kogure[1]

1. The University of Tokyo, 2. National Agriculture and Food Research Organization, 3. Japan Atomic Energy Agency

A significant amount of radiocesium was released due to the Fukushima Daiichi Nuclear Power Plant accident in March 2011, causing radioactive contamination in east Japan. Most of the radiocesium is believed to have been released in a gaseous state, descended with rainwater and sorbed mainly by clay minerals in soil. On the other hand, spherical microparticles substantially consisting of silicate glass (radiocesium-bearing microparticle, CsMP) were also released from the damaged reactors. CsMPs are generally spherules of a few microns in diameter and contain Cl, K, Fe, Zn, Mn, Rb, Sn, and Cs in silicate glass. Since CsMPs have very high radioactivity per particle compared with soil particles sorbing radiocesium, the influence of radiation on their vicinity is a concern. However, the knowledge about dynamics of CsMPs in the environment is still limited and required urgently. Here, we report heating and dissolution characteristics of CsMPs.

Incineration of radioactive waste including CsMPs is under consideration for volume reduction. Therefore, we collected CsMPs and heated in the air in order to investigate their thermal behavior. As a result of heating treatment, the radioactivity of CsMPs gradually decreased from 600 ˚C and almost disappeared when heated up to 1000 ˚C. Scanning electron microscope (SEM) examination revealed that the morphology of CsMPs did not change even after heating at 1000 ˚C, but Cl and alkaline elements such as Cs and K were diffused away from CsMPs. The internal structure of CsMPs after heating was also investigated using transmission electron microscopy (TEM). Fe, Zn and Sn originally dissolved in the glass matrix were crystallized to oxide particles inside the CsMPs. Furthermore, when CsMPs were heated together with weathered granite soil collected in Fukushima, the radiocesium released from CsMPs was adsorbed by soil particles. These results of heating experiments suggested that highly radioactive particles such as CsMPs do not remain in the waste incinerated at a sufficiently high temperature.

Although CsMPs have been reported as “insoluble” particles thus far, they should be gradually dissolved in the environment because they substantially consist of silicate glass. We conducted dissolution experiments using CsMPs collected from the environment and investigated the dissolution behavior and lifetime of CsMPs. CsMPs were incubated in three kind of solutions, namely pure water, artificial seawater, and hydrochloric acid, under various temperature conditions, and the dissolution rate of CsMPs was estimated from the decrease in radioactivity. Furthermore, the activation energy for dissolution was calculated from the Arrhenius plot, resulting in 65 and 88 kJ/mol for pure water (pH is ~5.2 due to absorption of carbon dioxide in the atmosphere) and seawater, respectively. The calculated dissolution rate at 13 ˚C (approximate average temperature in Fukushima) is ~10 times larger in seawater than in pure water, and CsMPs are expected to be completely dissolved in seawater within ~10 years. This suggests that most of the CsMPs that fell into the sea immediately after the accident have already been disappeared. SEM observation of the CsMPs before and after dissolution in pure water revealed that their size was decreased and their spherical shapes were considerably altered without maintaining geometry. In the case of the CsMPs dissolved in seawater, plate-like secondary minerals rich in Fe and Mg were precipitated around the CsMPs to form a crust, and glass matrix was dissolved inside the crust. In addition, when CsMPs were incubated in hydrochloric acid with pH adjusted to 3, the radioactivity decreased considerably at the beginning, but ceased to change with time. A layer mostly consisting of SiO_2 was formed on the surface of the CsMPs, which may become a passive layer inhibiting dissolution.

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Keywords: microparticle, silicate glass, cesium, thermal characteristics, dissolution, Fukushima nuclear plant accident

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Dynamics of atmospheric ^{131}I just after the Fukushima accident related to ^{137}Cs by analysis of published data

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The spatio-temporal distribution of atmospheric ^{131}I just after the Fukushima Daiichi Nuclear Power Plant (FD1NPP) accident has not been understood due to the very limited measurements, compared to those of atmospheric ^{137}Cs and to many datasets of ^{131}I deposition density measured in east Japan. Accordingly, current estimates of internal exposure from inhalation have large uncertainty. The purpose of this study is to clarify the behavior of atmospheric ^{131}I in east Japan just after the accident, analyzing all the published data in the east Fukushima and Kantou areas. In the Kantou area, we mainly analyzed the data measured at JAEA-Nuclear Science Research Institute (NSRI) in Tokai (Ohkura et al., 2012). In the east Fukushima area, we used the data measured by Ministry of Education, Culture, Sports, Science and Technology (MEXT, 2012), by US Department of Energy (DOE)/National Nuclear Safety Administration (DOE/NNSA, 2011), and by Tokyo Electric Power Company (TEPCO, 2011) who measured on the sites of FD1NPP and Fukushima Daini Nuclear Power Plant (FD2NPP). The particulate/aerosol ^{131}I(g) and volatile/gaseous ^{131}(a) concentrations were decay-corrected to March 11, 2011 to normalize all the data due to the short half-life time of 8 days (the symbol of * is used). The major results are as follows. (1) For most of the dataset, particulate radionuclides were collected on the first filter (HE-40T or HE-40TA), and gaseous radionuclides were collected on the second filter cartridge (CHC-50 impregnated with 10% of TEDA) to increase in the collection efficiency of gaseous ^{131}I. The ^{137}Cs concentrations were detected on not only the first filter but also the second filter. After checking the data at NSRI in detail, we used the ^{137}Cs data only on the first filter mainly due to any contamination of measurement/sampling system (Ohkura et al., 2013; Tsuruta et al., to be submitted), while we used the ^{131}I data collected on both of the first and second filters. (2) The ratios of ^{131}(a+g)*/^{137}Cs in radioactive plumes were divided to three groups of A (10), B (75), and C (360). In addition, the ratios of ^{131}I(a)*/^{131}I(a+g)* were also divided to the same three groups. (3) These differences were caused by each plume, regardless of the measurement sites located in east Fukushima or Kantou area. Radionuclides in the A group were estimated to be emitted from Unit 2 and/or Unit 3, because the ratio of 10 was nearly equal to the inventory data of 9.7 (Unit 2) and 9.2 (Unit 3) by Nishihara et al.(2012). In contrast, the ratios in groups B and C were much higher than in group A. (4) The extremely high ratios of ^{131}(a+g)* /^{137}Cs in Group C measured from the afternoon of March 21 to March 25 were possibly caused by a new emission event after water supply to FD1NPP, such as the one proposed by Hidaka and Ishikawa (2014). This new event should be studied in future, although Group C has not been focused until now.

Keywords: Fukushima Daiichi Nuclear Power Plant, Atmospheric 131I, Ratios of 131I/137Cs, Effect of water supply

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Distribution of ^{237}Np and Plutonium isotope in terrestrial environment in Fukushima Prefecture

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After the accident at the Fukushima Dai-ichi Nuclear Power Station (FDNPS) happened in March 2011, large amounts of radionuclides released from the FDNPS into the atmosphere and marine environments.The total amounts of ^{134}Cs and ^{137}Cs, which are volatile materials, released from the accident were estimated as 18 PBq and 15 PBq, respectively. In contrast, those of ^{238}Pu,^{239}Pu and^{240}Pu, which are non-volatile materials, amounts were estimated as 0.0019 PBq, 0.0000032 PBq and 0.0000032 PBq and these amounts were not many compared to abundance before the accident (Report of Japan government to the IAEA Ministerial Conference on Nuclear safety, 2011). ^{241}Pu, half-life of which is about 14 year, detected in forest litter samples at some stations collected in April and May, 2011 and it is suggested that these samples were originated from the FDNPS accident also using the results of ^{240}Pu/^{239}Pu and^{241}Pu/^{239}Pu atomic ratio (Zheng et al., 2013). It is possible to identify origin to Pu and Np isotopes using not only Pu isotope atomic ratio such as ^{240}Pu/^{239}Pu and^{241}Pu/^{239}Pu but also ^{237}Np/^{239}Pu atomic ratio. Shozugawa et al (2012) reported that many radionuclides including^{239}Np in terrestrial environment soil and pine leaf collected in front of FDNPS and Iiidate Villege were measured. Other than Shozugawa et al (2012), reports for Np in Environment after the FDNPS accident was almost nothing. In this study, we discussed spatial distributions and origin for Neptunium (Np) and Pulutonium (Pu) based on the results of the Neptuniumand plutonium atom ratios (^{237}Np/^{239}Pu,^{240}Pu/^{239}Pu, ^{241}Pu/^{239}Pu) in soil samples collected in Fukushima Prefecture.Collected soil samples were air-dried,and then, ashed using muffle furnace at 450˚C at least 4 hours to decompose the organic matter (Wang et al., 2015). 0.57 pg of ^{242}Pu was used as recovery tracer for^{237}Np and Pu isotopes. Then, the anion-exchange resin AG MP-1M was used separated of ^{237}Np and Pu isotopes from u, Th and other interfaces (details for Haung et al. prepared).^{237}Np and Pu isotope measured using the Sector-Field ICP-MS. The ^{237}Np activity concentrations in soil samples were 1/100-1/1000 values compared to those of ^{239}Pu and ^{240}Pu. The rough profiles for these all radionuclide decreased with increasing core depth. Both ^{237}Np/^{239}Pu and ^{240}Pu/^{239}Pu atomic ratios were generally within global fallout ranges. Hereafter, it is necessary to elucidate factor controlling a values of outside the range in some layer were outside value.

This work was partially supported by Research and Development to Radiological Sciences in Fukushima Prefecture.

Keywords: Fukushima Dai-ichi Nuclear accident, 237Np, Pu isotope

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Study on deposition of ^{134}Cs and ^{137}Cs from atmosphere to freshwater environment using a mountainous lake, Lake Haruna in Gunma Prefecture, Japan

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The Great East Japan Earthquake occurred on 11 March 2011 and damaged the Fukushima Daiichi Nuclear Power Plant (FDNPP) seriously. Through the FDNPP accident, a large amount of radiocesium was released to the environment. It is important to elucidate the short-term and long-term impacts of the accident on terrestrial environments.

This study investigated the deposition of ^{134}Cs and ^{137}Cs at a mountainous lake, Lake Haruna, which is located at 1084 m height in Gunma Prefecture, Japan. The lake has a small inflow stream and one outflow river with watershed of relatively high radiocesium accumulation area. The lake sediments were collected at two sites from northern part (HR1) and central part (HR2) of the lake by using a gravity corer in September 2015. The sediment core samples were sectioned for 1 cm interval. The sediment core was also collected at HR3 from central part of the lake in October 2017. After freeze-drying of the sectioned samples, the radioactivity of ^{134}Cs and ^{137}Cs were measured by a low background Ge detector of Low Level Radioactivity Laboratory, Kanazawa University and shows as Bq/kg in dry-sediment basis at the sampling date.

Radioactivity of ^{134}Cs and ^{137}Cs ranged from D.L. to 2,922 Bq/kg and from D.L. to 34,000 Bq/kg, respectively. Two peaks of the radioactivity are observed for the HR1 sediments at 2-3 cm and 5-6 cm depth in core. One distinct peak of the radioactivity of ^{134}Cs and ^{137}Cs is observed at 3-4 cm depth in the core of HR2. Maximum of the radioactivity is also detected for the HR3 sediment core (2,920 and 23,760 Bq/kg) at 4-5 cm depth. The sedimentation rate based on ^{210}Pb for the HR1, HR2 and HR3 was 0.14, 0.031and 0.026 $g/cm^2/y$, respectively. The higher sedimentation rate at HR1 shows two peaks, but lower sedimentation rate at HR2 and HR3 show one peak of radiocesium concentration. However, the inventory of ^{134}Cs is almost constant (2.1-2.3 $x10^4$ Bq/m^2) for the three sampling sites. Two major deposition was observed in the middle of March and the early of April 2011 from the monitoring data of air gamma-ray dose rate at Takasaki and the fallout analysis of radiocesium at Maebashi in Gunma Prefecture. These results suggest that the accumulation of rediocesium at Lake Haruna mainly results from atmospheric deposition and shows short-term deposition to the bottom sediment at early stage of the accident.

Keywords: lake sediment, sedimentation rate, radiocesium

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Spatial variability of radiocesium deposition through the tree canopy via branchflow and stemflow

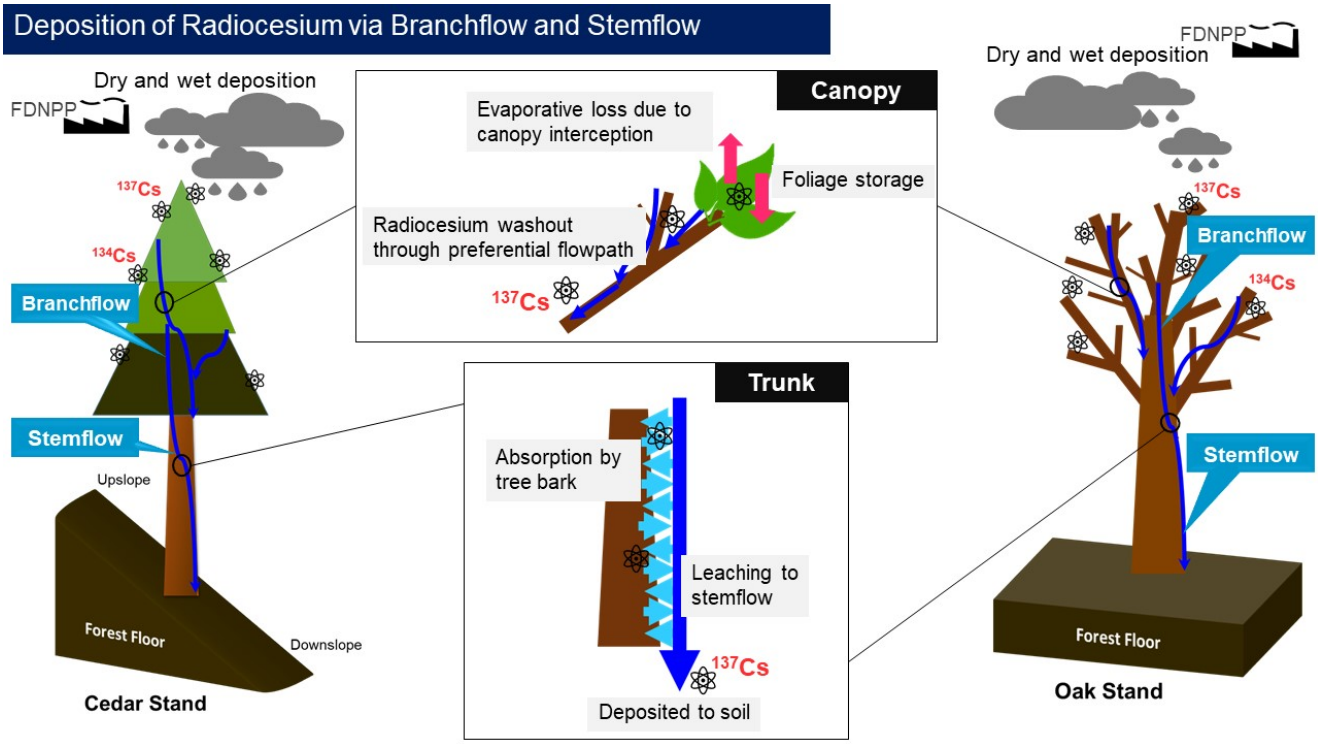
*Zul Hilmi Saidin[1], Yuichi Onda[2], Hiroaki Kato[2], Momo Kurihara[2], Kazuki Nanko[3], Delphis F. Levia[4]

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This study aims to clarify the spatial variability radiocesium deposition through the tree canopy via branchflow and stemflow in the aftermath of the Fukushima Dai-ichi Nuclear Power Plant accident. Working in both a coniferous forest (*Cryptomeria japonica*, young Japanese cedar stands, mean height is 10.9 m, mean DBH is 0.560 m) and a mixed deciduous broadleaved forest (*Quercus serrata*, Japanese oak stands, mean height is 14.3 m, mean DBH is 0.789 m), we investigated the fate of radiocesium transported by branchflow from upper and lower portions of canopy and deposited by stemflow at trunk-based. Particular attention was paid to the leachable radiocesium at the tree canopy and the mechanism of radiocesium transport via stemflow and branchflow. In addition, we used isotopes to clarify the signature of evaporation loss via branchflow and stemflow on its routing through the canopy. Significant variability of ^{137}Cs concentration was detected among the sampling periods and differed between the two forests, with the oak stand generally exhibiting higher a ^{137}Cs concentration than the cedar stand. The preliminary results further revealed that the ^{137}Cs concentration was larger from dead foliage as compared to mixed and young foliage at the branchflow of cedar stand. Radiocesium leached more in lower stemflow of the trunk compared to upper trunk stemflow, possibly due to the increased residence time of stemflow on the lower reaches of the trunk. We also found that the isotopic composition of branchflow was generally enriched in δ^{18}O and δD compared to open rainfall and throughfall. However, the differences in enrichment between branchflow and stemflow remain unclear. Canopy architecture and canopy cover affected the cycling of radiocesium in stemflow and branchflow by foliage storage and washout capacity.

Keywords: Radiocesium leaching, Isotopic composition, Stemflow and branchflow, Coniferous and broadleaved forests, Canopy architecture, Canopy cover

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-AG Applied Geosciences

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | 302 3F

[M-AG41] Dynamics of radionuclides emitted from Fukuchima Dai-ichi Nuclear Power Plant in the environment

convener:Yoshio Takahashi(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Kazuyuki Kita(Faculty of Science, Ibaraki University), Yuichi Onda(Center for Research on Isotopes and Environmental Dynamics, University of Tsukuba), Daisuke Tsumune(Central Research Institute of Electric Power Industry), Chairperson:Kazuyuki Kita(Ibaraki University), Daisuke Tsumune(Central Research Institute of Electric Power Industry)

The Great East Japan Earthquake caused the severe accident in TEPCO Fukushima dai-ichi nuclear power plant (FDNPP), leading to emission of huge amount of radionuclides to the environment. They have been transported and diffused by atmospheric motion, depositing them to soil and vegetation. Deposited radionuclides are dynamically shifted in the earth environment; atmosphere, soil, inland water, ocean, and ecosystem. To understand this dynamic shift in the environment and for the long-term prediction of the disaster by the radionuclides, investigation and discussion based on not only the earth sciences including ecology but also on the radiochemistry and other related sciences. In this session, various efforts to understand the dynamic behavior of radionuclides emitted from FDNPP accident in the earth system as well as to predict their influences on the environment. It is expected that this session will offer a good opportunity to discuss radionuclides in the earth environment from wide aspect and to exchange information in various research fields.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MAG41-07] Temporal changes in vertical distributions of radiocesium in forest soils after the FDNPP accident

★Invited Papers

*Junko Takahashi[1], Daichi Hihara[1], Takuya Sasaki[1], Yuichi Onda[1] (1.Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MAG41-08] Change of sediment sources in suspended sediments due to surface decontamination in the Niida river catchment area affected by the Fukushima Daiichi nuclear power plant accident

*Yuichi Onda[1], Yuki Yamanaka[1], Yoshifumi Wakiyama[2], Keisuke Taniguchi[3], Takaaki Kubo[1] (1.Center for Research on Isotopes and Environmental Dynamics, University of Tsukuba, 2.Institute of Environmental Radioactivity, Fukushima University, 3.Fukushima Prefectural Centre for Environmental Creation)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MAG41-09] Neasrshore transport of suspended radiocesium In the Fuksima Coast derived from Niida River induced by Typhoon Wipha

*Natsuki Tokunaga[1], Yusuke Uchiyama[1], Daisuke Tsumune[2], Masatoshi Yamada[5], Yutaka Tateda[2], Yukari Ito[3], Takashi Ishimaru[3], Yutaka Watanabe[7], Ken Ikehara[4], Miho Fukuda[6] (1.Kobe University, 2.Central Research Institute of Electric Power Industry, 3.Tokyo University of Marine Science and Technology, 4.National Institute of Advanced Industrial Science and Technology, 5.Hirosaki University, 6.National Institute of Radiological Sciences, 7.Hokkaido University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MAG41-10] Particle size distribution and radiocesium concentration in suspended particles within the high turbidity layer at near sea bottom off Fukushima prefecture

*Hideki Kaeriyama[1], Naoki Furuichi[2], Kouichi Sugimatsu[3], Yuya Shigenobu[1], Shizuho Miki[1], Takami Morita[1], Daisuke Ambe[1], Tadafumi Ichikawa[1] (1.National Research Institute of Fisheries Science, Japan Fisheries Research and Education Agency, 2.National Research Institute of Fisheries Engineering, Japan Fisheries Research and Education Agency, 3.Seikai National Research Institute, Japan Fisheries Research and Education Agency)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MAG41-11] Fukushima-derived radiocesium in the subarctic region of the North Pacific Ocean in the summer of 2017

★Invited Papers

*Yuichiro Kumamoto[1], Michio Aoyama[2], Yasunori Hamajima[3], Akihiko Murata[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Fukushima University, 3.Kanazawa University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MAG41-12] **Temporal and spatial variations of radiocaesium in the East China Sea and Sea of Japan until 2018**

*Michio Aoyama[1], Yayoi Inomata[2], Yasunori Hamajima[2] (1.Institute of Environmnetal Radioactivity, Fukushima University, 2.Institute of Nature and Environmental Technology, Kanazawa University)

Temporal changes in vertical distributions of radiocesium in forest soils after the FDNPP accident

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1. Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba

After the Fukushima Dai-ichi Nuclear Power Plant accident on March 2011, several studies including our own showed that the downward migration of ^{137}Cs from litter to mineral soil is more rapid in forests in Fukushima than in forests affected by the Chernobyl accident. Therefore, the downward migration within mineral soil layers is more important in predicting long-term dynamics of ^{137}Cs in forest ecosystems in Fukushima. In this study, temporal changes in the detailed vertical distribution of ^{137}Cs in litter and soil layers for 7 y (2011–2018) at three forest sites (Mixed Forest, Mature Cedar forest and Young Cedar forest) were investigated in Kawamata town, Yamakiya district to quantify the downward migration of radiocesium.

The soil samples were taken in 5 mm increments between 0–5 cm, 1.0 cm increments between 5–10 cm, and 5.0 cm increments between 10–20 cm using a scraper plate. From 2017, the saturation water under litter, 5 cm, 10 cm and 20 cm depth of soil layers were collected using tension-free lysimeter to estimate the amount of downward migration by soluble radiocesium in saturation water. The radioactivity of ^{137}Cs in the samples was determined by gamma-ray spectrometry.

For the Young Cedar site, the total inventory of ^{137}Cs in the litter and soil layers gradually increased with time owing to deposition from the canopy, whereas temporal changes in the total ^{137}Cs inventories were not clear for the Mixed Forest and Mature Cedar sites. The ^{137}Cs concentrations and inventories in the litter layer exponentially decreased with time for all sites, with more than 80–95% of the ^{137}Cs deposited on the forest floor distributed in the mineral soil layer by 2018. As the downward migration from litter to mineral soil progressed, the ^{137}Cs concentration in a few cm of mineral soil surface gradually increased and became higher than the ^{137}Cs concentration in the litter within 2–3 y of the accident. In the Mature Cedar site, the amount of downward migration of soluble radiocesium from litter layer to mineral soil surface was estimated at 0.60 kBq m^{-2} from Aug. 2017 to July 2018 and about 7% of total downward migration that was calculated from temporal changes in the vertical distribution of radiocesium. Both concentration and flux of radiocesium in saturation water were higher in summer than in winter. Because the dissolved organic carbon showed similar trend with radiocesium, it was suggested that radiocesium in litter and mineral soil was dissolved and penetrated downward with the decomposition of litter and soil organic matters.

The ^{137}Cs concentration in mineral soil layers exponentially decreased with depth throughout survey period, and an exponential equation fitted well. The relaxation depth of ^{137}Cs concentration in mineral soil layers estimated by the exponential equation were constantly increasing in the Mature and Young Cedar sites with 0.08 cm y^{-1}. In contrast, there was no temporal increase in the relaxation depth in the Mixed Forest site, although the percentage of ^{137}Cs inventory in subsurface soil layers deeper than 5 cm has increased with time.

Keywords: Fukushima Daiichi Nuclear Power Plant accident , forest soil, Cs-137, scraper plate, tension-free lysimeter

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Change of sediment sources in suspended sediments due to surface decontamination in the Niida river catchment area affected by the Fukushima Daiichi nuclear power plant accident

*Yuichi Onda[1], Yuki Yamanaka[1], Yoshifumi Wakiyama[2], Keisuke Taniguchi[3], Takaaki Kubo[1]

1. Center for Research on Isotopes and Environmental Dynamics, University of Tsukuba, 2. Institute of Environmental Radioactivity, Fukushima University, 3. Fukushima Prefectural Centre for Environmental Creation

The Fukushima Daiichi Nuclear Power Plant (FDNPP) on March 2011 accident released massive amounts of radiocesium into the terrestrial environment such as Cs-137 and Cs-134. The Niida river basin (265 km ^{2}) on the north eastern part of Fukushima prefecture is indeed a case in point. The river basin has a highly contaminated area on its upstream part and evacuation have been ordered, and the cropland and paddy field becomes grassland in the summer of 2011, but the downstream part has not contaminated so much. The upstream area of the basin had been subject to decontamination works, such as scraping surface soil and reversal tillage and so on, since 2012.

In the Niida river basin, we installed an integrated suspended sediment sampler, turbidity sensor, and water level sensor at the downstream site starting in December 2012, and another three sites, Sakegawa-bashi (SK), Notegami-Kita (NT) and Warabi-daira (WR) in July 2014. The monitoring has been continued until now. During our monitoring period, most of the agricultural land (paddy and cropland), the topsoil up to 5 cm and replaced with lower part of the soil taken from 2014 to 2015.

We found that the flux of suspended sediments has increased with executing rate escalation of decontamination activity. Also after the decontamination activities, the number of counterclockwise hystereses increased compared with other types. In this presentation, we will discuss the effect of decontamination on the fine sediment yield to the downstream, and the use of radiocesium as a tracer of suspendiment sediment sources.

Keywords: Cs-137, suspended sediment, Niida river, Decontamination works

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Neasrshore transport of suspended radiocesium In the Fuksima Coast derived from Niida River induced by Typhoon Wipha

*Natsuki Tokunaga[1], Yusuke Uchiyama[1], Daisuke Tsumune[2], Masatoshi Yamada[5], Yutaka Tateda[2], Yukari Ito[3], Takashi Ishimaru[3], Yutaka Watanabe[7], Ken Ikehara[4], Miho Fukuda[6]

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The Fukushima Nuclear Power Plant (FNPP) accidentally leaked substantial amount of radiocesium to the environment in March 2011. The radiocesium is known to have three input pathways to the marine environment: atmospheric deposition,direct discharge from the FNPP, and river discharges. The last process has lagged behind the accident by occasional floods that have delivered terrestrial deposition through hydrological processes, while the other two processes occurred immediately after the accident. Therefore, the local coastal seas have suffered from continuous contamination due to riverine suspended radiocesium inputs that must be assessed carefully. Niida River,Fukushima,has been a source of riverine suspended radiocesium even after the FNPP accident, as its watershed was prominently covered with the atmospheric deposition at the accident.

In this study, we examined the oceanic dispersal and inventories of the sediments and suspended radiocesium deposited in the ocean floor derived from Niida River byusing a quadruple nested JCOPE2-ROMS 3D oceanic circulation model in a high-resolution configuration at the lateral grid spacing of 50 m.This model is coupled with a 3D multi-class sediment transport model along with a two-layer stratigraphy model of the marine bed,the iRIC-Nays 2DH river sediment transport model,the SWAN spectral wave model,and a static radiocesium absorption model. A particular attention was paid to the storm and subsequent flood event associated with Typhoon 201326 (Wipha)passed off the Fukushima Coast in October 2013,which provoked an enormous amount of precipitation,subsequent increase of the riverine freshwater discharge, and associated sediment and suspended radiocesium fluxes to the ocean. The model results were diagnosed with a guide of several in situ observed data collected in the Fukushima Coast after the storm. We found that the modeled and observed lateral and vertical distributions of sediment grain sizes and attached radiocesium concentrations were reasonably well correlated and consistent each other. We then investigated the accumulation and erosion of the sediments and resultant suspended radiocesium distribution around the river mouth and nearshore areas along the Fukushima Coast.

Keywords: suspended radiocesium, ROMS

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Particle size distribution and radiocesium concentration in suspended particles within the high turbidity layer at near sea bottom off Fukushima prefecture

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The Fukushima Dai-ichi Nuclear Power Plant accident of March 2011 resulted in the release of radiocesium to the ocean. The concentration of Fukushima-derived ^{137}Cs in pelagic fishes had been decreased drastically during two years from the accident, associated with the concentration of dissolved ^{137}Cs due to the dispersion and dilution of seawater. The concentration of ^{137}Cs in demersal fishes had also been decreasing for eight years, although the decreasing rates of them are slower than those of pelagic fishes. The seabed sediment in the coastal region of Fukushima revealed higher concentration of ^{137}Cs than those observed before the accident. To elucidate the fate of Fukushima-derived radiocesium in the oceanic environment, the benthic ecosystem in the coastal region of Fukushima is the most important study area.

In this study, we focused on the high turbidity layer observed at near sea bottom as a possible source of radiocesium for the benthic organisms in the coastal region of Fukushima. Field observation was conducted in the coastal region off Fukushima and nearby prefectures during June–July 2018. The LISST-200X was used for obtaining the vertical profiles of volumetric concentration of particles and particle size frequency at 28 stations. LISST-HOLO was used concurrently at some stations shallower than 200 m to obtain holographic image of particle. To measure the concentration of ^{137}Cs in suspended materials, large volume *in-situ* pump was deployed on the sea bottom for collecting suspended materials just above the sea bottom (ca. 80 cm above bottom) at three stations.
The volumetric concentration of particle (especially >100 μm) was increased with depth and formed a peak at pycnocline and was decreased with depth. From holography images, diatom colonies and crustacean plankton (copepod) frequently observed at this peak may represent the sub-surface chlorophyll peak was developed around pycnocline. The increase of volumetric concentration of particle were also observed at near sea bottom at some stations located around continental shelf (ca. 100–200 m depth). The particles of 10–100 μm were abundant at this high turbidity sea bottom boundary layer, on the other hands the particles within this size range were less abundant in the above water column. The holography images of particles represented variable forms including crustacean plankton (copepod), rod shape fragment and amorphous detritus at the high turbidity sea bottom boundary layer. The ^{137}Cs concentration of suspended particle collected at near sea bottom ranged from 0.1 to 0.2 Bq g-dry^{-1} and was 2 to 13 times higher than that in the sea bottom sediment at same location. These results (10–100 μm particles abundant in sea bottom boundary layer and relatively high ^{137}Cs concentration in this particles) revealed the high turbidity layer at near sea bottom could be one of the sources for radiocesium uptake by the benthic organisms. Further studies needed to verify the role of this suspended particles not only the variability of ^{137}Cs concentration, but also portion of organic fraction, particle size distribution, and the horizontal distribution of particles in the continental shelf area off Fukushima.

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Keywords: Fukushima Dai-ichi Nuclear Power Plant accident, Radiocesium, high turbidity layer, particle size distribution

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Fukushima-derived radiocesium in the subarctic region of the North Pacific Ocean in the summer of 2017

*Yuichiro Kumamoto[1], Michio Aoyama[2], Yasunori Hamajima[3], Akihiko Murata[1]

1. Japan Agency for Marine-Earth Science and Technology, 2. Fukushima University, 3. Kanazawa University

The accident of Fukushima Dai-ichi Nuclear Power Plant occurred in March 2011 resulted in release of 20-40 PBq radiocesium into the environment. It is estimated that 70-80% of them deposited and discharged in the North Pacific Ocean and most of them are dissolved in seawater. Therefore, Fukushima-derived radiocesium has been spreading throughout the North Pacific along the surface water currents with dilution by seawater mixing. Previous studies revealed that radiocesium deposited and discharged in the coastal area of Japan was transported eastward along the surface current in the mid-latitude of the North Pacific Ocean and reached the west coast of the North American continent in 2015, about four years after the accident. We collected seawater samples during Japan Agency for Marine-Earth Science and Technology "Hakuho Maru" cruise conducted in the North Pacific in the summer of 2017 and measured activity concentrations of radiocesium in them. Because the activity concentration of Fukushima-derived ^{134}Cs has decreased to less than 1 Bq m^{-3} due to dilution and radioactive decay (its half-life is about 2 years), it is difficult to measure it unless it is concentrated. For the concentration, Cs resin (potassium nickel ferrocyanate on polyacrylnitrile, KNiFC-PAN) manufactured by Triskem was used. About 40 L of seawater sample was passed through 5 ml (about 1 g) of the Cs resin at a flow rate of 50 ml min^{-1} to concentrate the radiocesium in the resin. Stable cesium (^{133}Cs) chloride was added as a carrier to the seawater sample (concentration was about 100 ppb), and the recovery rate of radiocesium was estimated to be about 95% from a difference in ^{133}Cs concentration before and after the passing through the seawater sample. After washing the Cs resin in our laboratory on shore, activity concentrations of ^{134}Cs were measured using gamma ray spectrometers (Ge semiconductor detectors) in Japan Agency for Marine-Earth Science and Technology and Kanazawa University. According to vertical transection along with the two observation lines of east-west (47 north degree line) and north-south (145 west degree line) across the Gulf of Alaska in the eastern North Pacific, the activity concentration of Fukushima-derived ^{134}Cs in surface layer shallower than 300 m depth in the eastern and northern stations, namely stations closer to the coastal area of the North American continent was relatively high (the maximum decay-corrected concentration was 6 Bq m^{-3}). This suggests that Fukushima-derived ^{134}Cs reached the North American continent has been transported northward along the continent and then westward in high latitude (50-60 north degree) of the North Pacific. These results imply that Fukushima-derived ^{134}Cs will return to the coastal area of Japan along the anti-clockwise circulation in the subarctic area of the North Pacific (North Pacific subarctic gyre) within the next few years.

Keywords: Fukushima Dai-ichi Nuclear Power Plant accident, radiocesium, North Pacific

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Temporal and spatial variations of radiocaesium in the East China Sea and Sea of Japan until 2018

*Michio Aoyama[1], Yayoi Inomata[2], Yasunori Hamajima[2]

1. Institute of Environmnetal Radioactivity, Fukushima University, 2. Institute of Nature and Environmental Technology, Kanazawa University

The temporal and spatial variations of radiocaesium activity concentrations in the Sea of Japan (SOJ) and the East China Sea were investigated. We also investigated transport process from the North Pacific Ocean to the SOJ through the East China Sea (ECS) during 2012–2018. Since 2012, increase of Fukushima Dai-ichi Nuclear Power Plant derived ^{137}Cs activity concentrations were observed in the East China Sea (ECS) and Sea of Japan (SOJ) and reached maxima in 2014/2015 in the ECS and in 2015/2016 in the SOJ. In the ECS, the FNPP1-^{137}Cs activity concentrations tend to decrease after 2016. In 2017 and 2018, decreasing trend of FNPP1-^{137}Cs activity concentrations were also found in the SOJ. The propagation of Fukushima-derived radiocaesium in surface seawater from the ECS into the SOJ required approximately one year. The maximum FNPP1-^{137}Cs activity concentration at each monitoring station was 0.9-1.4 Bqm^{-3}, which contribute to about 40-49% increase against those to the ^{137}Cs activity concentration derived from the global fallout. It appeared that ^{134}Cs/^{137}Cs activity ratios indicated that part of the FNPP1-derived ^{137}Cs and ^{134}Cs was transported with 4-5 years-time scale to the ECS and then to the SOJ via Subtropical Mode Water from the North Pacific southern part of Japan (Inomata et al., 2018). In the ECS, clear meridional distribution of radiocaesium was observed in 2018. ^{137}Cs activity concentrations was low at Yonaguni and Ishigaki, south of ECS and high at west of Kyushu, north of ECS.

Keywords: Radiocaesium, Fukushima Dai-ichi Nuclear Power Plant accident, Sea of Japan, East China Sea

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-TT Technology & Techniques

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | 201A 2F

[M-TT48] Frontiers in Geochemistry

convener:Hirochika Sumino(Department of Basic Science, Graduate School of Arts and Sciences, The University of Tokyo), Tetsuya Yokoyama(Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology), Hajime Obata(Marine inorganic chemistry division, Atmosphere and Ocean Research Institute, University of Tokyo), Chairperson:Hirochika Sumino, Hajime Obata(Atmosphere and Ocean Research Institute, University of Tokyo), Tetsuya Yokoyama(Tokyo Institute of Technology)

In modern earth and planetary sciences, many new findings have been obtained by using state-of-the-art technique. These new findings include highly precise and accurate data, which is supported by recent developments of the new analytical methods. To use these data correctly and effectively, we need to deepen our knowledge on the methodology. This session aims at providing an opportunity for various geoscientists to get together and have a strategic discussion on frontiers in geochemistry and cosmochemistry. Especially, researchers, who would like to apply such innovative techniques, will have chances to discuss with those who work on devising new geochemical methods. We welcome a wide range of cutting-edge geochemical topics, including technical development, which have a potential for breakthrough of earth and planetary sciences. Any presentations related to the direction of geochemistry and cosmochemistry in future are also welcome. We expect wide-ranged and future-oriented discussion to develop geochemistry and cosmochemistry.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MTT48-01] Data science approaches to geochemical data analysis

★Invited Papers

*Kenta Ueki[1] (1.Japan Agency for Marine-Earth Science and Technology)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MTT48-02] Rapid *in situ* analyses of hydrogen and sulfur isotope ratios in basaltic glass by SIMS and their appilications

*Kenji Shimizu[1], Takayuki Ushikubo[1], Tomokazu Murai[2], Fumihiro Matsuura[2], Yuichiro Ueno[2] (1.Kochi Core Center, Japan Agency for Marine-Earth Science and Technology, 2.Tokyo Institute of Technology)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MTT48-03] Determination of siderophile elements in metallic materials using multiple spot laser ablation-ICP-MS technique

*Yoshiki Makino[1], Yasuo Kuroki[2], Takafumi Hirata[1] (1.Geochemical Research Center, Graduate School of Science, The University of Tokyo, 2.Thermo Fisher Scientific)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MTT48-04] Iron isotopic compositions of Luna 16, 20, 24 soils

★Invited Papers

*Satoki Okabayashi[1], Tetsuya Yokoyama[1], Takafumi Hirata[2], Kazuo Terakado[3], Erick M. Galimov[4] (1.Tokyo Institute of Technology, 2.The University of Tokyo, 3.Japan Space Forum, 4.Russian Academy of Science)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MTT48-05] Synthesis of calcite reference materials for *in situ* U–Pb dating through crystallization from amorphous calcium carbonates

*Yusuke Miyajima[1], Ayaka Saito[1], Hiroyuki Kagi[1], Tatsunori Yokoyama[2], Takafumi Hirata[1] (1.Geochemical Research Center, Graduate School of Science, The University of Tokyo, 2.Tono Geoscience Center, Japan Atomic Energy Agency (JAEA))

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MTT48-06] Magnetic mapping of a speleothem from the southern Pacific with a scanning SQUID microscopy and its magnetic mineralogy

*Naoto Fukuyo[1,2], Hirokuni Oda[3], Yusuke Yokoyama[1,2], Geoffrey Clark[4], Yuhji Yamamoto[5] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Department of Earth and Planetary Science, The University of Tokyo, 3.Institute of Geology and Geoinformation, 4.College of Asia and the Pacific,The Australian National University, 5.Center for Advanced Marine Core Research, Kochi University)

Data science approaches to geochemical data analysis

*Kenta Ueki[1]

1. Japan Agency for Marine-Earth Science and Technology

"Data science approaches" such as machine learning, multivariate statistical analysis, and artificial intelligence, are rapidly developing in various fields based on the recent advances in measurement techniques, rapid enhancement of database and improvement in computing power. Such data science approaches are increasingly being used in the Earth sciences. Geochemical data is high-dimensional and complex data of multivariate and multiple samples. By using the data science method, we can extract the fundamental structure or pattern from the high-dimensional geochemical data, and can evaluate the geological processes to derive the geochemical variations. We will present our recent results of the geochemical studies based on data science approaches, such as machine-learning-based geochemical tectonic discrimination and feature selection of global volcanic rocks, and stochastic crustal compositional model of the Japanese crust. In addition, we will discuss the future possibility of data science approach in the geochemistry.

Keywords: Data science, Geochemical data

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Rapid *in situ* analyses of hydrogen and sulfur isotope ratios in basaltic glass by SIMS and their appilications

*Kenji Shimizu[1], Takayuki Ushikubo[1], Tomokazu Murai[2], Fumihiro Matsuura[2], Yuichiro Ueno[2]

1. Kochi Core Center, Japan Agency for Marine-Earth Science and Technology, 2. Tokyo Institute of Technology

We developed rapid and accurate *in situ* analyses of hydrogen and sulfur isotope ratios of basaltic glass using high-resolution, multi-collection secondary ion mass spectrometry (CAMECA IMS-1280HR). Hydrogen and sulfur isotopes of standard basaltic glasses were determined by a high-temperature conversion elemental analyzer/isotope ratio mass spectrometer (IRMS) and IRMS, respectively. For the *in situ* analysis of sulfur isotopes, a defocused Cs beam (~0.5 nA; ~10 μm diameter) was used, but for hydrogen isotopes, we used a larger defocused beam (~5 nA; ~15 μm diameter) to decrease the hydrogen background. For analyses of D/H ($^{34}S/^{32}S$) ratios, ^{16}OH (^{32}S) and ^{16}OD (^{34}S) were measured in multi-detection mode with a Faraday cup and an axial electron multiplier, respectively. Each measurement lasted 6–7 minutes. Precisions (2 standard errors) for D/H and $^{34}S/^{32}S$ ratios were ~6 ‰(H_2O > 1 wt%) and ~0.6 ‰(S > 1000 ppm), respectively. Our developed method for rapid and high spatial resolution analysis can determine concentrations of volatiles, hydrogen and sulfur isotopes in a single small melt inclusion of ~30 μm diameter. Using this method, we analyzed hydrogen and sulfur isotope ratios of submarine basaltic glasses from mid-oceanic ridges and oceanic islands of Hawaii and confirmed that their D/H and S isotope ratios were consistent with reported values.

Keywords: SIMS, hydrogen isotope, sulfur isotope, basaltic glass

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Determination of siderophile elements in metallic materials using multiple spot laser ablation-ICP-MS technique

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1. Geochemical Research Center, Graduate School of Science, The University of Tokyo, 2. Thermo Fisher Scientific

Abundances of siderophile elements in metallic phase of the meteorites can provide various cosmochemical information for the formation sequence of the core formation on the small planets including planetesimals[1]. Among the siderophile elements, fractionation pattern of Mo and W relative to other refractory siderophiles of similar volatility (Re, Os, Ir, Ru, Pt) reflects the oxygen fugacity or the partial pressure of oxygen in early solar system[2]. Despite this, sensitive and precise elemental analysis on metallic materials have been retarded mainly due to analytical difficulties, originating from low concentration of the elements and matrix effects.

Laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) has been used as a method to directly determine trace elemental composition in a metallic iron[3, 4]. With the LA-ICP-MS technique, multi-element determinations for trace-elements can be achieved. Moreover, with the newly developed multiple spot laser ablation protocol, elemental sensitivity and analysis repeatability can be further improved, and now the elemental determinations for trace-elements with concentrations of lower than ng g^{-1} can be made.

One of the major analytical difficulty to obtain reliable abundance data for analytes would be the availability of calibration standard with proper concentration ranges. This is the main reason why resulting abundance values for the trace-elements became erroneous. Faced with this, we have developed new analytical protocol using multi-spot laser ablation technique using a Galvanometric optics (msLA-ICP-MS). With the multiple spot ablation, two or more solid samples can be ablated almost at a same time, and the laser ablation induced sample aerosol could be mixed and introduced into the ICP-MS, suggesting that mixing, dilution of analytes, and spiking of second elements can be made just like a treatment of solution samples. This suggests that concentration ranges of the analytes can be adjusted, and therefore, the ranges of the calibration curve can be fit to the concentration range of the analytes.

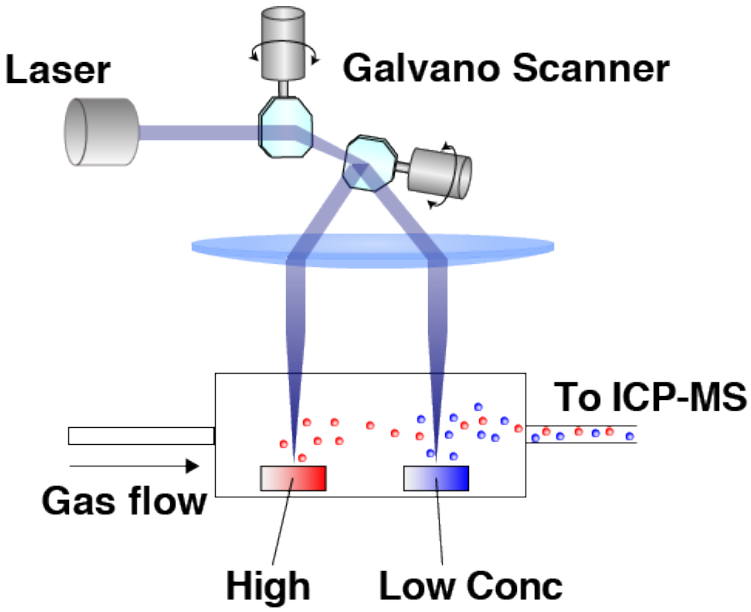
In this study, present msLA-ICP-MS was applied for elemental determinations of 35 trace elements (B, C, Mg, Al, Si, P, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, As, Zr, Nb, Mo, Ru, Rh, Pd, Sn, Sb, La, Ce, Ta, W, Re, Os, Ir, Pt, Pb) in 13 various metallic materials (iron meteorite, low alloy steel, stainless steel, tool steel). Hence, concentration range for the analytes were adjusted by mixing two standard materials (JSS 654 stainless steel and Hoba IV iron meteorite). To evaluate the accuracy of the measurements, abundances of Cr in various materials were measured by the msLA-ICP-MS technique. The resulting abundance values for Cr was 7080±120 $\mu g\ g^{-1}$ for NIST SRM 661 (low alloy steel), 15.78±0.41 % for JSS 650 (stainless steel), 23270±430 $\mu g\ g^{-1}$ for JSS 603 (tool steel). These results exhibited good agreement with the literature values within 5 %. The detection limit calculated from the calibration curve is about 1 $\mu g\ g^{-1}$, thus the measurement with about 6 orders of magnitude in dynamic range could be made. The precision of the measurements defined by repeatability of the measurements from 5 times repeated analysis was better than 3 %. The precision and accuracy of the results obtained by the msLA-ICP-MS technique were comparable to those obtained by the solution based ICP-MS. In addition, similar accuracy and precision were obtained for other trace elements acquired simultaneously.

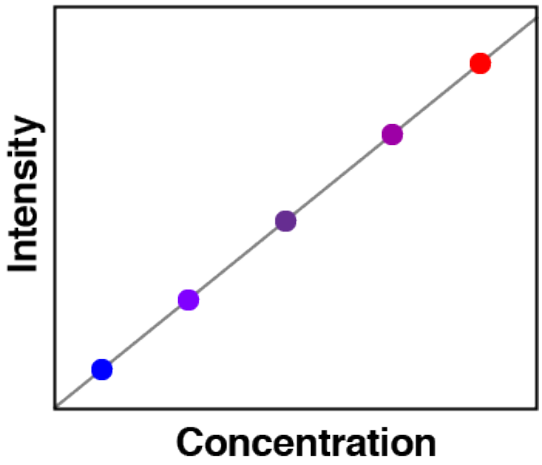
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These data obtained here clearly demonstrate that msLA-ICP-MS can become a powerful tool for elemental analysis in solid samples. In this presentation, we will describe both the principle of msLA-ICP-MS and its application for the trace elemental analysis in metallic irons.

Reference
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2. B Fegley and H Palme, EPSL, 311-326, 72, 1985.
3. A J Campbell and M Humayun, Anal Chem, 939-946, 71, 1999.
4. Okabayashi*et al.*, GCA, 197-215, 244, 2019.

Keywords: cosmochemistry, LA-ICP-MS, trace element, metal, siderophile element, meteorite





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Iron isotopic compositions of Luna 16, 20, 24 soils

*Satoki Okabayashi[1], Tetsuya Yokoyama[1], Takafumi Hirata[2], Kazuo Terakado[3], Erick M. Galimov[4]

1. Tokyo Institute of Technology, 2. The University of Tokyo, 3. Japan Space Forum, 4. Russian Academy of Science

Iron is one of the most abundant elements in the Moon. The Fe exhibits not only siderophile property but also lithophile and chalcophile properties, thus, it is included in most of the minerals and rocks that compose the Moon. Therefore, Fe isotopic composition of the Moon potentially record the fractionation process that occurred during the formation of the Moon and the differentiation or alteration after the Moon formation. Previous works on Fe isotopic analyses of lunar samples suggested that the observed Fe isotopic compositions record fractionation during evaporation of Fe related to giant impact [1], differentiation of lunar magma ocean [2]–[4], and space weathering [5]–[7].

At present, there are no lunar meteorites collected as fall, thus, returned samples of the Moon are important for lunar Fe isotopic studies. In this study, we have measured Fe isotopic ratios of soil samples from the Soviet Luna missions, Luna 16, 20, and 24, using MC-ICP-MS. A highly matured sample from Luna 16 shows clearly distinguished Fe isotopic compositions between the fine-grain and coarse-grain fractions, while such Fe isotopic discrepancies among different size fractions were much smaller in submature (Luna 20) and immature (Luna 24) samples. The Fe isotopic ratios of separated grains show that agglutinates have higher δ^{57}Fe values than the bulk and monomineralic grains, indicating the abundant np-Fe^0s in agglutinates and the partial evaporation of Fe during its melting.

The δ^{57}Fe value for the coarsest grain fraction of very low-Ti basalt from Luna 24 was found to be 0.08 ± 0.04‰, which is the first Fe isotopic composition reported for very low-Ti mare basalts. This value is clearly lower than previously reported δ^{57}Fe values for high-Ti and low-Ti basalts, and is nearly identical to those of Mg-suites. This observation is consistent with the Fe isotopic evolution model during differentiation of lunar magma ocean [3]. Furthermore, the Fe isotopic ratio of the very low-Ti basalt is indistinguishable from that of the Earth’ s mantle, thus, the bulk silicate Earth and Moon are considered to possess an identical or very close Fe isotopic composition.

References: [1] Poitrasson et al. (2009), *EPSL, 223*, 253-266. [2] Liu et al. (2010), *GCA, 74*, 6249-6262. [3] Sossi and Moynier (2017), *EPSL, 471*, 125-135. [4] Wang et al. (2015), *EPSL, 430*, 202-208. [5] Wiesli et al. (2003), *EPSL, 216*, 457-465. [6] Moynier et al. (2006), *GCA, 70*, 6103-6117. [7] Wang et al. (2012), *EPSL, 337-338*, 17-24.

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Synthesis of calcite reference materials for *in situ* U–Pb dating through crystallization from amorphous calcium carbonates

*Yusuke Miyajima[1], Ayaka Saito[1], Hiroyuki Kagi[1], Tatsunori Yokoyama[2], Takafumi Hirata[1]

1. Geochemical Research Center, Graduate School of Science, The University of Tokyo, 2. Tono Geoscience Center, Japan Atomic Energy Agency (JAEA)

Calcium carbonates are ubiquitously present throughout the Earth history as animal shells, speleothems, fault-related vein fillings, and hydrothermal or cold-seep precipitates. Direct dating of carbonates provides valuable information on paleoenvironmental change, tectonics, and fluid and material cycling. Uranium–lead (U–Pb) dating using high spatial-resolution laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) is a key technique to date natural carbonates such as fault-hosted calcite that cannot be dated by biostratigraphy or Sr isotope stratigraphy (Roberts and Walker, 2016; Beaudoin et al., 2018). *In situ* U–Pb dating by LA-ICP-MS needs matrix-matched reference materials to correct matrix-dependent elemental fractionation in LA-ICP-MS. Roberts et al. (2017) demonstrated that a natural calcite cement WC-1 (254.4 ±6.4 Ma) is suitable as a calcite reference material. However, the WC-1 calcite has an inhomogeneous distribution of U and Pb and lacks concordance in the U–Pb system (Roberts et al., 2017). In this study, we synthesized novel calcite reference materials with homogeneous U and Pb concentrations and isotope ratios. Incompatible elements such as Sr can be incorporated into calcite through pressure- or heat-induced crystallization from amorphous calcium carbonate (ACC) precipitated from element-doped reagent solution (Matsunuma et al., 2014; Saito et al., 2017). We incorporated U and Pb into calcite through heat-induced crystallization from U, Pb-doped ACC. The homogeneity of the U/Ca and Pb/Ca ratios in the synthetic calcite examined with LA-quadrupole (Q)-ICP-MS was generally better than 8% and 13%, respectively, in relative standard deviation (2SD, n = 10). The $^{207}Pb/^{206}Pb$ ratio of the synthetic calcite measured with LA-multiple-collector (MC)-ICP-MS was homogeneous within ~1% errors, whereas the $^{238}U/^{206}Pb$ ratio was less homogeneous (3%–11% errors). The inhomogeneity in the U/Pb isotope ratio would be propagated into the analytical precision for unknown samples. In order to test the usability of the synthetic calcite, we dated WC-1 using the synthetic calcite for correction of elemental fractionation. We calculated the nominal $^{238}U/^{206}Pb$ ratio in the synthetic calcite from its U and Pb concentrations measured by LA-Q-ICP-MS using Ca as an internal standard. We then obtained the fractionation factor to correct bias between the isotope ratios measured by LA-MC-ICP-MS and the nominal value. Using the fractionation factor, we could accurately date WC-1 with an ~3% precision (246.6 ±7.3 Ma). If the isotopic compositions of the synthetic calcite are certified by isotope-dilution technique, we could date natural carbonates with <10% precisions using the synthetic reference calcite.

Keywords: Amorphous calcium carbonate, LA-ICP-MS, Reference material, U–Pb geochronology

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Magnetic mapping of a speleothem from the southern Pacific with a scanning SQUID microscopy and its magnetic mineralogy

*Naoto Fukuyo[1,2], Hirokuni Oda[3], Yusuke Yokoyama[1,2], Geoffrey Clark[4], Yuhji Yamamoto[5]

1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. Department of Earth and Planetary Science, The University of Tokyo, 3. Institute of Geology and Geoinformation, 4. College of Asia and the Pacific,The Australian National University, 5. Center for Advanced Marine Core Research, Kochi University

Speleothems can be an ideal record of paleomagnetism since they retain continuous geomagnetic records in stable condition as well as having applicability of high-precision radiometric dating via U-series and radiocarbon techniques. Although their weak magnetic signals hinder this archive to be widely used in the field, Lascu et al. (2016) successfully reconstructed paleomagnetic signatures during the Laschamp excursion from a stalagmite. A scanning SQUID Microscope (SSM) can image very weak magnetic fields at high spatial resolution, and hence could potentially solve this obstacle. However, only a primitive paleomagnetic mapping without interpretation has been made on a speleothem using SSM (Myre et al., 2019). In this study, we have conducted magnetic imagings at submillimeter scale with an SSM at Geological Survey of Japan, AIST on a speleothem collected at Anahulu cave in Tongatapu Island, the Kingdom of Tonga. The ^{14}C age of the surface part of the stalagmite is around 10 ka. The stalagmite block samples were cut perpendicular to the growing direction and shaped to a thickness of ca.0.2 mm before measurements with the SSM. The measured magnetic field is ~±1.5 nT at a senor-to-sample distance of ~200 μm. In association with the laminated structures of the speleothem, we observe stronger magnetic field for the surface layer compared with that of the inner layers. Furthermore, we conducted several magnetic experiments; i.e. first-order reversal curve (FORC) measurements, and low temperature magnetometry. We also conducted decomposition of Isothermal Remanent Magnetization (IRM) acquisition curves at a room temperature and a temperature below Verwey transition. These results show that the speleothem contains a mixture of magnetite and maghemite with different magnetic domain states. The proportion of magnetite and maghemite are shown to be different between the surface layer and the inner layers. These observations are consistent with the magnetic image of a rock magnetic parameter representing coercivity (S-ratio) calculated by inversion of a series of IRM measurements with the SSM.

Keywords: Scanning SQUID microscopy, paleomagnetism, speleothem

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-TT Technology & Techniques

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | 201A 2F

[M-TT48] Frontiers in Geochemistry

convener:Hirochika Sumino(Department of Basic Science, Graduate School of Arts and Sciences, The University of Tokyo), Tetsuya Yokoyama(Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology), Hajime Obata(Marine inorganic chemistry division, Atmosphere and Ocean Research Institute, University of Tokyo), Chairperson:Hirochika Sumino, Hajime Obata(Atmosphere and Ocean Research Institute, University of Tokyo), Tetsuya Yokoyama(Tokyo Institute of Technology)

In modern earth and planetary sciences, many new findings have been obtained by using state-of-the-art technique. These new findings include highly precise and accurate data, which is supported by recent developments of the new analytical methods. To use these data correctly and effectively, we need to deepen our knowledge on the methodology. This session aims at providing an opportunity for various geoscientists to get together and have a strategic discussion on frontiers in geochemistry and cosmochemistry. Especially, researchers, who would like to apply such innovative techniques, will have chances to discuss with those who work on devising new geochemical methods. We welcome a wide range of cutting-edge geochemical topics, including technical development, which have a potential for breakthrough of earth and planetary sciences. Any presentations related to the direction of geochemistry and cosmochemistry in future are also welcome. We expect wide-ranged and future-oriented discussion to develop geochemistry and cosmochemistry.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MTT48-07] Uptake and accumulation of methylmercury by marine phytoplankton

★Invited Papers

*Yuya Tada[1], Kohji Marumoto[1] (1. National Institute For Minamata Disease)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MTT48-08] A protocol for simultaneous analysis of archaeal core and intact polar lipids using normal-phase HPLC/ESI-MS

*Shunsuke Horai[1], Hiroshi Naraoka[1,2] (1.Kyushu University, 2.Research Center for Planetary Trace Organic Compounds)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MTT48-09] Assessment of Northeastern Japan Tree-Ring Oxygen Isotopes for Reconstructing Early Summer Hydroclimate and Spring Arctic Oscillation

*Wataru Sakashita[1,2,3], Yusuke Yokoyama[3], Hiroko Miyahara[2], Takahiro AZE[3], Stephen Obrochta[4], Motonari Ohyama[5], Hitoshi Yonenobu[6] (1.Forestry and Forest Products Research Institute, 2.Musashino Art University, 3.Atmosphere and Ocean Research Institute, The University of Tokyo, 4.Akita Univeristy, 5.Tohoku University, 6.Naruto University of Education)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MTT48-10] **Development of the rotational diamond anvil cell for high-pressure deformation experiments and its measurement systems**

★Invited Papers

*Shintaro Azuma[1,2], Ryuichi Nomura[3,4], Kentaro Uesugi[5], Yu Nishihara[4], Doi Shunta[4], Takeshi Arimoto[4], Tetsuo Irifune[4] (1.Tokyo Tech., 2.Kyushu Univ., 3.Kyoto Univ., 4.Ehime Univ., 5.JASRI)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MTT48-11] Speciation of metal ions in hydrosphere: Further classification of intermediately hard ligands in HSAB theory

*Makoto Nagasawa[1], Masato Tanaka[1], Asami Miyaji[2], Yoshio Takahashi[1] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2.Hiroshima University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MTT48-12] Difference in the partition behaviors and speciation between scandium and other rare earth elements in nickel laterite ore deposits

Haibo Qin[1], Kenzo Sanematsu[2], Arcilla Carlo[3], *Yoshio Takahashi[1] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2.Institute for Geo-Resources and Environment, National Institute of Advanced Industrial Science and Technology (AIST), 3.National Institute of Geological Sciences, College of Science, University of the Philippines)

Uptake and accumulation of methylmercury by marine phytoplankton

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1. National Institute For Minamata Disease

Introduction: Eating marine fish are the main source of the toxic and bioaccumulative methylmercury (MeHg) exposure in human. However, information about the accumulation process of MeHg through marine food webs is severely limited. Phytoplankton serve as a main entry for dissolved methylmercury (MeHg) into aquatic food webs. Thus, measuring uptake ratio and accumulation of MeHg by marine phytoplankton is critical for understanding mercury risks for marine organisms and human. To date, most research on the algal uptake of MeHg were conducted using freshwater phytoplankton, and there is few studies on marine species. In this study, we examined the uptake and accumulation of MeHg using 5 marine phytoplankton cultures affiliated with different algal lineages (2 diatoms, cyanobacteria, pelagophyte, and haptophyte), and evaluated that the differences of bioaccumulation between dead and live cells.

Materials and methods: Five axenic phytoplankton cultures *Thalassiosira pseudonana* (CCMP1335), *Thalassiosira oceanica* (CCMP1005), *Synechococcus* sp. (CCMP1334) *Pelagomonas calceolate* (CCMP1756), *Emiliania huxleyi* (CCMP374) were used for incubation experiments with MeHg addition. After preculture in L1 medium, all species were cultured axenically in the L1 medium with MeHg (ca. 1,000 pg / l) at 22ºC under light or light:dark (12 h: 12 h) conditions. Incubation time was varied from several hours (short term) to days (long term). During incubation experiments, we collected subsamples of cultures several times. Phytoplankton cells (particulate fraction) were collected using the GF-75 glass-fiber filter, and stored at -80 ºC until further analysis. Filtrate (dissolved fraction) was amended with H_2SO_4 and stored at 4 ºC. To evaluate the bioaccumulation of dead and live cells, we used the *T. pseudonana* cells killed by heating (100 ºC for 20 min). Particulate and dissolved MeHg concentration were analyzed using a combined technique of dithizone extraction and the EPA method 1630.

Results and discussion: Incubation experiments revealed that all phytoplankton cultures incorporated and accumulated MeHg during incubation. In addition, incorporated MeHg would not be released from phytoplankton cells during incubation experiment. Short term incubation experiments revealed that phytoplankton cells took up 60 to 87% of the amended MeHg within 1 hour. Cellular MeHg concentration varied among phytoplankton cultures, and those of *Synechococcus* sp. (0.1-0.2 ag MeHg / cell) were relatively lower than those of other cultures. Experiments using dead and live cells showed that MeHg concentrations of dead cells were obviously lower than those of live cells, suggesting that a active MeHg uptake for this culture. Our results suggest that phytoplankton cells could actively take up and accumulate MeHg, and bioaccumulation ratio varied among phytoplankton species.

Keywords: Marine, Methylmercury, phytoplankton

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A protocol for simultaneous analysis of archaeal core and intact polar lipids using normal-phase HPLC/ESI-MS

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Isoprenoidal glycerol core lipids (CLs) from archaeal cell membranes have been utilized as proxies for paleo-environmental reconstruction (e.g., Schouten et al., 2002), and their intact forms (i.e., intact polar lipids: IPLs) can provide information on *in situ* archaeal activities in natural ecosystems (e.g., Lipp et al., 2008). Each form has been analyzed with normal phase (NP)-HPLC/ESI-MS for IPLs (Sturt et al., 2004) and with NP-HPLC/APCI-MS for CLs (Hopmans et al., 2000; Schouten et al., 2007) after the sample preparation (i.e. pre-separation of the total lipid extract into a polar and an apolar fraction, followed by acid hydrolysis of the polar fraction). However, such analytical protocols require relatively large amount of sample with great time and effort for the sample preparation. Furthermore, the acid hydrolysis of polar head groups and the APCI often cause degradation of labile lipids (e.g., hydroxyarchaeol) and byproduct formation (Liu et al., 2012; Sprott et al., 1990; Koga and Morii, 2005).

To overcome these shortcomings of traditional lipid analysis, we developed a novel NP-HPLC/ESI-MS protocol for simultaneous characterization of the distribution of CLs and IPLs from total lipid extracts in one analytical run. In order to cover the broad range of archaeal lipids in natural samples, the chromatographic separation and MS detection were optimized using the total lipid extracts of archaeal cultures having greatly different lipid compositions (*Methanosarcina barkeri* and *Sulfolobus acidcaldarius*).

With this protocol, CLs were separated according to structural variation of the alkyl chains and subsequently IPLs according to polar head group polarity into individual lipid classes. The distinct partitioning of separation part of CLs and IPLs is an important advantage when screening archaeal lipids in complex natural samples. Moreover, hydroxyarchaeol and their intact polar derivatives, which were lost in the conventional NP-HPLC/APCI-MS protocol, were detected in the total lipid extract from *M. bakeri*.

We also compared the quantitative accuracy and sensitivity on the detection of CLs between APCI and ESI-MS by using core GDGTs isolated and purified from a culture of *S.acidcaldarius*. As a result, the relative distributions of core GDGTs with NP-HPLC/ESI-MS were similar to those when analyzing with NP-HPLC/APCI-MS. This result suggests that our protocol can be applied to the study of core GDGT-based environmental proxies.

In addition to development of this protocol, we plan to apply the simultaneously chromatographic separation of this protocol to the preparation for compound-specific isotope analysis and structural identification of archaeal lipids, which will contribute for the study of archaeal activities in the environment that sample amounts are limited.

Keywords: Archaea, Intact polar lipids (IPLs), Core lipids (CLs), Simultaneous analysis

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Assessment of Northeastern Japan Tree-Ring Oxygen Isotopes for Reconstructing Early Summer Hydroclimate and Spring Arctic Oscillation

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The spring Arctic Oscillation (AO) significantly affects the subsequent summer rainfall in the East Asian Summer Monsoon (EASM) region, and analysis of meteorological data indicates this teleconnection strength varied on interdecadal timescales during the late 20th century. Tree-ring records may be able to extend the relatively short observational record, but the extent to which these proxy reconstructions correspond to AO variability has yet to be explored in this region. Therefore, we present new tree-ring cellulose oxygen isotope ($\delta^{18}O$) records from northeastern Japan (Akita, northern limit of EASM), spanning AD 1950 to 2003 which overlaps with the instrumental record. Tree-ring $\delta^{18}O$ is used for reconstructing the past hydroclimate variability and allows us to consider whether tree-ring $\delta^{18}O$ has the potential to clarify the longer-term interdecadal changes in the spring AO-EASM relationship. Measurements and analyses show that our tree-ring $\delta^{18}O$ datasets have a significant negative correlation with May-June-July relative humidity, and the tree-ring $\delta^{18}O$ in northeastern Japan also significantly correlates with the summer EASM index. Temporal comparisons between our record and observed monthly AO index indicate that reconstructed following early summer relative humidity significantly correlates to the previous March-April-May AO. This linkage changes on interdecadal timescales, and the linkage is relatively strong during early 1970s through early 1990s. Similar results are also obtained using a separate tree-ring $\delta^{18}O$ record from a separate location about 200 km to the southeast, suggesting that tree-ring cellulose $\delta^{18}O$ in northeastern Japan is indeed useful for better understanding the long-term teleconnection between the spring AO and EASM.

Keywords: Tree-ring, Oxygen isotopes, Northeastern Japan, Arctic Oscillation, East Asian summer monsoon

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Development of the rotational diamond anvil cell for high-pressure deformation experiments and its measurement systems

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1. Tokyo Tech., 2. Kyushu Univ., 3. Kyoto Univ., 4. Ehime Univ., 5. JASRI

The mechanical properties of lower mantle materials are key to understanding the dynamics and evolution in the Earth’s interior. However, the pressure range of deformation apparatuses which can achieve large strain is limited to ~30–40 GPa due to a technical reason. We developed a new deformation apparatus named rotational diamond anvil cell (rDAC). This deformation apparatus can apply the torsional deformation to a sample, thus the rDAC can theoretically produces an infinite strain within the sample under ultra-high pressure conditions, corresponding to those of core-mantle boundary [Nomura et al., 2017]. The rDAC is the most suitable deformation apparatus with which to investigate the mechanical properties of deep-Earth materials. In this presentation, we will mainly present the measurement systems, technology and idea which were applied to the rDAC.

Deformation apparatuses used in Earth science need high-pressure and high-temperature techniques, the constant strain rate, and the measurement systems of the stress and strain. The rDAC can apply high pressure and torsional deformation to a sample with constant strain rate by a gearbox and diamond anvils with grooves [Azuma et al., 2018]. *In situ* strain measurements are conducted using X-ray laminography techniques at BL47XU, SPring-8 [Nomura and Uesugi, 2016]. High-temperature conditions and stress measurements have not been achieved in rDAC. Recently, however, the vacuum chamber newly designed for rDAC was installed for high temperature experiments, and stress measurements using X-ray Diffraction (XRD) were applied to deformation experiments in rDAC at SPring-8 (Japan).

To test the high temperature technique and stress measurements using XRD with the new vacuum chamber, the mixture of bridgmanite $(Mg,Fe)SiO_3$ and ferropericlase (Mg,Fe)O, which was synthesized from San Carlos olivine, was deformed under torsion geometry using the rDAC at BL47XU, SPring-8. The vacuum chamber has a removable Kapton window for incident and diffracted X-ray, and can keep the vacuum state (<~10 Pa) to prevent the diamond anvils from oxidation during high-temperature deformation experiments. Platinum wires were used as a resistance heater surrounding the sample and Rhenium gasket. Stress was measured by collecting X-ray diffraction pattern at twelve different azimuthal angles, Ψ= 0º, ±30º, ±60º, ±90º, ±120º, ±150º, and 180º.

In heating experiments using new vacuum chamber, temperature was monitored by Pt/Rh thermocouple placed close to the sample and we succeeded in increasing temperature up to ~1000 K. However, the resistance heater (Pt) was unstable in vacuum. In the future, high-temperature deformation experiments using rDAC will be performed in reducing atmosphere produced by inactive gas (e.g., Argon gas) or internal heating system should be developed for the rDAC .

Stress in bridgmanite was estimated by using diffraction peaks (110) and (112) at P= 50 GPa and T= 673 K. Shear stress in bridgmanite was relatively constant values, whereas uniaxial stress changed during deformation experiments. This preliminary experiment was performed under low-temperature and high-pressure conditions, thus the equivalent stress in bridgmanite was about three times higher than that in previous studies [e.g., Girard et al., 2016].

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Keywords: High pressure, Deformation, Diamond anvil cell

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Speciation of metal ions in hydrosphere: Further classification of intermediately hard ligands in HSAB theory

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1. Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2. Hiroshima University

Complexation of metal cations with oxygen donor ligands such as hydroxide ion, carbonate ion, phosphate ion, and carboxylate ion is one of the most important factors controlling their behaviors in hydrosphere. Turner (1981) classified these ligands as “intermediately hard ligands” in HSAB (hard and soft acids and bases) theory. However, we found that the reactivity of hydroxide ion greatly depends on cation’s ionic radius, which results in distinguishing this ligand from the other intermediately hard ligands. Taking divalent alkaline earth metal ions as an example, Mg^{2+} mainly precipitates as hydroxide (brucite), whereas Ca^{2+} prefers carbonate (calcite) or phosphate (apatite) to hydroxide, but quantitative discussion on the mechanism has not been performed.

In this study, we evaluated the standard Gibbs free energy change of reaction ($\Delta G^0_R = \Delta H^0_R - T\Delta S^0_R$) on the complexation of hydrated metal cations with above ligands, based on thermodynamic data. The results revealed that the entropic contribution to the stabilization was large for hydroxide complexes of smaller cations. Since the entropy in aqueous complexation reaction is controlled by the number of water molecules released to the solution possibly due to replacement of the water molecules by inner-sphere complexation, it is suggested that hydroxide complexes of larger cations are less stable due to the small effect of the dehydration.

In order to support this suggestion, we conducted quantum chemical calculation, using Gaussian 09. The distance between hydrated metal cation (M) and oxygen of ligand (O) was calculated for several ions. The results showed that the average M-O distance of hydroxide complex increased with the increase of cation’s ionic radius more remarkably than that of the other complexes such as carbonate ion. This means that hydroxide favors to form outer-sphere complex for larger cations, which is consistent with our suggestion based on the thermodynamic data.

Keywords: Speciation, HSAB theory, Quantum chemical calculation, Inner-sphere complex, Outer-sphere complex

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Difference in the partition behaviors and speciation between scandium and other rare earth elements in nickel laterite ore deposits

Haibo Qin[1], Kenzo Sanematsu[2], Arcilla Carlo[3], *Yoshio Takahashi[1]

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Scandium (Sc) is a critical metal with wide applications in modern industrial applications. Consequently, the enrichment of Sc at earth surface has been of great interest in resource geology. It has been reported that laterite enriched with nickel (Ni laterite) contained significant amounts of Sc (about 80-100 ppm). The vertical profile of Ni laterite mainly consists of bed rock, saprolite, and limonite layers from bottom to the top. Generally speaking, Ni remobilized downward during weathering processes leads to the enrichment of Ni in the saprolite layer, while maximum Sc enrichment is found in the limonite layer mainly consisting of goethite. However, distribution and speciation of Sc in the limonite layer are not clear at present, which was examined by μ-XRF mapping and X-ray absorption fine structure (XAFS) spectroscopy in this study. In addition, similar information such as abundances and speciation was obtained also for other rare earth elements including yttrium (REY) to compare geochemical behaviors between Sc and REY.

Micro-XRF analysis revealed that Sc and Y are distributed to goethite in the limonite layer. Sequential extraction revealed that Sc remains in the residual phase which goethite is still present even after the treatments by reducing agents and aqua regia. XANES and EXAFS analyses for Sc in the limonite layer and its comparison with synthetic samples of Sc coprecipitated with goethite and Sc adsorbed on goethite revealed that Sc was incorporated within the goethite structure replacing Fe^{3+} site. This result is reasonable considering the similar ionic radii (6 coordination number) of Sc^{3+} (0.75 Å) and Fe^{3+} (0.65 Å). On the contrary, EXAFS for the Y samples synthesized similarly to Sc showed that Y cannot be incorporated within the goethite structure, possibly due to its large size (ionic radius of Y^{3+}: 0.90 Å) compared with Fe^{3+}. The sequential extraction showed that most of Y was present as ion-exchangeable species or Y in amorphous Fe and Mn oxides, which are consistent with the fact that Y is mainly present as adsorbed species on goethite. These results clearly explain fractionation of REY and Sc in limonite layer, with steep increase from Yb^{3+} to Sc^{3+} when we plot Sc at right of Lu in REY pattern.

The high concentration of Sc in Ni laterite is caused by (i) high concentration of Sc in the original rock (peridotite) and (ii) effective fixation of Sc^{3+} within goethite by substitution of Fe^{3+} site by Sc^{3+} during intense weathering to form laterite.

Keywords: scandium, rare earth elements, laterite

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[J] Oral | U (Union)：Union

Mon. May 27, 2019 9:30 AM - 10:30 AM JST | Mon. May 27, 2019 12:30 AM - 1:30 AM UTC | 101 1F

[U-05] Large-scale Research Projects: Master Plan 2020 and its beyond

convener:Eiichi Tajika(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Shigeko Haruyama(Department of Environmental Science, Graduate School of Bioresouces,Mie University), Ryoichi Fujii(Research Organization of Information and Systems), Hodaka Kawahata(Atmosphere Ocean Research Institute, the University of Tokyo), Chairperson:Eiichi Tajika, Shigeko Haruyama

Many of top sciences in Earth and Planetary Science (EPS) are progressed by big projects that require 10 billion JPY or more in 10 years or so. In order to realize such projects, we need an arena where they are brushed up through critical reviews among various fields in EPS. Deeper mutual understandings through serious discussions there will enable us to reach a final consensus on the priorities of the projects. The Master Plan (MP) of Large-scale Research issued by the Science Council of Japan strongly motivates us to follow the process described above. Indeed some of the selected projects have been funded by the Ministry of Education, Culture, Sports, Science & Technology since 2010.
Since the current Master Plan 2017 is going to be thoroughly revised in 2020, we propose to hold a session in which large-scale research projects are concisely introduced and critically reviewed. This session is to be convened by JpGU and EPS Committee of Science Council of Japan.

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

Introduction

9:45 AM - 10:08 AM JST | 12:45 AM - 1:08 AM UTC

[U05-01] International Astro-Bioscience Research Center

★Invited Papers

*Yukio Isozaki[1] (1.Department of Earth Science and Astronomy, Multi-disciplinary Sciences - General Systems Studies, Graduate School of Arts and Sciences, The University of Tokyo)

10:08 AM - 10:30 AM JST | 1:08 AM - 1:30 AM UTC

[U05-02] Study of coupling processes in the solar-terrestrial system

★Invited Papers

*Mamoru Yamamoto[1], Hiroyuki Hashiguchi[1], Tatsuhiro Yokoyama[1], Hiroshi Miyaoka[2], Yasunobu Ogawa[2], Kazuo Shiokawa[3], Satonori Nozawa[3], Akimasa Yoshikawa[4], Toshitaka Tsuda[5,1] (1.Research Institute for Sustainable Humanosphere, Kyoto University, 2.National Institute of Polar Research, 3.Institute for Space-Earth Environmental Laboratory, Nagoya University, 4.International Center for Space Weather Science and Education, Kyushu University, 5.Research Organization of Information and Systems)

International Astro-Bioscience Research Center

*Yukio Isozaki[1]

1. Department of Earth Science and Astronomy, Multi-disciplinary Sciences - General Systems Studies, Graduate School of Arts and Sciences, The University of Tokyo

“Large Scientific Research Projects” under national strategic perspectives naturally comprise multidisciplinary efforts of Japanese scientists, by aggregating cutting-edge technology and knowledge to tackle research issues that had yet to be explored by anyone and bringing about dramatic development of those fields. Such projects will continue to necessiate strategic, systematic promotion through a long-term outlook, while garnering the support and understanding of the general public and society overall. As to the earth and planetary sciences in Japan during the late 20th and early 21st centuries, most researches focused on individual fields, such as studies on atmosphere, ocean, surface environment, solid earth (plate, plume, geomagnetism etc.). Nonetheless, in the views from abroad, most of efforts appear to have been concentrated in transplanting ideas and technology from western communities without nurturing domestic original ones. Under the limited financial budget of Japan, there is one hopeful possibility in earth science, which enables multispheric system studies involving core, mantle, surface crust, biosphere, and outer space. The most advantageous estate in Japan is the “earth history samples” collected from various countries during the last 30 years bu Japanese earth scientists. As there is non-such analogue in the rest of the world, we should build a new project centered by a research center “Astro-Bioscience”, which promote intimate network with many countries centered in Japan in order to reveal the entire history of the Earth and life. This project is directly linked to the sustainability of our planet, to which all humans on the Earth are facing today.

Keywords: Astro-Bioscience, Earth history

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Study of coupling processes in the solar-terrestrial system

*Mamoru Yamamoto[1], Hiroyuki Hashiguchi[1], Tatsuhiro Yokoyama[1], Hiroshi Miyaoka[2], Yasunobu Ogawa[2], Kazuo Shiokawa[3], Satonori Nozawa[3], Akimasa Yoshikawa[4], Toshitaka Tsuda[5,1]

1. Research Institute for Sustainable Humanosphere, Kyoto University, 2. National Institute of Polar Research, 3. Institute for Space-Earth Environmental Laboratory, Nagoya University, 4. International Center for Space Weather Science and Education, Kyushu University, 5. Research Organization of Information and Systems

Energy from the sun is divided into radiation and solar wind (high-speed particles), which are maximum at the equatorial and polar regions, respectively. We study the flow of the energy and materials in the whole atmosphere by establishing following two large atmospheric radars at these singular points, and global observation network.
(1) Equatorial fountain
The energy and material flows that occur in all height regions of the equatorial atmosphere are named as "Equatorial Fountain." These processes from the bottom also cause various effects in the upper atmosphere. We establish Equatorial MU Rdar (EMU radar) in Indonesia as main instrument for the studies.
(2) Energy inputs into polar upper atmosphere and its response
The energy/particle inflow results in auroral Joule heating and ion drag of the atmosphere. The ion outflow from the polar ionosphere controls ambient plasma constituents in the magnetosphere. We will contribute the international EISCAT_3D radar project that has started in northern Scandinavia since 2017.
(3) Global network of observation and data
We develop a global observation network of compact radio and optical remote sensing equipment from the equator to polar region. Data from the observations will be archived and utilized by the data exchange framework of IUGONET.

This project was selected as one of important projects in both Masterplan 2014 and 2017. It was also selected as a new project in the roadmap 2014 by the Japanese Ministry of Education, Culture, Sports, Science and Technology. We continue proposing the project to Masterplan 2020.

Keywords: Equatorial MU Radar, EISCAT_3D Radar, International Observation Network, IUGONET

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[J] Oral | U (Union)：Union

Mon. May 27, 2019 10:45 AM - 12:15 PM JST | Mon. May 27, 2019 1:45 AM - 3:15 AM UTC | 101 1F

[U-05] Large-scale Research Projects: Master Plan 2020 and its beyond

convener:Eiichi Tajika(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Shigeko Haruyama(Department of Environmental Science, Graduate School of Bioresouces,Mie University), Ryoichi Fujii(Research Organization of Information and Systems), Hodaka Kawahata(Atmosphere Ocean Research Institute, the University of Tokyo), Chairperson:Shigeko Haruyama, Hodaka Kawahata

Many of top sciences in Earth and Planetary Science (EPS) are progressed by big projects that require 10 billion JPY or more in 10 years or so. In order to realize such projects, we need an arena where they are brushed up through critical reviews among various fields in EPS. Deeper mutual understandings through serious discussions there will enable us to reach a final consensus on the priorities of the projects. The Master Plan (MP) of Large-scale Research issued by the Science Council of Japan strongly motivates us to follow the process described above. Indeed some of the selected projects have been funded by the Ministry of Education, Culture, Sports, Science & Technology since 2010.
Since the current Master Plan 2017 is going to be thoroughly revised in 2020, we propose to hold a session in which large-scale research projects are concisely introduced and critically reviewed. This session is to be convened by JpGU and EPS Committee of Science Council of Japan.

10:45 AM - 11:08 AM JST | 1:45 AM - 2:08 AM UTC

[U05-03] Development of the global earth observation system using satellites

★Invited Papers

*Shinichi Sobue[1], Yoshiaki HONDA[3], Shuichi Rokugawa[2], Akira Iwasaki[2], Nobuhiro Takahashi[4], Yukari Takayabu[2], Riko Oki[1], Toshiyoshi Kimura[1], Teruyuki Nakajima[1], Takeo Tadono[1], Kosuke Yamamoto[1] (1.Japan Aerospace Exploration Agency, 2.University of Tokyo, 3.Chiba University, 4.Nagoya University)

11:08 AM - 11:31 AM JST | 2:08 AM - 2:31 AM UTC

[U05-04] Promotion of Scientific Research on Climate and Earth System Sciences Using Aircrafts

★Invited Papers

*Makoto Koike[1,2] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2.The Meteorological Society of Japan)

11:31 AM - 11:54 AM JST | 2:31 AM - 2:54 AM UTC

[U05-05] Global deployment of Deep Argo floats toward accurate prediction of future climate and ecosystem changes

★Invited Papers

*Toshiyuki Hibiya[1] (1. Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

11:54 AM - 12:15 PM JST | 2:54 AM - 3:15 AM UTC

[U05-06] A new aspect of the polar science: integrated observations of the ice sheet mass loss for better prediction of the sea level rise

★Invited Papers

*Takuji Nakamura[1], Shin Sugiyama[2], Ayako Abe-Ouchi[3], Teruo Aoki[4], Yoshifumi Nogi[1], Takeshi Tamura[1] (1.National Institute of Polar Research, 2.Institute of Low Temperature Science, Hokkaido Univ., 3.Atmosphere and Ocean Research Institute, the University of Tokyo, 4.The Graduate School of Natural Science and Technology, Okayama University)

Development of the global earth observation system using satellites

*Shinichi Sobue[1], Yoshiaki HONDA[3], Shuichi Rokugawa[2], Akira Iwasaki[2], Nobuhiro Takahashi[4], Yukari Takayabu[2], Riko Oki[1], Toshiyoshi Kimura[1], Teruyuki Nakajima[1], Takeo Tadono[1], Kosuke Yamamoto[1]

1. Japan Aerospace Exploration Agency, 2. University of Tokyo, 3. Chiba University, 4. Nagoya University

Global efforts to solve social and scientific issues related to the earth environment are ongoing globally and it is critical to develop and operate a global earth observation system. Especially, as also shown in “Yume road map”, the satellite-based observation system is indispensable tool from present to future. However, the Earth Observation Satellite, which simultaneously realizes the two functions of both scientific and practical observation, such as the GCOM series and the TRMM / GPM series, is marked as the "advancement of other remote sensing and sensor technologies" and there is no long-term plan beyond 2020 in the chart of the space basic program.

"Advanced Earth Science Research Working Group (WG)", one of the working groups of Task Force Remote Sensing Subcommittee (TF; 23 academic societies + 2 organizations), we created the "Earth Observation Grand Design" which shows the strategies for realizing the proposals of the Science Council of the scientific community and various institutions concerning Earth Observation after the successful endorsement at the TF general assembly. The purpose of this “Earth Observation Grand Design” is aimed at proposing Earth observation mission towards the space related ministries and agencies’ with brining consensus of new earth observation satellites missions from the academic societies and organizations in TF.

In the Earth Observation Grand Design published in 2018, the following five missions are proposing through a simple selection / review process as a mission to be realized in the short term, in addition to the mission described in the chart of space basic plan.

A) Mission on elucidating global climate change / water circulation mechanism

B) Mission for forest biomass estimation

C) Mission to reduce short life air pollution

D) Mission concerning elucidation of cloud and rainfall process

E) Mission concerning monitoring and elucidation of global environmental change (global radiation enforcement force and ecosystem change affecting global warming)

Based on the consent of the TF Executive Committee in late 2018, as a first step to evolve the above selection process with revision of Earth Observation Grand Design, we called for new satellite earth observation missions from a wider field and selected those missions, including ongoing satellites series missions such as high resolution optical and SAR mission, GHGs missions and geostationary observation missions, while ensuring fairness and transparency. We will make a primary selection of the proposal and

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will discuss further by JpGU 's special session coming. As a result, we will select additional missions as well as deepen consideration of promising proposals and establish a feedback process from experts toward realizing the mission.

By using those proposed missions, global climate change and water circulation mechanism will be studied to solve various social problems such as improvement of accuracy of global warming prediction, high accuracy of weather forecast, disaster, etc. These missions will also be expected to contribute to the achievement of Society 5.0 and UN / SDGs that compatibility of social tasks.

Keywords: Earth observation, Space basic plan, climate change

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Promotion of Scientific Research on Climate and Earth System Sciences Using Aircrafts

*Makoto Koike[1,2]

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The aim of this proposal is to promote climate and earth system research in the area of atmospheric science, oceanography, glaciology, volcanology, and ecology by introducing a dedicated aircraft for Earth observations.

The Earth’s environment has been changing rapidly, particularly as manifested by global warming, and the changes are imposing large impacts on the fundamental structures of our lives, including socio-economic activities and supplies of water and food. It is critically important to fully understand the current status of the changes and to investigate the controlling processes, in order to predict future changes and protect human society and ecosystems from serious damage. At present, direct atmospheric observations by aircraft are lacking in important geographical regions; they are needed for understanding greenhouse gases, aerosol-cloud interactions, and the hydrologic cycle, including predictions of typhoons and torrential downpours. Japan lacks an aircraft dedicated to scientific measurements, so Japanese scientists have been obliged to charter commercial aircraft for their experiments. Therefore it has been difficult to plan and conduct systematic aircraft experiments, which are indispensable for studies of climate and Earth system science.

In this study, we plan to acquire a dedicated aircraft and outfit it with an observation system that will be designed and utilized by scientists from a variety of fields and institutions on a long-term basis. Our aim is to enable the systematic planning of next-generation Earth observations and research activities by operating instrumented aircraft platforms on a long-term basis and attaining the highest levels of scientific outcome and impacts. We plan to provide today’s scientists and the next generation of scientists with exciting opportunities to use aircraft platforms to pursue new scientific ideas and to develop and use new technologies and methodologies. It is also planned to extend these new research opportunities to foreign scientists so that this Japanese system serves as a center of research and promotes Earth observations throughout Asia. The basic scientific knowledge obtained by this program will be made public in order to contribute to the welfare of world societies. All the processes involved in this research plan, including organizing scientists and activities, selection and scheduling of instruments, soliciting proposals, making field measurements, data archiving, and using the data, will be transparent to all scientific communities.

We plan to use the Gulfstream IV type aircraft as rental from a private company such as Diamond Air Service. The total cost is 15.5 billion Japanese yen for ten year project. The Institute for Space-Earth Environmental Research of Nagoya University has established the “Center for Orbital and Suborbital Observations” in order to play a central role in aircraft observations. This center will organize and manage activities related to aircraft observations in close cooperation with scientists from several institutions in Japan, such as the University of Tokyo, Chiba University, the Meteorological Research Institute, the National Institute for Environmental Studies, the National Institute of Polar Research, and the National Institute of Information and Communications Technology. We can receive advice and support aeronautical section of JAXA on determination of test plan and flight conditions in the flight test to realize more efficient and safety flight experiment. Through this study, we will contribute to SDSs and Future

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Earth project.

Keywords: climate, Earth system, aircraft observations, atmosphere, ocean, ecosystem

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Global deployment of Deep Argo floats toward accurate prediction of future climate and ecosystem changes

*Toshiyuki Hibiya[1]

1. Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo

Long-term assessment and conservation of marine bio-resources are crucial in securing the global food supply. Given the very rapid warming of global climate at present, however, marine environmental changes could be a very serious threat to human beings. Actually, acidification of surface seawater and decrease of dissolved oxygen in subsurface layers have been detected recently; if these trends are significant, an irreversible global/oceanic change in a longer time scale would be realistic. The deep oceanic circulation plays a key role in the marine environmental change. A recent numerical model suggests a global temperature change of more than 4°C and a decrease of marine biological production by 20% under a condition of weakened deep oceanic circulation. The actual feature and mechanism of the deep oceanic circulation are still largely unknown, and the comprehensive observation of deep sea would be also important in the assessment of oceanic ecosystem.

The Oceanographic Society of Japan submitted a research proposal in association with the 16 academic societies in theFisheries/Oceanography Research Liaison Counciland the Paleontological Society of Japan.The proposal aims to unveil the deep oceanic circulation, which is currently acting as the bottleneck in reproducingpast and future climate variability and global environmental changes in numerical models.More specifically, the proposal focuses on observation of turbulence in the deep sea with a turbulence sensor attached to the deep-sea Argo float (target depth more than 4000 meters) or "Deep NINJA". More than 10 floats of this type with conventional temperature and salinity sensors are in actual operation in the Southern Ocean. By deploying approximately 1000 floats, observation of temperature, salinity and turbulence will be conducted globally from the ocean surface to seafloor. The obtained data will be incorporated into a coupled atmosphere-ocean global climate model, and the simulation conducted using the leading Japanese supercomputer facility would yield an accurate reproduction and prediction of the past and future climate. Responses of biological community to the reproduced paleo-environmental changes can be validated by paleontological data such as microfossil record in sediment core, and the validation further refine the model prediction. A far more accurate prediction of future climate, marine biological production and marine bio-resources will be achieved through the proposed research project.

Keywords: Deep Argo floats, Turbulence in the deep ocean, Deep ocean circulation, Prediction of future climate changes, Prediction of future ecosystem changes

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A new aspect of the polar science: integrated observations of the ice sheet mass loss for better prediction of the sea level rise

*Takuji Nakamura[1], Shin Sugiyama[2], Ayako Abe-Ouchi[3], Teruo Aoki[4], Yoshifumi Nogi[1], Takeshi Tamura[1]

1. National Institute of Polar Research, 2. Institute of Low Temperature Science, Hokkaido Univ., 3. Atmosphere and Ocean Research Institute, the University of Tokyo, 4. The Graduate School of Natural Science and Technology, Okayama University

Recently the global environmental change is of great interest for the governments and general public, as well as scientists on the earth and planets. The Arctic and the Antarctic regions significantly affect global environment and also provide invaluable information on its variation. In the Arctic region, for example, temperature increase due to the global warming is the largest on the globe. The climate change is most significantly emerging which causes change of ecology, human economic activity and life. On the other hand, very little is known on the response of the huge Antarctic ice sheet to the global warming, and hence a possible change in Antarctic region on a global scale and its prediction are of greatest interest. Variations in both polar regions are not independent but connected through the ocean and atmosphere circulations, and therefore it is necessary to consider them to be one unified system. Moreover, the Arctic and Antarctic regions are the best observation and/or investigation field for space/planetary sciences, atmospheric/hydrospheric sciences, and solid earth sciences, indicating that the polar regions are important windows for earth and planetary sciences.

Greenland Ice Sheet amounts about 9 % of total ice mass on the glove, and its mass loss is becoming faster due to the rapid warming in the Arctic region. This causes acceleration of the global sea level rise. On the other hand, the Antarctic Ice Sheet, which as about an order larger mass, also indicating a significant mass loss in the western part. Once the East Antarctic Ice Sheet also started to melt quickly, which has much larger mass than the West Antarctic Ice Sheet, the sea level rise would become fatal. Thus, it is very important to understand the current variation of the ice sheets, which could cause more than 60 m of sea level rise as a total amount, and monitor its trend.

This proposal focuses on the sea level rise due to the ice sheet mass loss. We propose to carry out integrated observations at remote sites in the Antarctica and Greenland, by deploying new technical challenge with un-manned and remote controlled system. Then, by unifying in-situ observations, detailed analyses, satellite observations and numerical modelings, we plan to clarity variations of the ice sheet and ocean in the past and at present, then improve the forecast of future sea level rise, which might rapidly proceed even within this century.

Keywords: Polar Science, Arctic, Antarctic, Sea level rise, Ice sheet

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[J] Oral | U (Union)：Union

Mon. May 27, 2019 1:45 PM - 3:15 PM JST | Mon. May 27, 2019 4:45 AM - 6:15 AM UTC | 101 1F

[U-05] Large-scale Research Projects: Master Plan 2020 and its beyond

convener:Eiichi Tajika(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Shigeko Haruyama(Department of Environmental Science, Graduate School of Bioresouces,Mie University), Ryoichi Fujii(Research Organization of Information and Systems), Hodaka Kawahata(Atmosphere Ocean Research Institute, the University of Tokyo), Chairperson:Hodaka Kawahata, Eiichi Tajika

Many of top sciences in Earth and Planetary Science (EPS) are progressed by big projects that require 10 billion JPY or more in 10 years or so. In order to realize such projects, we need an arena where they are brushed up through critical reviews among various fields in EPS. Deeper mutual understandings through serious discussions there will enable us to reach a final consensus on the priorities of the projects. The Master Plan (MP) of Large-scale Research issued by the Science Council of Japan strongly motivates us to follow the process described above. Indeed some of the selected projects have been funded by the Ministry of Education, Culture, Sports, Science & Technology since 2010.
Since the current Master Plan 2017 is going to be thoroughly revised in 2020, we propose to hold a session in which large-scale research projects are concisely introduced and critically reviewed. This session is to be convened by JpGU and EPS Committee of Science Council of Japan.

1:45 PM - 2:08 PM JST | 4:45 AM - 5:08 AM UTC

[U05-07] New frontier of Earth, Space and Life Sciences pioneered by the innovative developments of new-generation mass spectrometry

★Invited Papers

*Kentaro Terada[1] (1.Department of Earth and Space Science, Graduate School of Science, Osaka University)

2:08 PM - 2:31 PM JST | 5:08 AM - 5:31 AM UTC

[U05-08] Building of archive and curating system for astrogeoscience materials

★Invited Papers

*Tsuyoshi Komiya[1] (1.Department of Earth Science & Astronomy Graduate School of Arts and Sciences The University of Tokyo)

2:31 PM - 2:54 PM JST | 5:31 AM - 5:54 AM UTC

[U05-09] Innovative 4D imaging of subduction-zones through real-time observatories, ultra-deep drilling and high-pressure experiments

★Invited Papers

*Masataka Kinoshita[1], Naoshi Hirata[1], Masanao Shinohara[1], Tetsuo Irifune[2], Hiroyuki Kagi[7], Teruyuki Kato[3], Shigeaki Ono[4], Katsuyoshi Michibayashi[6], Natsue Abe[4], Fumio Inagaki[4], Kentaro Omura[5], Kazushige Obara[1] (1.Earthquake Research Institute, University of Tokyo, 2.Ehime University, 3.Hot Springs Research Institute, 4.JAMSTEC, 5.NIED, 6.Nagoya Univ., 7.Geochemical Research Center, Univ. Tokyo)

2:54 PM - 3:15 PM JST | 5:54 AM - 6:15 AM UTC

[U05-10] Construction of the Cooperative Research Infrastructure for Intelligent Muography in Earth and Planetary Sciences, Other Sciences, and Society

★Invited Papers

*Hiroyuki Tanaka[1] (1.Earthquake Research Institute, the University of Tokyo)

New frontier of Earth, Space and Life Sciences pioneered by the innovative developments of new-generation mass spectrometry

*Kentaro Terada[1]

1. Department of Earth and Space Science, Graduate School of Science, Osaka University

So far, various mass spectrometers, which can determine elemental abundance, isotopic composition and molecular weight of macromolecule have greatly contributed to understanding of the Earth, Space and Life sciences. Above all, high-precision isotopic measurements of natural samples using sensitive mass spectrometers provide us an important clue to decipher the origin and evolution of the Earth and/or Solar system. Whereas, it is also known that many unresolved scientific issues are still remained because of technical restrains of “general-purpose” commercially-available mass spectrometers. Therefore, the “science-oriented” development of mass spectrometer has been highly desired.

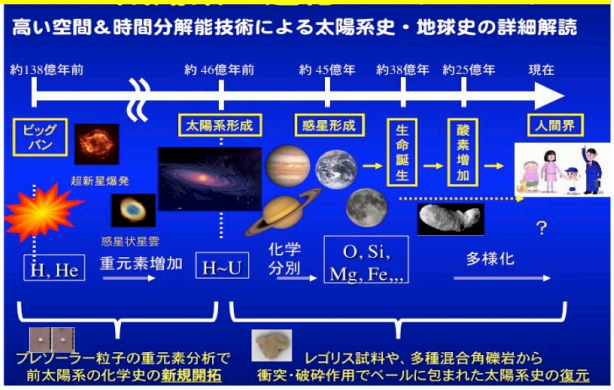
Here, Osaka University, Geochemical Society Japan, and Mass Spectrometry Society of Japan collectively propose the ideas of an innovative development of mass spectrometers that are specialized for the “Scientific issues”, which consists of two directions; (1) high-sensitive and high-spacial resolution and/or (2) reduction in size and weight with high-mass resolution. These innovative development conducted by Osaka University would pioneer a new horizon of the Earth and Planetary Science such a decipher of the pre-solar history, on-site real–time geo-cosmo-chemistry so on. These technical innovation of mass spectrometers designed for the cruel Earth and space Science would also promote the other science such as agriculture, material science and life science, so on.

Keywords: Mass spectrometer, Isotope measurement, innovative development

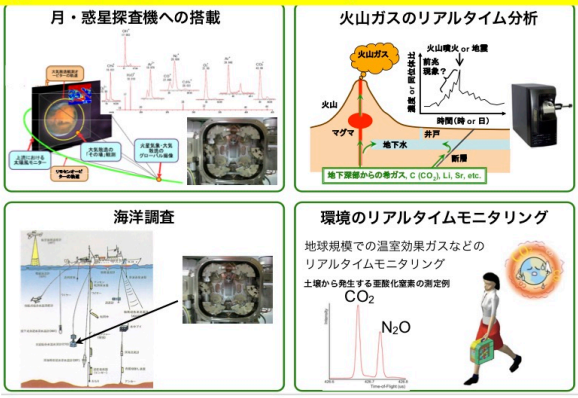
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新しいサイエンスへの挑戦。他分野への波及効果

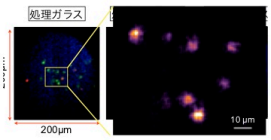
前太陽系史を含む、太陽系史の高精度解読
(高空間分解能、高感度磁場型CQHによる)



オンサイト・リアルタイム同位体分析
(小型飛行時間型MULTUMによる)



異分野への応用



有機材料などの高品質データ評価
（工学、材料科学への応用）



呼気、唾液、歯肉溝滲出液
などオンサイト診断
（医学、歯学への応用）



土壌のリアルタイムモニター
(農学への応用)

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Building of archive and curating system for astrogeoscience materials

*Tsuyoshi Komiya[1]

1. Department of Earth Science & Astronomy Graduate School of Arts and Sciences The University of Tokyo

We, Geological Society of Japan, propose “Building of archive and curating system for astrogeoscience materials” for Master Plan 2020.

Approximately 150 years passed after foundation of modern science in Japan. The Japanese researchers collected great amounts of terrestrial samples and meteorites, from over the world as well as Japan, using national and private funds during this period. Natural history is traditionally regarded as important in European countries and USA, but it is neglected more or less in Japan. As a result, Japan is far behind the European countries and USA as regards the preservation of the samples for future work, and curating system of the samples.

However, many paradigms were born from the well-organized sample archive such as Burgess Shale collection for the Cambrian Explosion and recent discovery of deep-sea economic deposit, and so on.

In addition, social responsibility of science is often emphasized in many European courtiers and USA: Open access of scientific journals, data and original samples, and guarantee of reliability of original data. However, Japan is also far behind other countries including China regards the open access.

We would like to propose building of archive and curating system for astrogeoscience materials for the future works and social responsibility.

This program is proposed by Geological society of Japan, and supported by AIST (Geological survey of Japan), National Institute of Polar Research, National Museum of Nature and Science, JAMSTEC, Kanagawa Prefectural museum of Natural History, and departments of Earth and Planetary sciences of 28 universities.

Keywords: Astrogeoscience materials, Archive and curating system

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Innovative 4D imaging of subduction-zones through real-time observatories, ultra-deep drilling and high-pressure experiments

*Masataka Kinoshita[1], Naoshi Hirata[1], Masanao Shinohara[1], Tetsuo Irifune[2], Hiroyuki Kagi[7], Teruyuki Kato[3], Shigeaki Ono[4], Katsuyoshi Michibayashi[6], Natsue Abe[4], Fumio Inagaki[4], Kentaro Omura[5], Kazushige Obara[1]

1. Earthquake Research Institute, University of Tokyo, 2. Ehime University, 3. Hot Springs Research Institute, 4. JAMSTEC, 5. NIED, 6. Nagoya Univ., 7. Geochemical Research Center, Univ. Tokyo

In 2017, we submitted a proposal for the Masterplan for Advancing Major Academic Research, entitled “Earthquake and volcanic eruption prediction science through integrated onland, seafloor and ocean drilling observations -Challenge of the spatio-temporal informatics in subduction zones- “, to the Science Council of Japan. Here, we integrate this plan with the ocean-buoy GNSS observatory project and high-pressure (down to the mantle) experiments project to create a high-precision, time-lapse imaging around the subduction zones, in order to delineate the earthquake and volcanic eruption scenarios and eventually to predict the far fate of the Earth and ocean. For this purpose, we propose to construct a real-time observatory network for earthquake and crustal deformation monitoring through seafloor cables and GNSS buoys. We also propose to obtain (and try to reproduce) the state and property around the subduction zones and in the mantle, by means of ultra-deep drilling and ultra-high pressure experiments. We are extremely interested in the mantle rheology, which is primarily controlled by the thermal structure and the abundance in volatiles (e.g. water), which we believe is only possible by integration of geophysical observation and by ground-truthing, insitu experiments.

Keywords: Seafloor cable network, Ultra-deep drilling, High pressure experiments, GNSS buoy, Subduction zone, Mantle rheology

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Construction of the Cooperative Research Infrastructure for Intelligent Muography in Earth and Planetary Sciences, Other Sciences, and Society

*Hiroyuki Tanaka[1]

1. Earthquake Research Institute, the University of Tokyo

Since 10 years ago when Japan first used muography to visualise the internal structure of volcanoes for the first time (with elementary particle originated in the universe), this technique has been evolving. In 2019, at least 7 ventures were generated in Canada, Finland, France, Israel, Spain, UK, and USA. Japan still holds the technological initiative in this field, and based on this advantageous position, we will construct the cooperative research infrastructure for intelligent muography in earth and planetary sciences, other sciences, and society by adding the artificial intelligent function.

Keywords: muography

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[J] Oral | U (Union)：Union

Mon. May 27, 2019 3:30 PM - 5:00 PM JST | Mon. May 27, 2019 6:30 AM - 8:00 AM UTC | 101 1F

[U-05] Large-scale Research Projects: Master Plan 2020 and its beyond

convener:Eiichi Tajika(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Shigeko Haruyama(Department of Environmental Science, Graduate School of Bioresouces,Mie University), Ryoichi Fujii(Research Organization of Information and Systems), Hodaka Kawahata(Atmosphere Ocean Research Institute, the University of Tokyo), Chairperson:Eiichi Tajika, Shigeko Haruyama

Many of top sciences in Earth and Planetary Science (EPS) are progressed by big projects that require 10 billion JPY or more in 10 years or so. In order to realize such projects, we need an arena where they are brushed up through critical reviews among various fields in EPS. Deeper mutual understandings through serious discussions there will enable us to reach a final consensus on the priorities of the projects. The Master Plan (MP) of Large-scale Research issued by the Science Council of Japan strongly motivates us to follow the process described above. Indeed some of the selected projects have been funded by the Ministry of Education, Culture, Sports, Science & Technology since 2010.
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3:30 PM - 3:53 PM JST | 6:30 AM - 6:53 AM UTC

[U05-11] Consortium for Planetary Exploration

★Invited Papers

*Yoshi-Yuki Hayashi[1], Shigeto Watanabe[2,5], Taishi Nakamoto[3,4] (1.Department of Planetology/CPS, Graduate School of Science, Kobe University, 2.SGEPSS, 3.The Japanese Society for Planetary Sciences, 4.Dept. of Earth and Planetary Sciences, Tokyo Institute of Technology, 5.Hokkaido Information University)

3:53 PM - 4:16 PM JST | 6:53 AM - 7:16 AM UTC

[U05-12] Japanese contribution to CAESAR: comet astrobiology exploration sample return

★Invited Papers

*Tomoki Nakamura[1], Kazuhiko Yamada[2], Yoshihiro Furukawa[1], Yuki Kimura[3], Aki Takigawa[4], Tomohiro Usui[2], Hitoshi Kuninaka[2], Team CAESAR SRC team (1.Tohoku University, 2.ISAS/JAXA, 3.Hokkaido University, 4.Kyoto University)

4:16 PM - 4:38 PM JST | 7:16 AM - 7:38 AM UTC

[U05-13] Strategic Mars exploration: Orbiter and EDL demonstration mission for space weather, climate, and aquatic environment

★Invited Papers

*Kanako Seki[1], Shigeto Watanabe[2], Taishi Nakamoto[3], Naoki Terada[4], Atsushi Yamazaki[5], Ayako Matsuoka[5], Tomohiro Usui[5], Yasuhito Sekine[3], Kazuhisa Fujita[5], Shoichiro Yokota[6], Satoshi Kasahara[1], Yoshifumi Saito[5], Hiromu Nakagawa[4], Atsushi Kumamoto[4], Hiroyuki Maezawa[7], Mars Orbiter and EDL Technology Demonstration Mission Planning Team (1.Graduate School of Science, University of Tokyo, 2.Department of Cosmosciences, Hokkaido University, 3.Tokyo Institute of Technology, 4.Graduate School of Science, Tohoku University, 5.ISAS, JAXA, 6.Graduate School of Science, Osaka University, 7.Department of Physical Science, Osaka Prefecture University)

4:38 PM - 4:53 PM JST | 7:38 AM - 7:53 AM UTC

Discussion

Consortium for Planetary Exploration

*Yoshi-Yuki Hayashi[1], Shigeto Watanabe[2,5], Taishi Nakamoto[3,4]

1. Department of Planetology/CPS, Graduate School of Science, Kobe University, 2. SGEPSS, 3. The Japanese Society for Planetary Sciences, 4. Dept. of Earth and Planetary Sciences, Tokyo Institute of Technology, 5. Hokkaido Information University

Consortium for Planetary Exploration is planed to establish a set of distributed infrastructures in the fields of solar system sciences in Japan to plan, promote, and realize Japanese solar system exploration missions by supporting, cooperating and/or leading the mission implementing agency, JAXA, from the viewpoint of sciences, and also promoting international corporations among other organizations in the world, and help the science community maximize scientific outcomes from those missions. The consortium is to fulfill the lack of scientific leaders of such fields as data reduction, simulation modeling, instrument development, material analyses who have good experience and expertise both of the solar system sciences and the mission planning and driving, and also fundamental environments for research and development. More importantly, the focus of the consortium plan is not only to improve the number of researchers and the fundamental environments, but to cultivate graduate students and young scientist to be working on those places. The requirement for the consortium will be briefly summarized in the presentation.

Keywords: planetary exploration, infrastructure for research and dvelopment , cultivating human resources

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Japanese contribution to CAESAR: comet astrobiology exploration sample return

*Tomoki Nakamura[1], Kazuhiko Yamada[2], Yoshihiro Furukawa[1], Yuki Kimura[3], Aki Takigawa[4], Tomohiro Usui[2], Hitoshi Kuninaka[2], Team CAESAR SRC team

1. Tohoku University, 2. ISAS/JAXA, 3. Hokkaido University, 4. Kyoto University

Comet is the most ideal target for Japanese planetary scientists who investigate the origin of the solar systems, particularly the origin of habitable planets. However, the mission scale of the comet sample return exceeds the Japanese space mission capability. Thus, the involvements to an international mission is more realistic strategy to share the science values of cometary sample return. A NASA NEW Frontier 4 cometary sample return proposal team requested JAXA to participate in the proposal, providing key devices and knowledge which have acquired in previous successful missions. This Master Plan proposal explains the science and engineering contributions to the NEW Frontier 4 proposal from Japan so far and in the future and how this mission provides valuable opportunities to the Japanese planetary science community.

Comets contain minerals, volatiles, and organic compounds that formed before the formation of the solar system. Thus, the cometary sample is a key material to access the origin of our solar system and the origin of life’s building blocks in space. Comet astrobiology exploration sample return (CAESAR) is the first mission to bring the macro cometary materials to the Earth without significant alteration. Japanese planetary science community have a strategy to promote the missions which investigate the formation of habitable planetary environments and its continuation. The target of CAESAR fits the strategy and particularly, investigates the materials which formed our planetary system and the origin of prebiotic organic compounds. This mission is one of the two finalist of NASA New Frontier 4 mission that has been selected from 12 proposals. JAXA is a major partner in the CAESAR mission, developing a sample return capsule based on the heritage of Hayabusa mission. Japanese sciences have also involved in the proposal planning and will be responsible for several sample analysis. The sample return of CAESAR is the most challenging among of the history of human’s sample return mission, trying to get the most abundant sample form the most far objects with the lowest temperature. This provides significant science values and also provides significant engineering heritage for Japanese communities

The early evolution of solar system stars from the conversion of interplanetary dusts into planetary materials. Hayabusa and Hayabusa 2 have strategy to investigate materials formed in the inner region of the solar system. CAESAR have complementary strategy to investigate the samples form outer region of the solar system in which material before the formation of the solar system present abundantly than inner solar system. In the astrobiological motivation, CAESAR has complementary strategy to Hayabusa 2 mission. CAESAR investigates cometary organics which have been provided mostly with micrometeorites to the Earth whereas Hayabusa 2 investigates organic compounds which have been provided mostly with meteorites. These achievements will contribute significantly to understand the origin of solar system and the origin of prebiotic organic compounds on the Earth.

CAESAR-JAPAN is working as a preproject (Phase A), developing components of sample return capsule and revising the proposal. The final selection for NASA New Frontier 4 will be open this summer. After the first step analysis, the CAESAR sample will be distributed to international science community including Japan. This will contribute significantly in planetary science, astrobiology, astronomy, and related

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disciples.

Keywords: Comet sample return

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Strategic Mars exploration: Orbiter and EDL demonstration mission for space weather, climate, and aquatic environment

*Kanako Seki[1], Shigeto Watanabe[2], Taishi Nakamoto[3], Naoki Terada[4], Atsushi Yamazaki[5], Ayako Matsuoka[5], Tomohiro Usui[5], Yasuhito Sekine[3], Kazuhisa Fujita[5], Shoichiro Yokota[6], Satoshi Kasahara[1], Yoshifumi Saito[5], Hiromu Nakagawa[4], Atsushi Kumamoto[4], Hiroyuki Maezawa[7], Mars Orbiter and EDL Technology Demonstration Mission Planning Team

1. Graduate School of Science, University of Tokyo, 2. Department of Cosmosciences, Hokkaido University, 3. Tokyo Institute of Technology, 4. Graduate School of Science, Tohoku University, 5. ISAS, JAXA, 6. Graduate School of Science, Osaka University, 7. Department of Physical Science, Osaka Prefecture University

This presentation will report on outline of the strategic Mars exploration with an orbiter and EDL technology demonstration to investigate the space weather, climate, and aqua-environment at Mars, which is to be submitted to the Master Plan 2020 of the Science Council of Japan. The research project was previously proposed from Society of Geomagnetism and Earth, Planetary and Space Sciences (SGEPSS) as “Exploration of the space weather and climate at Mars,” which is listed in the Master Plan 2017 of the Science Council of Japan as the large scientific research project number 79, category number 24-2. The project has been developed since then through discussions over larger related academic communities including the planetary science. Here we propose the renewed project as a joint proposal between SGEPSS and the Japanese Society for Planetary Sciences.
In the roadmap of the solar system exploration in coming 20 years, understanding of the formation and evolution of the habitable environment is regarded as an essential goal of the planetary science. Among various targets, Mars is an idealtarget for comparative planetology and astrobiological researches, since it once had a habitable environment with an abundant water on its surface. Mars sample return mission with international collaborations is under planning for the 2030’s. In order for Japan to play a leading role there,implementation of our original strategic Mars exploration missions in 2020’s is under vital demands from both the scientific and technological points of view.
As an important step in the Japanese strategic Mars exploration to strengthen our ability to contribute the future Martian exploration scenario by ISECG (international space exploration coordination group), this project combines the orbiter and EDL (entry, descending, and landing) technology demonstration, focusing on the responses of Martian environment to extreme solar variations and its co-evolution with subsurface aquatic environment.The mission will elucidate influence of the active sun on the habitable environment and provide the basis for our future landing exploration in 2030’s. In particular, by investigating the instantaneous response to extreme solar variations, which can be usual conditions in ancient sun, we will obtain the key knowledge to understand how atmospheric escape to space contributes to the loss of habitable environment from ancient Mars. The project will also provide knowledge about Martian radiation environment and will achieve demonstration of key technologies for the future landing exploration as well as important information of possible landing sites.In order to achieve the goal, we identified three observational requirements and 11 model payloads for the mission. In the presentation, details of these items will be also introduced.

Keywords: Mars, Exploration, Master Plan, space weather, space climate, Water

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[J] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

Mon. May 27, 2019 9:00 AM - 10:30 AM JST | Mon. May 27, 2019 12:00 AM - 1:30 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-PS06] Planetary Sciences

convener:Kenji Kurosaki(Department of Physics, Nagoya University), Yusuke Nakauchi(Japan Aerospace Exploration Agency), Chairperson:Kiyoshi Kuramoto(Hokkaido University), Takanori Sasaki(Department of Astronomy, Kyoto University)

We call for general interest papers for Planetary Scienses. Planetary Sciences consist of a variety of studies on the past, present, and future of our solar system and exoplanetary systems, Discussions based on various backgrounds are encouraged.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[PPS06-01] Current status of the PLANETS telescope project for planetary and exoplanetary atmospheric monitoring

*Takeshi Sakanoi[1], Masato Kagitani[1], Yasumasa Hirahara[2], Jeffery Kuhn[3], Svetalana Berdyugina[4], Marcelo Emilio[5], Hiromu Nakagawa[6], Mikio Kurita[7], Yasumasa Kasaba[1], Takahiro Obara[1], Shoichi Okano[1] (1.Planetary Plasma and Atmospheric Research Center, Graduate School of Science, Tohoku University, 2.Graduate School of Environmental Studies, Nagoya University, 3.IfA, University of Hawaii, U.S.A., 4.KIS, Germany, 5.Universidade Estadual de Ponta Grossa, Brazil, 6.Graduate School of Science, Tohoku University, 7.Graduate School of Science, Kyoto University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[PPS06-02] Martian Moon eXploration MMX: science objectives and their promotion

*Kiyoshi Kuramoto[1,2], Yasuhiro Kawakatsu[2], Masaki Fujimoto[2], Jean Pierre Bibring[3], David Lawrence[4], Hidenori Genda[5], Naru Hirata[6], Takeshi Imamura[7], Shingo Kameda[8], Koji Matsumoto[9], Hideaki Miyamoto[7], Tomokatsu Morota[10], Hiroshi Nagaoka[2], Hiromu Nakagawa[11], Tomoki Nakamura[11], Kazunori Ogawa[12], Hisashi Otake[2], Masanobu Ozaki[2], Sho Sasaki[13], Hiroki Senshu[14], Shogo Tachibana[7,2], Naoki Terada[11], Tomohiro Usui[2], Koji Wada[14], Sei-ichiro WATANABE[10], MMX study team (1.Hokkaido Univ., 2.JAXA, 3.IAS, 4.APL, 5.ELSI, 6.Aizu Univ., 7.Univ. of Tokyo, 8.Rikkyo Univ., 9.NAOJ, 10.Nagoya Univ., 11.Tohoku Univ., 12.Kobe Univ., 13.Osaka Univ., 14.Chiba Inst. Tech.)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[PPS06-03] Implantation of Martian Materials in the Inner Solar System by a Mega Impact on Mars

*Ryuki Hyodo[1], Hidenori Genda[1] (1.Tokyo Institute of Technology, Earth Life Science Institute)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[PPS06-04] Hydrodynamic escape of a reduced proto-atmosphere on early Mars

*Tatsuya Yoshida[1], Kiyoshi Kuramoto[1] (1.Hokkaido University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[PPS06-05] Orbital evolution of Martian moons by rotating Martian proto-atmosphere with low angular momentum

*Ryo Matsuoka[1], Kiyoshi Kuramoto[1] (1.Department of Cosmosciences, Graduateschool of Science, Hokkaido University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[PPS06-06] N-body simulations of Moon formation with cooling evolution of the protolunar disk

*Takanori Sasaki[1], Natsuki Hosono[2] (1.Department of Astronomy, Kyoto University, 2.Japan Agency for Marine-Earth Science and Technology)

Current status of the PLANETS telescope project for planetary and exoplanetary atmospheric monitoring

*Takeshi Sakanoi[1], Masato Kagitani[1], Yasumasa Hirahara[2], Jeffery Kuhn[3], Svetalana Berdyugina[4], Marcelo Emilio[5], Hiromu Nakagawa[6], Mikio Kurita[7], Yasumasa Kasaba[1], Takahiro Obara[1], Shoichi Okano[1]

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We are conducting a 1.8-m aperture off-axis telescope project PLANETS under international collaborations. In this presentation, we report the current status of PLANETS project and our scientific targets, and also promote use cases in other research fields in astronomy and planetary/exoplanetary sciences. PLANETS is characterized by low-scattering and high-contrast capability thanks to off-axis mirror system, and also by monitoring observation. We mainly concern variations in planetary atmospheres, faint gases produced from satellites, exoplanetary atmosphere, and also welcome other targets that match to the advantages of PLANETS. Continuous monitoring is essential to understanding the planetary atmospheric phenomena, and therefore, own facilities with even small- and medium sized telescopes and instruments are important. We have demonstrated that continuous monitoring is effective for understanding planetary and satellite phenomena using small telescopes at the summit of Mt. Haleakala, Hawaii (3050 m altitudes). We are now operating 40 cm (T40) and 60 cm (T60) telescopes at Haleakala combined with high-resolution spectrometers in visible and infrared ranges to observe faint atmospheric emissions/absorptions, such as plasma and neutral torus produced by Jupiter’s satellite Io, neutral torus produced by Saturn’s satellite Enceladus, gases in Venus and Mars, sodium gasses of Mercury, and so on. The polarization imager DIPOL-2 is also installed to measure the weak polarization of exoplanetary light. Our and guest investigators’ observations are also linked to Mercury, Venus (Akatsuki), Mars (Mars Express, MAVEN) and Jupiter (Juno) missions.
To achieve precise spectroscopy and polarimetry for faint emissions/absorption in planetary/exoplanetary atmospheres and satellites, PLANET’s a 1.8-m aperture with low-scattered light optics is necessary. PLANETS project is managed by the PLANETS Foundation (www.planets.life), which is an internationally organized entity whose board members are from several institutes in Japan, USA, Germany, Brazil, and France. This off-axis optical system brings us unrivaled high-dynamic range scientific capabilities on coronagraphy and polarimetry. It will have a Gregoian focus with a FOV of 6' (Fno=13) and a Coude focus with a FOV of 20" (Fno=49). The main mirror is Clearceram Z-HS with a diameter of 1850 mm, which is now on the final polishing process. We are designing mechanical structure of telescope for both cases of equatorial mount and azimuthal-elevation mount. We are also designing a mirror support structure in two ways, active support and passive support. We are aiming to get first light with PLANETS telescope within next several years.

Keywords: PLANETS, planet, exoplanet

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Martian Moon eXploration MMX: science objectives and their promotion

*Kiyoshi Kuramoto[1,2], Yasuhiro Kawakatsu[2], Masaki Fujimoto[2], Jean Pierre Bibring[3], David Lawrence[4], Hidenori Genda[5], Naru Hirata[6], Takeshi Imamura[7], Shingo Kameda[8], Koji Matsumoto[9], Hideaki Miyamoto[7], Tomokatsu Morota[10], Hiroshi Nagaoka[2], Hiromu Nakagawa[11], Tomoki Nakamura[11], Kazunori Ogawa[12], Hisashi Otake[2], Masanobu Ozaki[2], Sho Sasaki[13], Hiroki Senshu[14], Shogo Tachibana[7,2], Naoki Terada[11], Tomohiro Usui[2], Koji Wada[14], Sei-ichiro WATANABE[10], MMX study team

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Martian Moons eXploration, the next Japanese sample return mission following Hayabusa 2, is under extensive study for the upshift to phase B with a schedule to be launched in 2024 and return to Earth in 2029. MMX will make close-up observations of Phobos and Deimos over ~3 years and sample return from a moon, from which the origin of the Martian moons will be conclusively revealed. Simultaneously, the formation and evolution of a habitable planet having liquid water and atmosphere will be elucidated from the deep search for both moons and parallel Mars atmosphere observations, by making the best use of the inherent nature of the moons that have long history since the formation stage of Mars and orbits near the parent planet. Particularly, MMX will shed light on the formation and early evolution of Mars and the volatile transport from the outer planet region to inner one in early solar system, which are hardly assessed from the survey of Martian surface geology alone. Mission instruments to be on board are telescope camera (TENGOO), multiband visible camera (OROCHI), infrared spectroscopic imager (MacrOmega), gamma-ray and neutron spectrometer (MEGANE), light detection and ranging (LIDAR), dust monitor (CMDM), ion mass spectrum analyzer (MSA) and sampler. A rover is also under study as an additional science instrument to probe the moon’s surface microscopic structure and composition. To achieve the mission science objectives, it is essentially important to conduct close interplay among analyses of data from multi-instruments, sample analyses, and theoretical studies. To traverse the instrument development teams and data analysis, sample analysis and theoretical scientists, the MMX science board is going to be organized the sub-science teams, which will produce the best initial scientific results fully answering the mission objectives and conduct preparations for observations, data analyses, sample analyses in parallel with theoretical studies.

Keywords: MMX, sample return, Phobos, Deimos, Mars, Early solar system

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Implantation of Martian Materials in the Inner Solar System by a Mega Impact on Mars

*Ryuki Hyodo[1], Hidenori Genda[1]

1. Tokyo Institute of Technology, Earth Life Science Institute

The rare asteroids, called A-type asteroids, orbit within the Hungarian region and within the main asteroid belt region. They have olivine-rich spectral features [DeMeo&Carry 2013]. Their origin is still under debate even though some could be mantle materials fragmented and ejected by a catastrophic impact of differentiated primordial asteroid [Sanchez et al. 2014]. On the other hand, olivine is a major mineral of the Martian upper mantle with ~60 wt% [e.g. Bertka&Fei 1997, Zuber 2001]. Also, at the surface of Martian grabens, such as Nili Fossae, an olivine-rich signature is detected [Hoefen et al. 2003, Mustard et al. 2009].

Recent studies showed that a giant impact may occur on Mars and it produced Mars-orbiting debris from which Martian moons, Phobos and Deimos, acreete [Rosenblatt et al. 2016, Hesselbrock&Minton 2017, Hyodo et al. 2017, Canup&Salmon 2018]. Recently, Polishook et al. (2017) suggested that such Martian-moon forming impact may also produce debris that escapes from Mars' gravitational field, and some of them may have delivered to the asteroid region. However, quantitative arguments such as mass, composition and orbits of the impact ejecta have been not studied yet.

In this talk, we will present our recent work [Hyodo&Genda 2018, ApJL] that investigated the compositional and thermodynamic properties of the impact ejecta produced by a giant impact that forms Martian moons [Hyodo et al. 2017]. We also present their mass and heliocentric orbits and discuss the possibility of forming rare A-type asteroids.

We perform high-resolution SPH simulations of Mars' giant impact (impactor mass of ~0.03 mass of Mars, impact velocity of ~6 km/s and impact angle of 45 degrees without pre-impact Martian spin). We found that the giant impact produced the following escaping debris [Hyodo&Genda 2018, ApJL]:

1. Mass of ~$10^{-2}M_{Mars}$
2. ~20wt% originates from Mars and the rest originates from the impactor
3. ~50% of the Martian material originates from Martian mantle (between 50 and 200 km in depth)
4. Temperature ranges between 1000 and 4000K with a peak around 2000 K

Assuming the Mg# (=Mg/(Mg+Fe) in mol) of bulk silicate Mars of ~75% [Elkins-Tanton et al. 2003] and thus ($Mg_{0.75}$, $Fe_{0.25}$) SiO_4olivine solid solution as a major mineral of the Martian upper mantle, solidus and liquidus temperatures are about 1850 K and 2000 K [Bowen&Schairer 1935]. Then, using our SPH simulations, we found that ~10% of escaping Martian mantle debris does not melt but ~70% of the debris completely melts. In the case of partial melting (2000 K), ~20% of the Martian mantle debris avoids melting and thus they would preserve their primitive minerarogy. Hence, the unmelted Martian mantle material (olivine-rich material) is estimated to be about ~2% of the total ejected mass (~1.7×10^{20}kg). This mass is much larger than those of current A-type asteroids found in the Hungarian region (~2.8×10^{15}kg) and the current main asteroid belt (~8.9×10^{18}kg).

The orbits of the ejected particles are distributed between ~0.5-3.0 AU with eccentricity upto ~0.6 and

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inclination up to ~0.3 radian. Detailed stidues on the long-term evolution of the debris is required but the initial orbits of the debris shows that they can easily reach the asteroid belt region and thus unmelted Martian mantle material (a maximum of ~2% of the total debris mass) is potentially expected to settle into stable orbits as rare A-type asteroids found in the Hungarian and main asteroid belt regions.

We also expect that the debris hit the pre-existing asteroids with impact velocity larger than 5 km/s. The nominal collision velocity between existing asteroid is ~5km/s [Bottke et al. 1994]. Such high-velocity collision between the debris and pre-existing asteroid may record a reset of ^{40}Ar–^{39}Ar age and/or impact melts [Kurosawa&Genda 2018] and thus the timing of the giant impact on Mars may be recorded in some chondrite.

Keywords: Mars, A-type asteroids, Asteroids

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Hydrodynamic escape of a reduced proto-atmosphere on early Mars

*Tatsuya Yoshida[1], Kiyoshi Kuramoto[1]

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The short growth time of proto-Mars inferred from analyses of Martian meteorites implies that the proto-Mars likely gravitationally maintained both the solar nebula component and the impact degassed component as a proto-atmosphere. Planetary building blocks containing metallic iron should induce production of reduced volatiles such as H_2, CH_4 and CO because metallic iron acts as a reductant for the degassed component (Kuramoto and Matsui, 1996). Atmospheres with reduced compositions are promising sites for photochemical production of organic matters precursory for life (Schlesinger and Miller, 1983). If a reduced proto-atmosphere was formed and maintained on early Mars, it may be important as a field for synthesis of organic matters linked to the emergence of life organisms.

However, the reduced proto-atmosphere once possibly formed on a rocky planet has been considered to be rapidly lost by hydrodynamic escape. Hydrodynamic escape occurs when radiative heating of an atmosphere accelerates a radial outflow of an atmosphere against the planetary gravity and it is possibly induced by the extreme ultraviolet (EUV) flux of the young Sun. Previous numerical studies (Lammer et al., 2013; Erkaev et al., 2014) estimate the atmospheric escape rate of an oxidized Martian proto-atmosphere, suggesting that the proto-atmosphere with the amount equivalent to ~100 bar could have been lost per 10 Myr under the EUV flux 100 times the present. But their result likely depends on the assumption that molecules are fully dissociated into atoms. Since the gravity on Mars is small, it is likely that a considerable fraction of molecules stays undissociated in the escape outflow. If infrared active molecules are included in the atmosphere, they may reduce the atmospheric escape rate by radiative cooling. If the atmospheric escape rate decreases, the reduced environment that is suitable for producing organic matters likely continues for a long time. So far, the effect of radiative cooling on hydrodynamic escape remains poorly understood. Here, we develop a one-dimensional hydrodynamic escape model which include radiative cooling processes and photochemical processes for a multi-component atmosphere. We calculate the escape rate of a reduced Martian proto-atmosphere and estimate the duration of the reduced environment on early Mars.

We solved the fluid equations for a multi-component gas assuming spherical symmetry considering radiative processes and photochemical processes. These equations are solved by numerical integration about time until the physical quantities settle into steady profiles. We use the UV spectrum 100 Myr after the birth of the Sun estimated by the observations of solar-type G stars. We consider CO and CH_4 as radiative coolant, and consider their energy transitions with high emissivity. We calculate the radiative cooling rate by using the photon escape probability. In this modeling, a hybrid-type atmosphere in which the degassed component and solar nebula component are mixed is supposed with 18 chemical components including photolysis products.

The mass escape rate decreases more than one order as the mixing fraction of CO and CH_4 increases > 10% because of the energy loss by radiative cooling of CO and CH_4. Concurrently, the mass fractionation between H_2 and other heavier species occurs more remarkably. Time scale for H_2 loss may be longer than 100 Myr when the the degassed component is larger than ~1.0×10^{21} kg equivalent to ~100 bar atmosphere. In many simulation cases, CO and CH_4 are left behind implying that the reduced environment further continues until these reduced species are oxidized by photolysis. Our result suggests

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a reduced environment on early Mars may have continued more than 100 Myr and played an important role producing organic matters.

Keywords: hydrodynamic escape, early Mars, reduced atmosphere

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Orbital evolution of Martian moons by rotating Martian proto-atmosphere with low angular momentum

*Ryo Matsuoka[1], Kiyoshi Kuramoto[1]

1. Department of Cosmosciences, Graduateschool of Science, Hokkaido University

Martian moons, Phobos and Deimos has radii about several km to 10 km, and irregular shapes. Their low albedos and reflectance spectra are similar to those of primitive carbonaceous asteroid which supports “capture scenario” for their origin.

In previous studies considering the capture due to energy dissipation by gas drag from the Martian proto-atmosphere caused by the gravitational bound of the nebula gas, it is possible to circularize the moons’ orbit (Hunten 1979, Sasaki 1990). While this spherically symmetric atmospheric structure can make moon’s orbit circular, it is impossible to attenuate the orbital inclination of the moon. Also, the satellite constantly receives atmospheric drag and cause moons to fall into Mars eventually. Although the giant impact theory (e.g. Rosenblatt+ 2016) explains such moons’ orbital feature, it is difficult to form moons with carbonaceous composition because of high temperature environment during moon formation. On the other hand, in context of capture scenario, Matsuoka & Kuramoto (2018, JpGU) considered the atmospheric rotation and showed that the attenuation of inclination occurred and the orbital shrinking was inhibited. However, since this atmosphere has extremely large angular momentum (1.3 times the Martian spin anugular momentum) due to Keplerian rotation beyond the co-rotational radii, thus it seems difficult to realize to form. Also, there is a problem that moons are formed and stay beyond Deimos’ orbit. In this study, we construct models of rotating atmosphere with much small anugular momentm and show that it is more advantageous in explaining the orbital features of the current Martian moons.

This study assumed that atmospheric rotation is limited within the Bondi radii and the velocity field is modeled as follows so that the rotational velocity becomes continuous by changes with distance. (1) Mars surface to co-rotational radii R_C: co-rotational atmosphere with Mars’ spin. (2) co-rotational radii to Bondi radii R_B: attenuated atmospheric rotation with distance given by $v(r)=((R_B-r)/(R_B-R_C))^{\Gamma} v_K(r)$ (v_K is a Keplerian velocity, Γ is a constant which we set unity in this study). (3) Bondi radii to Hill radii: stationary atmosphere connecting nebula at Hill radii. Such atmosphere can be regarded as a case that has not enough angular momentum to make Keplerian rotation outside the co-rotational radii. The density field of the atmosphere was determined by the balance of centrifugal force by this velocity field, Mars gravity and pressure gradient, and the drag force by these velocity field and density field were given to the equation of motion of moons. This atmosphere has low angular momentum of only 0.14 % of the Martian spin angular momentum.

In numerical experiments, moons have the inward radial velocity component in all regions, but the orbital shrinkage is suppressed near the co-rotational radii due to small speed difference between moons and atmosphere. The typical timescale of attenuation of semi-major axes of Phobos size moons is the order of 10^4 yr or more. This timescale sharply increased as approaching the co-rotational radii, indicating that the moons stay well in this region. This result naturally explains the initial position near the co-rotational radii of moons before tidal orbital evolution. Since there is a speed difference between moons and the atmosphere even if the inclination takes small value, the attenuation of inclination occurs efficiently. In contrast to timescale of inclination decay derived in our previous study that is rapidly increasing with the

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decay of inclination, timescale derived in this study has an upper limit of several thousand years for a Phobos size moon. This result explains small orbital inclination of the current Martian moons. Such tendencies are recognized in the same way when Γ has different positive values, and in the cases of the Deimos size moons, such orbital evolution occur more rapidly than those of Phobos size moons.

Keywords: Martian moons, Satellite formation

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N-body simulations of Moon formation with cooling evolution of the protolunar disk

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The previous studies about Moon formation focused on the first and last stages: the giant impact process (~1 day) has been investigated by SPH simulations, and the lunar accretion process (~1 month) from the circumterrestrial particulate disk has been investigated by N-body simulations. Although the Moon formation process should proceed on the cooling timescale of the protolunar disk (~100 years), there has been no study to simulate the long-term evolution of the disk. In this study, we developed an N-body code to simulate the cooling evolution of a protolunar disk in vapor/melt equilibrium, and executed long-term N-body simulations for the disk evolution and lunar accretion processes simultaneously with PEZY-SC processors. Our result showed that "mini-Moons" system would form instead of forming a single Moon.

Keywords: Moon, formation, N-body simulation, protolunar disk, PEZY-SC

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[J] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

Mon. May 27, 2019 10:45 AM - 12:15 PM JST | Mon. May 27, 2019 1:45 AM - 3:15 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-PS06] Planetary Sciences

convener:Kenji Kurosaki(Department of Physics, Nagoya University), Yusuke Nakauchi(Japan Aerospace Exploration Agency), Chairperson:Hiroyuki Kurokawa(東京工業大学 地球生命研究所), Yuki Tanaka(Tokyo Institute of Technology)

We call for general interest papers for Planetary Scienses. Planetary Sciences consist of a variety of studies on the past, present, and future of our solar system and exoplanetary systems, Discussions based on various backgrounds are encouraged.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[PPS06-07] Possibility of giant planet formation by pebble accretion in Class 0/I YSOs

*Yuki Tanaka[1], Yusuke Tsukamoto[2] (1.Tokyo Institute of Technology, 2.Kagoshima University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[PPS06-08] The effect of the three-dimensional gas flow around an embedded planet on pebble accretion

*Ayumu Kuwahara[1], Hiroyuki Kurokawa[2] (1.Tokyo Institute of Technology, 2.Earth-Life Science Institute)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[PPS06-09] Icy pebble accretion onto terrestrial planets: the effect of gas flow

*Hiroyuki Kurokawa[1], Ayumu Kuwahara[2], Satoshi Okuzumi[2] (1.Earth-Life Science Institute, Tokyo Institute of Technology, 2.Tokyo Institute of Technology)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[PPS06-10] Delivery of ammonia ice to Ceres by pebble accretion

*Yuto Nara[1], Satoshi Okuzumi[1], Hiroyuki Kurokawa[2] (1.Tokyo Institute of Technology, 2.Earth-Life Science Institute, Tokyo Institute of Technology)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[PPS06-11] Volatile-driven cryovolcanic eruption on asteroid Ceres as a probe to its interior

*Koki Yumoto[1], Yuichiro Cho[1], Seiji Sugita[1] (1.Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[PPS06-12] Ice sheet formation on synchrnously rotating earth-like planets in M-dwarf abitable zones

Soma Arai[1], Kiyoshi Kuramoto[1], *Masaki Ishiwatari[1], Shunichi Kamata[1] (1.Department of Cosmosciences, Graduate school of Science, Hokkaido University)

Possibility of giant planet formation by pebble accretion in Class 0/I YSOs

*Yuki Tanaka[1], Yusuke Tsukamoto[2]

1. Tokyo Institute of Technology, 2. Kagoshima University

Recently, pebble accretion in protoplanetary disks attracts attention in theoretical works of planet formation. In this process, it is thought that cm-sized particles, so-called pebbles, drift inward in the disk, and growth of planets will be accelerated due to accretion of pebbles onto proto-planets. Various theoretical works which assume pebble accretion, such as giant planet formation and formation of super-Earths systems, have been done so far.

Meanwhile, recent radio observations by ALMA have revealed that existence of clear gaps and rings in many very young protoplanetary disks. Mechanisms to generate these structures of gaps and rings are yet to be investigated, and many theoretical models have been proposed. One of these hypotheses is that gas giants in the disks carve gaps in the dust disks and create such structures. Numerical simulations which assumed the existence of the planet have been shown that gaps and rings similar to the observations can be represented. However, a time-scale for planet formation will be long because the observed radii of gaps and rings are relatively large, so it is unclear whether the planet with enough mass to create a gap can form in very young disks.

Here we focus on planet formation in much earlier stages, Class 0/I phases. Combining an analytical model of a gravitationally unstable disk around Class 0/I YSOs with a model of pebble accretion, we investigate possibility of giant planet formation in the early stages of disk evolution. We find that in many cases a time-scale of pebble accretion in the condition of Class 0/I YSOs is much shorter compared to that in a typical protoplanetary disk, because of larger mass accretion rates. We also find, however, the accretion time-scale is not always a decreasing function of the gas accretion rate, and the time-scale can be longer as the increase of the gas accretion rate depending on parameters. Using derived time-scales, we investigate growth of proto-planets with different parameters such as the gas accretion rate and dust-to-gas mass ratio. Based on our results, we discuss a required initial mass of the proto-planets to form cores of the giant planets within Class 0/I phases.

Keywords: Planet formation, Protoplanetary disk, Pebble accreton, Class 0/I YSOs

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The effect of the three-dimensional gas flow around an embedded planet on pebble accretion

*Ayumu Kuwahara[1], Hiroyuki Kurokawa[2]

1. Tokyo Institute of Technology, 2. Earth-Life Science Institute

Pebble accretion is a new model of planet formation, which may overcome several problems remaining in conventional planetesimal accretion theory. Accreting mm—cm-sized particles, called pebbles, onto the proto-cores can form the massive cores faster than accreting the planetesimals. In addition to the formation of the Jovian cores in a realistic timescale, pebble accretion scenario can explain the formation of various types of planets—for instance, close-in super Earths, water-rich planets, and the size distribution of terrestrial planets in the solar system. The key point of this scenario is that the pebbles experience not only the gravitational interaction with the proto-cores but also gas drag. The hydrodynamic effect is important when we consider the planet formation via pebble accretion.

Previous works have found the three-dimensional flow field around an embedded planet. Gas from the protoplanetary disk enters the Bondi or Hill sphere of the planet at high latitude and exits through the mid-plane region in the isothermal condition (Kuwahara et al. 2019). This recycling mechanism may have both positive and negative effect on the accretion of solid materials. When the particles are moving in the region at high latitude of the planet, the accretion may be promoted by the inflow of gas. On the other hand, if the particles are in the mid-plane region, the accretion of the particles can be suppressed by the outflow barrier. Though some studies considered the accretion of dust particles in the realistic flow field (Ormel 2013; Popovas et al. 2018ab), the effect on the accretion efficiency is not fully understood. This study aims to understand the hydrodynamic effect and to obtain the accretion efficiency of particles for the range of planetary masses and particle sizes.

In this study, using the numerical data obtained from three-dimensional hydrodynamical simulations, we numerically integrated the equation of motion of pebbles including the gravitational interactions and gas drag under the influence of the flow field in three dimensions. We also performed the similar calculations on the Keplerian shear flow field without the effect of planet gravity on the flow, then investigated how the description of the pebble accretion changed on the flow pattern, pebble size, and dimensionless planetary mass, $m=R_{\mathrm{Bondi}}/H$, where R_{Bondi} and H are the Bondi radius of the planet and disk scale height, respectively.

In the flow field, we found that the description of pebble accretion differs from that of in the Keplerian shear flow. Pebbles at high altitude tend to descend toward the planet because of the downward stream of gas. The accretion rate of pebbles became smaller than in the Keplerian shear flow. In spite of the pebbles descend toward the planet, the accretion of pebbles can be suppressed because of the effect of the flow field. Since the gas flows rapidly in the vicinity of the planet, the gas flow field deflects the trajectories of the pebble in the vicinity of the planet and reduces its accretion rate. The flow field has the stronger effect on the smaller pebbles. Based on these results, we will discuss the implications for planet formation via pebble accretion.

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Popovas, A., Nordlund, Å., & Ramsey, J. P. 2018, MNRAS: Letters, 482, L107

Keywords: hydrodynamics, protoplanetary disk, planet formation

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Icy pebble accretion onto terrestrial planets: the effect of gas flow

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Earth, the only life-hosting planet we know, is characterized by the small water fraction in the bulk composition: the ocean mass being 0.023% of the Earth mass. Because the abundance of water control the physical and chemical evolution of planets by atmosphere-hydrosphere-lithosphere interactions and by changing the mantle properties, unveiling how water-depleted planets form is crucial for understanding the emergence of habitability on them. Pevious studies have pointed out that icy pebble accretion following the snow line migration in protoplanetary disks typically deliver an excess amount of water to terrestrial planets unless the initial size of the disk is small (30--50 au) or a giant planet in the outer orbit (e.g., Jupiter in our solar system) formed early (Morbidelli et al. 2016; Sato et all. 2016; Ida et al. 2019). In contrast to the previous studies where the accretion rate derived for pebbles moving in (sub-) Keplerian flow, we used the accretion rate derived for pebbles moving in the gas flow perturbed by the gravity of the planet (Kuwahara et al. 2019; Kuwahara et al. in prep.). The presence of horseshoe region and outflow shuts off the accretion of small pebbles. We show that, because migrating icy pebbles at ~1 au are small, the gas flow significantly suppress the accretion onto Earth-sized planets, whereas Mars-sized planets accretes a significant amount of icy pebbles. Our results suggest that Earth-like, water-depleted rocky planets may form in a disk-size range wider than previously considered and in the systems where no giant planet exists.

Keywords: Planet formation, Origin of water, Pebble accretion

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Delivery of ammonia ice to Ceres by pebble accretion

*Yuto Nara[1], Satoshi Okuzumi[1], Hiroyuki Kurokawa[2]

1. Tokyo Institute of Technology, 2. Earth-Life Science Institute, Tokyo Institute of Technology

Recent studies with the spectrometer onboard the Dawn spacecraft detected the presence of ammoniated phyllosilicates on the surface of Ceres. It is presumed that ammonia may have reacted with the phyllosilicates on Ceres during differentiation. Ammonia can not exist alone as a solid in the current temperature at the location of Ceres. It has yet to be shown how ammonia is delivered to Ceres.

In this study, by adopting a theory "Ceres formed a protoplanetary core around the current main asteroid belt and accreted ammonia-bearing ice pebbles there", we aim to give constraints on the free parameters of the protosolar nebula. We numerically calculate the growth and radial inward drift of icy dust particles, and the evolution of the surface density of the gas flow and the disk temperature in a viscous disk. We employ a formula of pebble accretion presented by a previous study to quantify the amount of ammonia-bearing ice pebbles delivered to asteroids at 2.8 au.

We find that when the free parameters of the protosolar nebula satisfy certain conditions, Ceres accretes ammonia-bearing ice pebbles with ~ 10 –100 km thickness on its surface by pebble accretion. This result can explain the observations that there is ~ 15km of relief with craters on the surface of Ceres, and the ammoniated phyllosilicates on its surface were formed globally. In our result, we support the disk model with strong turbulence. Moreover, we suggest if ammoniated phyllosilicates come from pebble accretion, the amount of ammoniated phyllosilicates on planets' surface strongly depends on accreting planet masses.

Keywords: pebble accretion, asteroid, protosolar nebula

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Volatile-driven cryovolcanic eruption on asteroid Ceres as a probe to its interior

*Koki Yumoto[1], Yuichiro Cho[1], Seiji Sugita[1]

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Introduction: Imageries from NASA's DAWN mission revealed the presence of localized bright spots (or faculae) exhibiting brighter materials with likely composition of anhydrous sodium carbonate (De Sanctis et al., 2016) within the dark Ceres surface. These materials are assumed to be remnants of cryovolcanic ejecta which ascended from brine reservoirs thorough impact induced fractures. Quick et al., (2018) showed that excess pressure caused by the gradual freezing chamber could be a driving source for its ascent. However, DAWN image revealed the presence of both explosive (e.g. Vinalia faculae) and effusive (i.e. Cerealia facula and Ahuna Mons) eruptions, implying the possibility that fragmentations of cryomagma are induced by exsolved volatiles and this could be a primal driving source.
Objectives: Volatile exsolution are known to play an important role in ascent dynamics of silicate volcanism, and it enables ascent of relatively high density cryomagmas, but their contributions to cryovolcanism are not well understood. This study attempts to obtain new constraints on the properties of a subsurface brine reservoir and conduit geometry based on phase equilibria and model calculations.
Model: The equilibrium composition of CO_2-H_2O-NaCl system by Akinfiev & Diamond (2010) was used as the cryomagma composition. The cryomagma is assumed to have a viscosity of 10^5-10^8 Pa s (Quick et al., 2018), and this slurry-like rheology constrains the temperature within the solidus and liquidus curves along decompression. If we assume ascents to be isothermal at velocity $>10^{-3}$ m/s (Quick et al., 2018) and salinity lower than the stability region of hydrohalites, then the temperature of cryomagma should be within ~260 - 270 K, consistent with impact simulation (Bowling et al., 2018), and salinity <~20 wt%. One-dimensional 2-phase (i.e. cryomagma and exsolved gaseous volatile) steady flow in a cryovolcanic conduit was modelled with the theory developed by Kozono & Koyaguchi (2009) for terrestrial volcanoes. Major modifications in our model were, adjustment of the henry's law, application of choking condition at the surface, and the liquid stability of CO_2. The depth, volatile content, viscosity of brine reservoir, and conduit radius were constrained from the estimated explosive eruption velocity of Vinalia faculae 26 - 54 m/s (Quick et al., 2018) derived from its emplaced radius.
Result and Discussion: Calculation results indicated that for a given viscosity (e.g, 10^5 Pa s), a series of combinations of conduit radius and volatile content, ranging from 10 m and 4 - 7 wt% to 50 m and 0.8 - 3 wt%, 200 m and 0.7 - 3 wt%, can achieve the above eruption velocity. Note that plausible conduit radii should lie within 1 - 100 m (Fagents 2003) and robust upper limit is given by observed radii of vent-like feature ~200 m. We found that reservoir depths have little influence on eruption velocities. For a given viscosity (10^6 Pa s), similar combinations of conduit radius and volatile content ranging from 50 m and 2 - 3 wt% to 200 m and 0.7 - 3 wt% can achieve the eruption velocity. Although higher viscosity $>10^7$ Pa s can achieve similar eruption velocity when a larger conduit radius >100 m is assumed, such large conduits are not consistent with estimations (Quick & Marsh, 2016). Results for explosive eruptions experienced fragmentation at >100 m depth and showed that volatiles could drive the ascent and cause fragmentation of cryomagmas. If effusive eruptions occurred from the same reservoir, conduit radii should be <1 m. However, the probable abundance of such conduits is inconsistent with the lack of effusive eruptions on Ceres and thus could have formed differently, such as diapiric ascents (Buczkowski et al., 2018). Our model calculations showed that cryomagmas could be volatile-driven and may cause fragmentations to erupt explosively. Also, constraints from our calculation showed that Ceres subsurface could be volatile-rich than previously assumed.

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Keywords: Ceres, cryovolcano, DAWN, facula, eruption

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Ice sheet formation on synchrnously rotating earth-like planets in M-dwarf abitable zones

Soma Arai[1], Kiyoshi Kuramoto[1], *Masaki Ishiwatari[1], Shunichi Kamata[1]

1. Department of Cosmosciences, Graduate school of Science, Hokkaido University

It is considered that terrestrial planets near M-dwarf are synchronously rotating (Von Bloh et al, 2007). Some of such planets exist in the habitable zone defined by vertical one-dimensional atmospheric models and are expected to have liquid water on their surface. However, in synchronously rotating planets, there is a possibility that all of liquid water are lost since water vapor transported form warm day-side to cold night-side is condensed on night-side surface as ice. In order to examine this problem, Menou (2013) conducted atmospheric general circulation model (AGCM) experiments using a synchronously rotating planet configuration with surface water of 50m depth. He estimated ice sheet thickness formed on the planet surface based on the calculated amounts of precipitation and surface evaporation. The result is that the amount of ice sheet on night-side can reach the all amount of surface water given to the planet. In his estimation, GCM results obtained without topography were utilized. Since surface height will change according to the growth of ice sheet, atmospheric circulation are influenced by topography of ice sheet and distributions of precipitation and surface evaporation are also changed. Therefore, the ice sheet thickness can be different from the values estimated by Menou (2013). In this study, in order to consider the effect of the topography produced by ice sheet formation in the night-side, we perform GCM experiment with changing surface height distribution.

The model utilized is DCPAM5(https://www.gfd-dennou.org/library/dcpam/). Atmospheric constituents and parameters such as planet radius are same as those of Earth. We perform two kinds of experiments: one is aqua-planet experiment in which all surface are covered with water or ice, the another is land-planet experiment in which initial water of 20cm depth is given to day-side surface and water transport on the surface is neglected. In land-planet experiment, surface liquid water distribution is determined by atmospheric transport. The value of surface albedo is fixed to 0.15. First, integration for 1500 days with no topography is performed, then thickness of ice sheet is prognosed with considering melting of ice at the bottom of ice sheet and condensation of ice on the surface calculated from distributions of precipitation and surface evaporation. Then, using the horizontal distribution of surface height estimated by the above method, integration for 1500 days is performed and ice sheet height is prognosed again. With repeating these procedures, we search for equilibrium states in which ice sheet thickness becomes constant in time. The results of land planet experiment show that an equilibrium state with ice sheet over 4000m height can be obtained. Contrary to this, in aqua-planet experiment, equilibrium state are not been obtained in our experiment. Ice sheets with height over 10000m are formed in the night-side, although the value of ice sheet height is transient. The result of the experiment with topography determined by the above estimated ice sheet height show that day-side surface temperature become lower than 273K, and therefore, globally ice-covered state can emerge. As for the reason, we consider that day-side surface is cooled by cold air blowing from night-side with high elevation to day-side with low elevation. Since albedo change due to the ice sheet formation is neglected in our experiments, our result suggests that the atmospheric circulation influenced by ice sheet topography can produce globally ice-covered state.

Keywords: synchronously rotating planets, atmospheric general circulation model, ice sheet, globally ice-covered state, existence of liquid water

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[J] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

Mon. May 27, 2019 1:45 PM - 3:15 PM JST | Mon. May 27, 2019 4:45 AM - 6:15 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-PS06] Planetary Sciences

convener:Kenji Kurosaki(Department of Physics, Nagoya University), Yusuke Nakauchi(Japan Aerospace Exploration Agency), Chairperson:荻原 正博(国立天文台), Yuri Fujii(Nagoya University)

We call for general interest papers for Planetary Scienses. Planetary Sciences consist of a variety of studies on the past, present, and future of our solar system and exoplanetary systems, Discussions based on various backgrounds are encouraged.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[PPS06-13] Three-dimensional linear calculation for non-isothermal type 1 planetary migration

*Kohei Okada[1], Hidekazu Tanaka[1] (1.Tohoku University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[PPS06-14] Dependence of Central star mass on Protoplanetary disk evolution

*Ryuunosuke Nakano[1], Takeru Suzuki[1], Masahiro Ogihara[2], Eiichiro Kokubo[2] (1.University of Tokyo, 2.National Astronomical Observatory of Japan)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[PPS06-15] Radiation Hydrodynamic Simulations of the Formation of Circumplanetary Disks

*Yuri Fujii[1], Oliver Gressel[2], Kengo Tomida[3], Udo Zieglar[2] (1.Institute for Advanced Research, Nagoya University, 2.Leibniz Institute for Astrophysics Potsdam, 3.Osaka University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[PPS06-16] Inefficient Magnetic Accretion Heating in Protoplanetary Disks: Evolution of The Snow Line

*Shoji Mori[1], Xuening Bai[2], Satoshi Okuzumi[3] (1.Department of Astronomy, The University of Tokyo, 2.Tsinghua Center for Astrophysics, Tsinghua University, 3.Department of Earth and Planetary Sciences, Tokyo Institute of Technology)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[PPS06-17] Formation of super-Earths and their atmospheres with *N*-body simulations

*Masahiro Ogihara[1], Yasunori Hori[2,1] (1.National Astronomical Observatory of Japan, 2.Astrobiology Center)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[PPS06-18] The orbital stability of planets in resonances: the evolution of mass ratio

*Yuji Matsumoto[1], Masahiro Ogihara[2] (1.Academia Sinica Institute of Astronomy and Astrophysics, 2.National Astronomical Observatory of Japan)

Three-dimensional linear calculation for non-isothermal type 1 planetary migration

*Kohei Okada[1], Hidekazu Tanaka[1]

1. Tohoku University

Planet migration is one of the serious problems in the standard theory of planet formation. A planet excites density waves, that causes a rapid inward migration in a protoplanetary disk. In this study, we formulate the linear wave excitation by a planet in three-dimensional non-isothermal gaseous disks and calculate the torque on the planet more correctly than previous studies.
The torque on a planet has been studied by linear and non-linear calculations. In previous three-dimensional linear calculations the torque was calculated only for isothermal disks. This is because the three-dimensional linear equation has the term that is strongly divergent at corotation in non-isothermal disks. This problem has not been resolved yet and we cannot test non-linear three-dimensional calculations with linear calculations.
In linear studies of gravitational interaction between a planet and a three-dimensional gaseous disk, there are two-dimensional waves that do not have the z-component of velocity and three-dimensional waves that have non-zero v_z. Only three-dimensional waves have a divergent term but it is known that the absolute values of the torque in three-dimensional waves are much small than those of two-dimensional waves in the isothermal disk. In this study, therefore, we ignored three-dimensional waves and examined the torque on a planet in three-dimensional non-isothermal disk approximately. Actually since there is no sign of divergent in previous non-linear hydro-dynamical simulations, this approximation seems good.
With this approximation, we carry out the three-dimensional non-isothermal linear calculation. The obtained torque coincides with non-linear three-dimensional hydro-dynamical simulations. Because of this, we confirmed that our three-dimensional linear calculation is accurate.

Keywords: Protoplanetary disks, Planetary migration, Linear theory

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Dependence of Central star mass on Protoplanetary disk evolution

*Ryuunosuke Nakano[1], Takeru Suzuki[1], Masahiro Ogihara[2], Eiichiro Kokubo[2]

1. University of Tokyo, 2. National Astronomical Observatory of Japan

More than 4000 outer planets have been discovered in recent years. The discovery of rocky planets such as the Earth is increasing with this. On the other hand, how such a planetary system was born and evolved has a big uncertainty factor. Understanding the evolution of protoplanetary disks are fundamentally important in considering the formation and evolution of planets. The disk is made of dust and gas and plays a central role in the formation and evolution of rocks and planets, but in order to clarify the dynamics and growth of dust, it is necessary to understand the physical state of the background gas component. It is still unknown how the dissipation of the disk is done by photoevaporation from the central star and by the wind of the magnetically driven disk wind but how they contribute over time and also depend on the difference in mass of the central star.

In this study, a one-dimensional radial simulation of gas components of protoplanetary disks was done in consideration of photoevaporation by X-ray (Owen et al. 2010) and magnetically driven disk wind (Suzuki & Inutsuka et al., 2009). We investigated how the evolution of the disk changes by the difference of the central star mass.

We performed the evolution of protoplanetary disks with different masses of the central stars. If we define the evaporation time at 1au as the time when the surface density there falls below the observable level, it is shorter for a more massive central star, because the photoevaporation is more efficient.

In contrast, the evaporation time at the snowline shows the opposite trend; the evaporation is more rapid for disks with less massive central stars. This is because the location of the snowline has a very sensitive dependence on the mass of a central star.

Keywords: Protoplanetary disk, Low mass stars

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Radiation Hydrodynamic Simulations of the Formation of Circumplanetary Disks

*Yuri Fujii[1], Oliver Gressel[2], Kengo Tomida[3], Udo Zieglar[2]

1. Institute for Advanced Research, Nagoya University, 2. Leibniz Institute for Astrophysics Potsdam, 3. Osaka University

Formation of regular moons and/or planetary atmospheres are governed by the gas flow into the vicinity of forming giant planets. Gas around a sufficiently massive planet is thought to form a circumplanetary disk instead of falling directly onto the planet. Recent studies, however, have shown that the circumplanetary gas forms an expanded envelope rather than a thin, rotationally supported Keplerian disk in cases where the gas temperature is very high. Thus, calculating the temperature of the accretion flow properly is important to determine the disk structure. We performed three-dimensional radiation hydrodynamic simulations of the formation of circumplanetary disks with an equation of states that considers effects such as hydrogen dissociation and helium and hydrogen ionization. The region within the deep potential of the planet reached very high temperature regime, however, we observe a disk to form in our simulations.

Keywords: circumplanetary disks, radiation hydrodynamic simulations, satellite formation

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Inefficient Magnetic Accretion Heating in Protoplanetary Disks: Evolution of The Snow Line

*Shoji Mori[1], Xuening Bai[2], Satoshi Okuzumi[3]

1. Department of Astronomy, The University of Tokyo, 2. Tsinghua Center for Astrophysics, Tsinghua University, 3. Department of Earth and Planetary Sciences, Tokyo Institute of Technology

The structures of the inner region of protoplanetary disks are essential for understanding the formation process of terrestrial planets. The gas temperature in the region is thought to be determined by accretion heating, which is conventionally attributed to turbulent dissipation. Because the turbulent dissipation occurs in the disk, the released heat accumulates in the disk and thereby effectively increases the disk temperature. However, recent studies have suggested that the inner disk (a few AU) is largely laminar, with accretion primarily driven by magnetized disk winds, as a result of nonideal magnetohydrodynamic (MHD) effects from weakly ionized gas, suggesting an alternative heating mechanism by Joule dissipation.

Purpose of this study is to investigate the accretion heating with the nonideal MHD effects and to understand thermal structure in the inner disk region. We perform local stratified MHD simulations including nonideal MHD effects and investigate the role of Joule heating and the resulting disk vertical temperature profiles. We find that Joule heating occurs at several scale heights above the midplane, making the midplane temperature much lower than that with the conventional viscous heating model. Also, 80 % of the accretion energy is flown out by the disk wind. Our results further suggest that the midplane temperature in the inner region is almost entirely determined by irradiation heating. We also discuss the evolution of the water snow line based on our results and the formation process of the earth.

Keywords: Protoplanetary disks, Magnetohydrodynamic simulation, Snow line

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Formation of super-Earths and their atmospheres with *N*-body simulations

*Masahiro Ogihara[1], Yasunori Hori[2,1]

1. National Astronomical Observatory of Japan, 2. Astrobiology Center

A large number of super-Earths have been discovered by various exoplanet search programs that include the Kepler mission, which provide the perfect opportunity for a development of planet formation theory. In fact, recent *N*-body simulations have made major progress in understanding the origin of close-in super-Earths (e.g., Izidoro et al. 2017; Ogihara et al. 2018). In these previous studies, they focus on orbital properties (e.g., period-ratio distribution) and aim to reproduce them.

In this study, we also pay attention to the amount of atmospheres and make further progress in formation models of super-Earths. According to the mass-radius relation of transiting super-Earths, it is unlikely that they generally possess massive atmospheres. This is consistent with the fact that the occurrence rate of hot Jupiters is considerably smaller than that of close-in super-Earths. The amount of atmospheres would provide useful constraints on the development of formation models of super-Earths. The gas accretion onto super-Earth cores depends on several factors (e.g., formation history, disk evolution); therefore it is crucial to follow the planetary growth, the orbital evolution, and the atmospheric accretion self-consistently.

We perform *N*-body simulations of super-Earth formation in an evolving disk considering the accretion of atmospheres. In our simulations, we also consider the pebble accretion, which is a physical process in which protoplanets grow rapidly through accumulation of small particles under gas drag. The pebble accretion would help to accelerate the core formation of gas giants in the outer region. Moreover, the pebble accretion may play an important role in the accretion of close-in super-Earths.

In this presentation, we are going to discuss several important questions about the origin of super-Earths. For example, we aim to reveal realistic formation processes by results of *N*-body simulations that include the atmospheric accretion, the pebble accretion, and the disk evolution. Then we discuss properties of formed super-Earths and compare with observed super-Earth systems. We also determine whether the pebble accretion can prevent the accumulation of massive atmospheres.

Keywords: Super-Earths, N-body simulation, Planet formation, Pebble accretion

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The orbital stability of planets in resonances: the evolution of mass ratio

*Yuji Matsumoto[1], Masahiro Ogihara[2]

1. Academia Sinica Institute of Astronomy and Astrophysics, 2. National Astronomical Observatory of Japan

Many systems composed of Earth or super-Earth sized planets are observed to date (e.g., Gillon et al., 2017). In some systems, three or four adjacent planets are in a series of mean motion resonances, called resonant chains (Mills et al., 2016; Luger et al., 2017). The resonant chain can be reproduced when the planets migrate inward (e.g., Ogihara & Ida 2009; Izidoro et al., 2017; Bitsch et al., 2019). After gas depletion, planets in resonant chain become orbitally unstable when their number exceeds the critical number that the planets are stable in resonance (Matsumoto et al., 2012). Izidoro et al. (2017) showed over half systems hold more than five planets in their simulations that planets are stable in resonant chain after gas depletion. The disagreement of the number of planets in resonant chain between observations and simulations can be explained by some mechanism reduces the orbital stability of planets in resonances.

The mass ratios between planets in close-in orbits and their central stars would not keep the same value after their formation. There are some mechanisms that super-Earths lose their envelopes, e.g., energy limited escape (Owen 2018). Also, young stars lose their mass by the stellar wind and coronal mass ejection (Cranmer 2017).

We perform simulations that the planets trapped in the first order resonant chain considering their mass ratio change. At first, planets migrate in the disk gas and are trapped in the resonant chain composed of the same resonant commensurability. Then, the disk gas is removed and the mass ratio between planets and the central star is changed, exponentially. When the number of planets in resonant chain exceeds the critical number corresponding resonant chain, their crossing time increases as the mass ratio decreases since the separation normalized by Hill radii becomes larger. In the cases that the resonant systems hold less planets than the critical number, planets sometimes cause orbital instability when their mass ratios change. In some conditions, the orbits of planets in resonant chain become unstable, when their mass ratios decrease only a few percent. Such instabilities tend to occur in systems that hold more planets.

Keywords: orbital stability, mean motion resonance

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[J] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

Mon. May 27, 2019 3:30 PM - 5:00 PM JST | Mon. May 27, 2019 6:30 AM - 8:00 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-PS06] Planetary Sciences

convener:Kenji Kurosaki(Department of Physics, Nagoya University), Yusuke Nakauchi(Japan Aerospace Exploration Agency), Chairperson:Kenji Kurosaki(名古屋大学大学院 理学研究科), Yusuke Nakauchi(JAXA/ISAS)

We call for general interest papers for Planetary Scienses. Planetary Sciences consist of a variety of studies on the past, present, and future of our solar system and exoplanetary systems, Discussions based on various backgrounds are encouraged.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[PPS06-19] Experimental study on the structure of shock remnant magnetization

*Shota Kato[1], Masahiko Sato[1], Kosuke Kurosawa[2], Masashi Ushioda[3], Sunao Hasegawa[4] (1.The University of Tokyo, 2.Planetary Exploration Research Center, Chiba Institute of Technology, 3.Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology, 4.Japan Aerospace Exploration Agency)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[PPS06-20] Low-dispersion spectra of lunar impact flashes in 2018 Geminids

*Masahisa Yanagisawa[1], Yuki Uchida[1], Seiya Kurihara[1], Shinsuke Abe[2], Ryota Fuse[2], Keisuke Onodera[3,4], Ryuhei Yamada[5] (1.The University of Electro-Communications, 2.Nihon University, 3.SOKENDAI (The Graduate University for Advanced Studies), 4.Institute of Space and Astronautical Science/Japan Aerospace Exploration Agency, 5.The University of Aizu)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[PPS06-21] High velocity cratering experiments on sand-gypsum targets simulating asteroids

*Ryo Sugimura[1], Masahiko Arakawa[1], Minami Yasui[1], Takuya Ishiguro[1] (1.Kobe University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[PPS06-22] Experimental study on collisional processes of highly porous ice balls simulating Saturn's ring particles

*Yukari Toyoda[1], Minami Yasui[1], Masahiko Arakawa[1] (1.Graduate School of Science, Kobe University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[PPS06-23] IN-SITU FORMATION OF THE URANIAN SATELLITES FROM WIDE DEBRIS DISK FORMED BY GIANT IMPACT

*Ishizawa Yuya[1], Takanori Sasaki[1], Natsuki Hosono[2] (1.Department of Astronomy, Kyoto University, 2.JAMSTEC)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[PPS06-24] Effect on the obliquity due to a giant impact on a rotating ice giant

*Kenji Kurosaki[1], Shu-ichiro Inutsuka[1] (1.Department of Physics, Nagoya University)

Experimental study on the structure of shock remnant magnetization

*Shota Kato[1], Masahiko Sato[1], Kosuke Kurosawa[2], Masashi Ushioda[3], Sunao Hasegawa[4]

1. The University of Tokyo, 2. Planetary Exploration Research Center, Chiba Institute of Technology, 3. Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology, 4. Japan Aerospace Exploration Agency

The history of planetary magnetism is a key to understanding the evolution of planets. We focus on shock remnant magnetization (SRM) as a record of the magnetic field of planets: the magnetic anomaly field from SRM of a planetary crust can be measured by spacecraft magnetometers. It is essential to understand the structure of SRM for estimating planetary paleofield from magnetic field data because the observed magnetic anomaly field above craters is determined by the sum of the contribution of the materials beneath the crater with the SRM. In this study, the structure of SRM is experimentally investigated by using a two-stage light gas gun placed at the Institute of Space and Astronautical Science(ISAS) of Japan Aerospace and Exploration Agency(JAXA). We measured the SRM of 3 mm cube samples cut from basalt cylinders shocked in the weak magnetic field. The characteristic features of SRM structure are as follows: (1) The intensity of SRM tends to increase with increasing the distance in less than ~10 mm from the collision point. (2) The intensity of SRM tends to decrease with increasing the distance in more than ~10 mm from the collision point. Then the intensity of SRM of blocks are compared with the pressure and temperature from iSALE (Impact-SALE) calculation. In this talk, we will discuss the structure of SRM and the relationship between the SRM structure and the calculated change in pressure and temperature.

Acknowledgement: We appreciate the developers of iSALE, including G. Collins, K. Wünnemann, B. Ivanov, J. Melosh, and D. Elbeshausen.

Keywords: shock remnant magnetization, planetary paleofield, magnetic anomaly

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Low-dispersion spectra of lunar impact flashes in 2018 Geminids

*Masahisa Yanagisawa[1], Yuki Uchida[1], Seiya Kurihara[1], Shinsuke Abe[2], Ryota Fuse[2], Keisuke Onodera[3,4], Ryuhei Yamada[5]

1. The University of Electro-Communications, 2. Nihon University, 3. SOKENDAI (The Graduate University for Advanced Studies), 4. Institute of Space and Astronautical Science/Japan Aerospace Exploration Agency, 5. The University of Aizu

In the collisions in the solar system, there are many cases where the collisions occur at speeds exceeding 10 km/s, which are difficult to reproduce in laboratory experiments. In such a collision, melting, evaporation, and ionization of silicate, iron, etc. which do not occur at a speed lower than this occur. Understanding of high-speed collisions accompanying such processes is an important issue for planetary sciences. However, it is not clear yet what kind of phenomenon actually occurs. We can approach this problem from the observation of lunar impact flashes.

Several research results have been reported on the occurrence frequency and brightness of lunar impact flashes and their time variations. However, there are few reports on their spectra. As part of the SAKURA Japan-France joint observation project, that is, the joint observation of meteoroids' impacts as lunar seismic sources, we observed the flashes due to the collisions of December Geminids' meteoroids by simple spectral cameras for visible wavelength (Fig. 1) [1]. At the University of Electro-Communications (Chofu-shi, Tokyo), observations were made with two spectral cameras attached to a Newtonian telescope with an aperture of 450 mm and a focal length of 2015 mm and a Schmidt–Cassegrain telescope with an aperture of 280 mm and an effective focal length of 920 mm. At Nihon University (Funabashi-shi, Chiba Prefecture), observations were carried out mainly with an ordinary movie camera attached to a telescope with a 400 mm aperture.

Thirteen flashes were detected by the observations at the University of Electro-Communications on 15th December, 2018 (JST) and nine of them were detected simultaneously at Nihon University. For those that were not detected at the same time, it is conceivable that there are differences in the sensitivity of the observation devices and temporary interruptions of observation, but the examination in detail is a future task. We named these 13 events from A to M. Their locations on the lunar surface are shown in Fig. 2 [2]. Their spectra were obtained by comparing their spectral images with those of comparison stars which were observed every 30 minutes [2, 3]. An example is shown in Fig. 3. Most of the flash spectra can be approximated well by the blackbody radiation spectrum of about 3000 K, but some are not. For the former, they would be due to the blackbody radiations from micro-droplets of melted rocks generated at the impacts. On the other hand, there is a possibility that the latter may be reflection of sunlight by space debris.

References (in Japanese): [1] Kakinuma, F., A spectral camera for observing lunar impact flashes, Master thesis, the University of Electro-Communications, 2016, http://id.nii.ac.jp/1438/00008427/. [2] Uchida, Y., Low-dispersion spectra of lunar impact flashes I, Master thesis, the University of Electro-Communications, 2018. [3] Kurihara, S., Low-dispersion spectra of lunar impact flashes II, Master thesis, the University of Electro-Communications, 2018.

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Keywords: lunar impact flash, spectrum, impact

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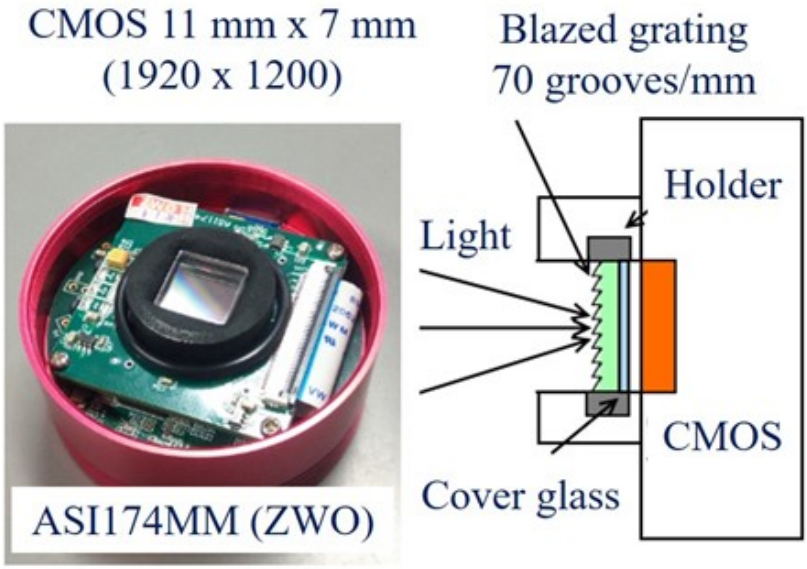


Figure 1. A simple spectral camera [1]. A grating is glued on the cover glass of a CMOS image sensor.

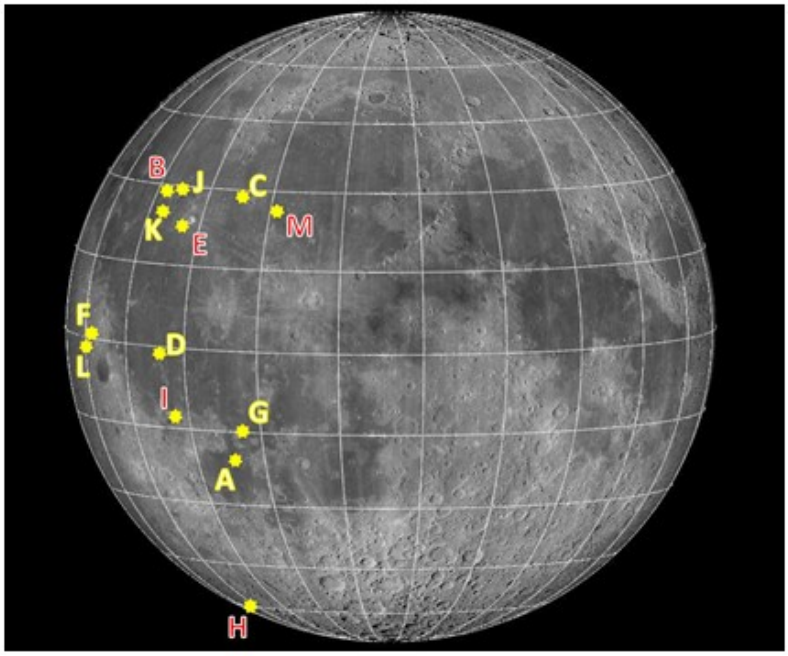


Figure 2. Locations of impact flashes (A-M) observed on December 15, 2018 [2].

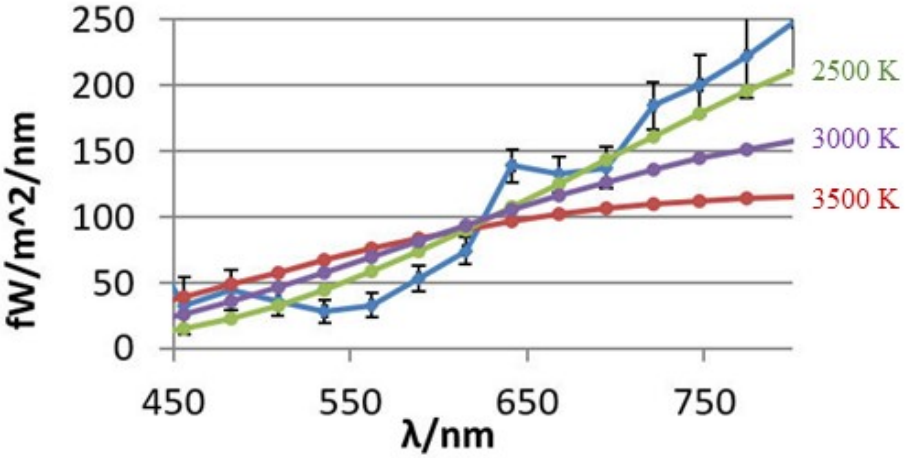


Figure 3. The spectrum of H impact flash. Black body spectra are shown with smooth lines [2].

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High velocity cratering experiments on sand-gypsum targets simulating asteroids

*Ryo Sugimura[1], Masahiko Arakawa[1], Minami Yasui[1], Takuya Ishiguro[1]

1. Kobe University

A lot of impact craters are found on asteroids. To clarify the impact cratering processes on asteroids, many researchers conducted impact cratering experiments using various materials such as sand, ice, and basalt. Housen and Holsapple (2011) proposed crater scaling laws and it enable us to extrapolate experimental results to asteroid impact results on the surface. They referred rocky materials having the compressive strength larger than several MPa to constructed the crater scaling laws, but it is unclear whether these scaling laws can be applied to porous materials having low strength or not. Therefore, we conducted impact cratering experiments in order to study the cratering processes on porous rocky asteroids with low strength and the effects of the strength on the crater size and the ejecta velocity. Then, we propose the crater scaling laws applicable to low strength porous materials.

A low strength target was made by mixing quart sands with the diameter of 100 μm with porous gypsum. The mixing ratio of sand to gypsum was changed from 2:1 to 30:1 in the wt.%, and the measured tensile strength was found to change with this mixing ratio. Impact experiments were conducted by using a two-stage light gas gun, and an Al spherical projectile with the size of 2mm was launched at the velocity of 2, 4 and 6km/s. The impact-cratering process was observed by using a high-speed video camera at the framing speed of 10^5fps. Furthermore, we set a 1cm-slit on the target surface to observe 2-dimensional ejecta flow: the slit can exclude most of the ejecta covering through the line of sight of the high-speed camera. This 2-dimensional ejecta observation gave us an accurate relationship between the initial position and the velocity of ejecta fragments.

The tensile strength of the porous mixed sample was measured by a Brazilian test and we found that the tensile strength was changed in the three orders of magnitude from 1MPa to 1kPa with the increase of the sand volume content from 30 to 50%.

The morphology of the recovered crater was characterized by two regions: they are a spall region and a pit region. The spall region looks rough circle but actually it has a polygonal shape with a shallow depth, and it is formed by tensile wave reflected from the surface. The pit region exists at the center of the crater and it has a semi-spherical shape with the diameter rather smaller than the spall region. This spherical region could be formed by the compressive wave and the shear failure was expected in this region. The spall diameter was found to increase with the decrease of the target tensile strength, however the crater depth, which is defined as the depth from the initial surface to the pit floor, showed constant, irrespective of the tensile strength. Moreover, it is very difficult to recognize features characterizing a pit and a spall region in the crater interior for the low strength target as low as 1kPa.

We constructed a crater size scaling law on the strength regime by using our results and compared it to the previous studies obtained for a high strength material. Then, the obtained scaling law for a weak target was written by , where $\pi_R$is the scaled crater radius and $\pi_Y$is the scaled strength in the conventional scaling laws. We found that our $\pi_R$was smaller than the $\pi_R$of frozen sand but larger than the $\pi_R$of porous gypsum. We also constructed the crater scaling law for the crater depth, and it was written by , where π_d is the scaled crater depth, and then it is obvious that $\pi_d$was almost constant, irrespective of

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the tensile strength. The reason why our π_R is smaller than the result of frozen sand is considered to be due to the impact energy being consumed by collapsing tiny porous in the gypsum in the target.

Keywords: cratering experiment, strength, porosity, crater scaling law, ejecta velocity

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Experimental study on collisional processes of highly porous ice balls simulating Saturn’s ring particles

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Introduction: Saturn's rings consist of mm- to meter-sized particles of water ice, and they collide with each other at the relative speed slower than a few cm/s. After the collisions, the ring particles coagulate or rebound or fracture, and it could affect the evolution and the structure of Saturn's rings. Saturn’s rings were a very thin disk (the thickness thinner than 100-200 m) and this is because the particles collide with each other inelastically so the kinetic energy might dissipate effectively. Therefore, in order to clarify the formation processes and the evolution of Saturn’s rings, it is necessary to investigate the collisional properties of the ring particles. In particular, it is very important to examine the effects of material properties of the ring particles and the impact velocity on the coefficient of restitution (*e*).

It is estimated from ground observations and planetary explorations that the ring particles are speculated to be a non-porous ice, porous ice (snow), non-porous ice covered with frost etc. Previous studies have investigated the e of non-porous ice and that covered by the frost, but the e of porous ice (snow) has not been investigated yet in detail. In this study, we focused on the porosity of Saturn‘s ring particles and examined the dependence of the porosity on the relationship between the *e* and the impact velocity.

Experimental methods: We used ice balls with a smooth surface and snowballs with the porosity of 45, 50, 60% having the diameter of 3 cm to simulate the Saturn’s ring particles. We conducted free fall experiments of the balls on an ice plate with a smooth surface and a granite plate. The impact velocity changed from 0.8 to 280 cm/s. We measured the e by two methods. One is an acoustic emission (AE) method. The AE sensor was attached on the plate and it could detect the elastic wave by each collision of the ball. So the impact and the rebound velocities of the ball could be calculated by measuring the time interval between the collisions. Another is a laser displacement meter method. A laser displacement meter was used to measure the position of the free falling ball with time. The e was calculated from the time interval between the collisions of the ball, as same as AE method.

Experimental Results: In the case of ice ball- ice plate collision, the e was almost constant (~0.9) at low impact velocity (quasi-elastic region), while as the impact velocity exceeded a critical velocity, the e decreased drastically (inelastic region). This critical velocity, v_c, was obtained to be 24.5 cm/s. In the inelastic region, the relationship between the e and the impact velocity could be fitted by using the empirical equation, $e=e_{qe}(v_i/v_c)^{-\log(v_i/v_c)}$, where v_i is the impact velocity and e_{qe} is the average value of the e in the quasi-elastic region. In the case of ice ball-granite plate collision, the relationship between the e and the impact velocity was similar to that of ice ball-ice plate collision, but the v_c was obtained to be 11.2 cm/s, which is almost a half of the ice ball-ice plate collision result.

The e of the snowball continued to decrease as the impact velocity increased and the critical velocity, v_c, could not be appeared for both collisions on the granite plate and the ice plate. Furthermore, the e of the

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snowball decreased as the porosity increased monotonically, but they merged with each other at the impact velocity lower than 10 cm/s. This is because the kinetic energy of the snowball was consumed by crushing the pores near the impact point on the snowball surface at higher impact velocities. We found that the relationship between the impact velocity and the e could be shown by $e=a\cdot v_i^{-b}$ where a and b are constant. The a was obtained as 0.9 - 0.97, irrespective of the porosity, while the b increased with the increase of the porosity.

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IN-SITU FORMATION OF THE URANIAN SATELLITES FROM WIDE DEBRIS DISK FORMED BY GIANT IMPACT

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1. Department of Astronomy, Kyoto University, 2. JAMSTEC

We adopted the so-called giant impact scenario to explain both the large axial tilt of Uranus and the formation of the Uranian regular satellites simultaneously. Hydrodynamic simulations for a giant impact onto proto-Uranus have been carried out, which showed that the giant impact can explain the large axial tilt of Uranus and also suggested that ejected materials produced by the giant impact could be distributed throughout the current orbits of the Uranian regular satellites.
In this study, we modeled wide debris disks of solids with several conditions, and performed N-body simulations to investigate the in-situ satellite formation from the wide debris disks to constrain the parameters of debris disks for the in-situ satellite formation. We found that the five major satellites formed around the current orbits from wide debris disks with several times the total satellite mass. Although one or two large satellites usually form inside the current orbits of the major satellites, such satellites would migrate inward due to the tidal torque from the planet and finally be disrupted by the planetary tides or fall onto the planet over several hundred million years. We also propose that the Uranian rings could form from the disrupted satellites and the inner regular satellites could form by use of the ring materials.

Keywords: Satellite formation, Uranus, Giant impact

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Effect on the obliquity due to a giant impact on a rotating ice giant

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Solar system planets have intrinsic rotation period and obliquity. Especially, Uranus's obliquity is 98 degrees, which is larger than Jupiter, Saturn, and Neptune. Obliquity of Uranus is to the giant impact event. However, previous studies ignored the pre-impact rotation of Uranus. To understand the tilted rotation axis via a giant impact, we calculate the giant impact on a rotating target. We use Godunov Smoothed Particle Hydrodynamics simulation. We include that a giant impact can reproduce the present obliquity of Uranus if the impactor collides on anti-rotating direction.

Keywords: Ice giant, Giant impact, Uranus

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[J] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

Mon. May 27, 2019 9:00 AM - 10:30 AM JST | Mon. May 27, 2019 12:00 AM - 1:30 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[P-PS07] Formation and evolution of planetary materials in the Solar System

convener:Yoko Kebukawa(Faculty of Engineering, Yokohama National University), Wataru Fujiya(Ibaraki University, College of Science), Shin Ozawa(Department of Earth Science, Graduate School of Science, Tohoku University), Megumi Matsumoto(Graduate School of Science, Tohoku University), Chairperson:Wataru Fujiya, Shin Ozawa

This session will focus on the evolution in the Solar System with interaction and co-evolution in minerals, water, organic matter, and noble gas in meteorites and interplanetary dust particles. New innovative analytical and theoretical techniques in various fields will be discussed. The developing methods are welcome to submit for the future mainstream of meteorite study. In order to explore the planetary materials and their evolution, both meteorite studies and experimental approaches are necessary. In this session, we will discuss these topics from extraterrestrial sample analyses and experimental works. Research works on undifferentiated and differentiated meteorites and parent body processes such as aqueous alteration, thermal metamorphism, shock metamorphism, volcanic activity, and core-mantle-crust differentiation are especially included in this session.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[PPS07-07] **Evaluation of shock metamorphism of eucrites by X-ray diffraction analysis**

*Rei Kanemaru[1], Naoya Imae[2,1], Akira Yamaguchi[2,1], Hirotugu Nishido[3] (1.The Graduate University for Advanced Studyies, 2.National Institute of Polar Research, 3.Okayama University of scienece)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[PPS07-08] Hf-W dating of main-group pallasites

*Yoshitaka Homma[1], Tsuyoshi Iizuka[1], Akira Ishikawa[2] (1.Department of Earth and Planetary Science, The University of Tokyo, 2.Department of Earth and Planetary Sciences, Tokyo Institute of Technology)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[PPS07-09] Mineralogical study of TCIs in CM carbonaceous chondrites

*Akane Iemoto[1], Yusuke Seto[1], Akira Miyake[2] (1.Graduate School of Science, Kobe University, 2.Graduate School of Science, Kyoto University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[PPS07-10] Importance of 10Be as a key indicator of (solar) cosmic ray irradiation in the early solar system

*Hajime Hiyagon[1], Yuuki Tanimura[1], Tomoya Nakamura[1], Kohei Fukuda[3], Wataru Fujiya[4], Naoji Sugiura[1], Takanori Kagoshima[2], Naoto Takahata[2], Yuji Sano[2] (1.Graduate School of Science, The University of Tokyo, 2.Atmosphere and Ocean Research Institute, the University of Tokyo, 3.Department of Geoscience, University of Wisconsin-Madison, 4.College of Science, Ibaraki University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[PPS07-11] **3D microstructure of a cosmic symplectite in primitive carbonaceous chondrite Acfer 094**

*Megumi Matsumoto[1,2], Akira Tsuchiyama[1], Junya Matsuno[1], Aiko Nakato[1,3], Akira Miyake[1], Motoo Ito[4], Naotaka Tomioka[4], Yu Kodama[5], Kentaro Uesugi[6], Akihisa Takeuchi[6], Tsukasa Nakano[7], Epifanio Vaccaro[8] (1.Graduate School of Science, Kyoto Univ., 2.Graduate School of Science, Tohoku Univ., 3.JAXA, ISAS, 4.JAMSTEC, 5.Marine Work Japan LTD., 6.JASRI, 7.AIST, Geological Survey Japan, 8.Natural History Museum, London)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[PPS07-12] Chondrule-like objects and refractory inclusions in GEMS-bearing Antarctic micrometeorites and an interplanetary dust particle.

*Takaaki Noguchi[1], Noriaki Ohashi[2], John P. Bradley[3], Daisuke Nakashima[4], Tomoki Nakamura[4], Makoto Kimura[5], Takayuki Ushikubo[6], Noriko T. Kita[7], Naoya Imae[5] (1.Department of Arts and Science, Kyushu University, 2.NEC Networks and System Integration Co., 3.Univ. of Hawaii at Manoa, 4.Tohoku Univ., 5.National Institute of Polar Research, 6.Kochi Institute for Core Sample Research, JAMSTEC, 7.Univ. of Wisconsin-Madison)

Evaluation of shock metamorphism of eucrites by X-ray diffraction analysis

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1. The Graduate University for Advanced Studyies, 2. National Institute of Polar Research, 3. Okayama University of scienece

Introduction

Eucrites have been considered to come from the surface crust of asteroid 4 Vesta. Eucrites experienced varying degrees of shock and thermal metamorphism. The scaling of the degree of shock metamorphism necessary for the understanding of the formation history of Vesta. However, the degree of shock metamorphism has not been established. Recent studies of X-ray diffraction (XRD) analyses using the in-plane rotation of polished thin sections (PTSs) for ordinary chondrites [2] showed that the XRD technique has a potential for the classification and identification of shock and metamorphic stages. In this study, we applied this technique for the thin or thick sections of 13 basaltic and 3 cumulate eucrites. We show that the bulk XRD data may be a useful indicator for characterizing the shock degree for eucrites.

Measurement and analytical methods

We performed X-ray measurement by SmartLab (RIGAKU) at National Institute of Polar Research, Tokyo, on the condition of Cu Kα with 40 kV and 40 mA through the slit of 10 x 5 mm in size.

We defined the shock degrees of studied eucrites from A to D by the petrographic and mineralogical features of thin and thick sections: shock degree A (unshocked) = sharp optical extinction of plagioclase and pyroxenes, shock degree B (low) = weak undulatory extinction or mosaicism of plagioclase and pyroxene, shock degree C (moderate) = the presence of maskelynite, and shock degree D (high) = most (>70-80 vol%) of the plagioclase converted to maskelynite. The degrees of A, B, and C, D for eucrites roughly correspond to 0, 1 and 2 of shock stage for basaltic meteorites defined by Bischoff and Stöffler. (1992) [3], and S1, S2-4, and S5 for enstatite chondrites by defined Rubin et al. (1997) [4], respectively.

Results

We obtained the XRD patterns of 12 eucrites exhibiting the high degree of randomness (e.g., Agoult), whereas four eucrites show the feature of the crystal orientation (e.g., Moama). We identified the peaks of plagioclase, pigeonite, and augite from the XRD patterns of eucrites. The bulk XRD data of each eucrite shows the positive correlation between the full width at half maximum (FWHM) values (for both mean and total) and the shock degree estimated from the textures. On the other hand, the number of the peak in the XRD pattern shows a negative correlation for the increasing of shock degree.

The specific peaks of plagioclase (especially -202) show the decreasing peak intensity and the increasing FWHM values for the increasing shock degree. The peak of pyroxene (pigeonite 310 and augite -311) (2theta = ~30.7º) also shows the increasing FWHM value of pyroxenes for the increasing shock degree.

Discussion

The increase of the averaged FWHM values for each eucrite are related to the shock metamorphism of pyroxene and plagioclase. The negative correlation between the peak intensities of plagioclase and shock degree implies the maskelynitization of plagioclase by shock metamorphism. In particular, most of the plagioclase peaks in A-87272, the strongest shocked sample (D) studied here, have disappeared. The pyroxene peaks show a positive correlation between the FWHM value and shock degree, whereas there is no correlation between the peak intensity and shock degree. This indicates that the shock metamorphism produces the strain in pyroxenes.

In-plane rotation of PTSs method of XRD analysis for eucrites is affected by the crystal orientation in the meteorites, especially coarse-grained unbrecciated rocks and crystalline portions in brecciated rocks.

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Nevertheless, we suggest that the FWHM is a useful indicator for measurements of the shock degree of eucrites, since this factor is not affected by the randomness of the crystal orientation of the meteorites.

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Keywords: Eucrites, Shock degree, XRD analysis

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Hf-W dating of main-group pallasites

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Pallasites are stony-iron meteorites consisting mainly of olivine and FeNi metal, providing us a unique opportunity to study an interior of their parent body. Classically, pallasites have been thought to represent the core-mantle boundary of their parent body, since there are some links with IIIAB irons, which are the representative of the core (e.g. Clayton & Mayeda, 1996). Yet, some recent studies suggest pallasite formed at a shallower region than the core-mantle boundary likely by impact mixing (e.g. Yang et al., 2010; Tarduno et al., 2012). Chronological investigations of pallasites are important since they enable to determine the ages and the timescales of crystallization of pallasite minerals. Although the Al-Mg dating of pallasite olivine yielded a model age of 1.27 Myrs after the CAI formation (Baker et al., 2012), other chronological constraints are still required for resolving the two contrasting models of pallasite formation. Here we apply the Hf-W chronology to four pallasites to constrain when the metal segregated on their parent body. Previously reported W isotopic data of pallasites show a large variation in $\varepsilon^{182/184}$W (Quitté et al., 2005), some of which correspond to the model ages older than CAIs. These isotopic data may reflect multiple causes and effects, such as a nucleosynthetic anomaly, radiogenic and neutron capture effects. We combined the W and the Pt isotopic measurements to evaluate the neutron capture effect which may lead to misinterpretation in age. Also, we measured unradiogenic W isotopes to estimate if the nucleosynthetic anomaly existed in the pallasite parent body. The obtained $\varepsilon^{182/184}$W values corrected for the neutron capture effect by using Pt isotope data range from -3.53 ±0.14 to -3.45 ±0.18, which correspond to the model Hf-W ages of -0.30 ±1.43 to 0.31 ±1.74 Myrs after the CAI formation. Moreover, the $\varepsilon^{183/184}$W values are indistinguishable from the terrestrial value, suggesting that the pallasite parent body accreted in the inner solar system. The model Hf-W ages obtained in this study are coincident with the model Hf-W ages of magmatic irons (Kruijer et al., 2013) and the model Al-Mg age of pallasite olivine, suggesting its magmatic origin rather than impact origin. The implication is that the pallasite metal was originated from the planetary core and was segregated within first 2 Myrs of the solar system evolution.

Keywords: Pallasite, Hf-W chronology, Neutron capture effect, Nucleosynthesis, Core-mantle boundary

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Mineralogical study of TCIs in CM carbonaceous chondrites

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Introduction

TCIs, intergrowths of tochilinite ($6(Fe_{0.9}S)\cdot 5[(Mg,Fe)(OH)_2]$) and cronstedtite (Fe-bearing serpentine) occur in most of CM chondrites, which are considered to be aqueous alteration products on the chondrite parent bodies. Based on the textures and chemistries, they can be divided into two types. Type I appears as massive and are generally found in chondrules, while type II exhibits fibrous textures and are generally found within the matrix. Many researchers support that kamacite in chondrules had been altered into type-I TCIs. However, precursors or alteration processes of type-II TCIs are still remains unknown. TCIs potentially provide important information regarding aqueous environments on chondrite parent bodies. Here, we report microtextures of type-II TCIs in 4 CM chondrites and review the formation process.

Materials and methods

We observed the following CM chondrites; QUE97990 (2.6), Murchison (2.5), Nogoya (2.2), Cold Bokkeveld (2.2). The number in parenthesis are the alteration index for CM chondrites proposed by Rubin et al. (2007), in which they defined the index ranging from 2.6 (moderately altered) to 2.0 (highly altered). Textural observation and chemical analyses were performed using an SEM-EDS (JEOL, JSM6480LAII), and nanometer-scale observations using an STEM-EDS (JEOL, JEM2100F) after processing into thin films using an FIB (FEI, Quanta 3Di).

Results and discussion

In QUE97990 and Murchison, less altered meteorites in this study, the type-II TCIs are distributed in the matrices. They are aggregates of a few μm-sized tochilinite and cronstedtite, where thin tochilinite veins occurred inside cronstedtite, suggesting that tochilinite had formed after the formation of cronstedtite. This gives us a constraint on the aqueous condition of CM chondrites. In Nogoya, the TCIs texture showed that very fine serpentine-rich region is located at core, and toward rim, gradually changed to fibrous cronstedtite and mixed-layer phase (alternate layer phase of tochilinite and cronstedtite structure in nanometer scale). The TCIs of Cold Bokkeveld also showed the core-rim structure, where core is often rich in mixed layer phase, and rim is consists of relatively coarse-grained tochilinite and cronstedtite. In the latter two highly altered CM chondrites, the both core showed very fine, fibrous, and fluffy texture, and no evidence of precursor material, suggesting that type-II TCIs were directly formed from water solution.

Keywords: CM carbonaceous chondrites, aqueous alteration, TCIs, STEM

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Importance of 10Be as a key indicator of (solar) cosmic ray irradiation in the early solar system

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Beryllium-10, which decays to ^{10}B with a half-life of 1.4 Myr, is produced mainly by spallation reactions of solar system materials induced by solar or galactic cosmic rays, but not by thermonuclear reactions in stars. Possible existence of ^{10}Be in the early solar system materials, therefore, has significant importance in considering irradiation processes near the early Sun or in the molecular cloud [1].

Excesses in ^{10}B correlated with Be/B ratios in a number of CAIs from CV chondrites [2-9] suggest the presence of live ^{10}Be at the time of CAI formation. The inferred initial ^{10}Be/^{9}Be ratios are mostly within the range of (0.5-1) x 10^{-3}, though the data are restricted to coarse-grained CAIs from CV chondrites. Recent studies including small CAIs from CH/CB chondrites [10-12] show that the initial ^{10}Be/^{9}Be ratios may be much higher and more variable (from ~10^{-4} to ~10^{-2}), suggesting that the origin of ^{10}Be in CAIs is spallation reactions induced by solar cosmic rays.

Data for chondrules are scarce. Sugiura (2001) [13] analyzed anorthite in chondrules from the Y82094 (ungrouped C3.2) chondrite and found a possible correlation between ^{10}B excesses and Be/B ratios, but the results are not conclusive due to relatively large errors. We further conducted Be-B isotope analyses for chondrules in Y82094 chondrite using NanoSIMS at the Atmosphere and Ocean Research Institute, The University of Tokyo [14]. Resolvable excesses in ^{10}B are found in some of the Y82094 chondrules, but ^{10}Be was probably not alive at the time of the chondrule formation. Some carriers of excess ^{10}B are required in the precursor materials of these chondrules.

Here we review recent progress in Be-B isotopic studies and discuss their importance in understanding the irradiation processes in the early solar system. We will also show our some new results on Be-B systematics for chondrules from Y82094 (C 3.2) and NWA7936 (LL 3.15) chondrite.

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Keywords: Beryllium-10, early solar system, cosmic ray, irradiation, CAIs, chondrules

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3D microstructure of a cosmic symplectite in primitive carbonaceous chondrite Acfer 094

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Introduction

Oxygen isotopic compositions can be used to identify the origins of planetary materials. Components of carbonaceous chondrites show wide range of oxygen isotopic compositions ($\delta^{17,18}$O: ~-50–0 ‰) that keep nearly constant δ^{17}O/ δ^{18}O ratio of ~1 [e.g.,[1]]. The isotopic variation is thought to be resulted from both mass-dependent isotope fractionation and mixing of two distinct reservoirs of ^{16}O-rich and ^{17,18}O-rich in the solar nebula. The composition of the ^{16}O-rich reservoir has been estimated from the isotopic compositions of CAIs and AOAs which were originated from the reservoir [e.g.,[2]]. Recently, Fe-rich material originated from the ^{17,18}O-rich reservoir, called cosmic symplectite (COS), has been reported from the primitive carbonaceous chondrite Acfer 094 [3]. COS have the heaviest oxygen isotopic composition ($\delta^{17,18}$O: ~180 ‰) among solar materials and consist of nanometer-scaled symplectitically intergrowth of magnetite and Fe-Ni sulfides [3,4]. They are thought to have formed by oxidation of Fe-Ni metal and sulfides by ^{17,18}O-rich water or water vapor in the early Solar System. However, petrological and mineralogical information of COS still remain limited. In this study, we performed synchrotron radiation-based X-ray computed tomography (SR-XCT) and NanoSIMS analysis to investigate the origin of COS.

Results and discussion

First, we observed a polished Acfer 094 section (~2.2 mm^2) by FE-SEM and found five COS grains. The COS grains (~10 μm) show rope-like structure like as COS reported by Abe et al. (2017) [5]. One of the five COS grains was extracted as a block (~25×25×30 μm) using FIB and analyzed by high spatial resolution (~100 nm) SR-XCT at SPring-8 BL47XU. The 3D image shows that the COS grain has irregular shape with many topographic depressions on the surface and contains small (<1 μm) inclusions. The inclusions are not connected to the outside of the COS by clack, ensuring that they were trapped when the host COS formed. We made a cross section surface of the inclusions using FIB and analyzed it by FE-SEM. The inclusions have Na, S, O rich compositions, and such material was not observed in the surrounding matrix. We confirmed that the COS, host of the inclusions, consist of symplectitically intergrowth of magnetite and Fe-Ni sulfides.

We obtained oxygen isotopic composition of the COS gain using NanoSIMS. The COS grain has ^{17,18}O-rich composition (δ^{17}O = 159.06 ±5.79 (1 σ) ‰, δ^{18}O = 166.31 ±3.18 (1 σ) ‰) which is similar to the COS grains reported by previous study [3]. We could not check the difference in oxygen isotopic compositions between the inclusions and the host COS because the inclusions were too small to obtain their compositions.

The inclusions found in this study have not been reported from other COS grains. It is possible that

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previous studies could not find the inclusions because most of the inclusions were plucked from the host COS during sample polishing. In fact, many COS grains reported in previous studies contain abundant pores which probably formed by plucking of inclusions. If inclusion is common in COS, it is important to constrain the origin of COS. We will present the results of further TEM analysis of the COS and their inclusions, and discuss the origin of them.

References: [1] Clayton (1993), *Annu. Rev. Earth Planet. Sci.*, **21**, 115–149. [2] Krot et al. (2002), *Science*, **295**, 1051–1054. [3] Sakamoto et al. (2007), *Science*, **317**, 231–233. [4] Seto et al. (2008), *GCA*, **72**, 2723–2734. [5] Abe et al. (2017), *Geochem. J.*, **51**, 3–15.

Keywords: Acfer 094, Cosmic symplectite, SR-XCT, NanoSIMS

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Chondrule-like objects and refractory inclusions in GEMS-bearing Antarctic micrometeorites and an interplanetary dust particle.

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Glass with embedded metal and sulfide (GEMS) is regarded as a characteristic component of cometary dust. GEMS-bearing Antarctic micrometeorites (AMMs) and interplanetary dust particles (IDPs) containing chondrules and refractory inclusions are important to understand comets as well as P- and D-type asteroids.

We found three chondrules and a refractory inclusion (RI) in GEMS-bearing AMMs and IDP. We investigated them by TEM, FE-SEM, FE-EPMA, and SIMS. All the chondrules belong to type II (Mg# <90). An AMM contains a spinel-hibonite-perovskite (sp-hb-pv) inclusion, in which spinel contains tiny (<100 nm) Ti-bearing Zr oxides and Mo- and Ru-bearing Ir-Os alloy and that perovskite contains Y and Zr, suggestive of ultra-refractory nature. All the fine-grained matrices are highly porous and contain GEMS, olivine, low-Ca pyroxene including enstatite whisker, high-Ca pyroxene, pyrrhotite. In addition, the matrix and the embedded RI contains minor phyllosilicate. Oxygen isotopic ratios of olivine and pyroxene in two chondrules are plotted 0.7‰ below and 2.7‰ above the terrestrial fractionation line on the three-oxygen isotope diagram, respectively. Oxygen isotope ratios of spinel in the RI are $\delta^{18}O$ of -43.8‰ to -45.1‰ and $\delta^{17}O$ of -44.8‰ to -46.8‰, respectively. Resolvable ^{26}Mg excesses ($\delta^{26}Mg^*$ ~ 13±2‰ and 14±3‰) are observed in hibonite with $^{27}Al/^{24}Mg$ ratios of 35-43, while spinel show marginal excess (~1‰).

The olivine/(olivine + low-Ca pyroxene) ratios were deduced from the mid-infrared spectra of asteroids and comets; those of B-, G-, and C-type asteroids, P- and D-type asteroids, and comets are <12%, 36-52%, and >50%, respectively. The ratios of the matrices in the samples range from 0.4 to 0.61, which are well above the values of B-, G-, and C-type asteroids and comparable with those of P- and D-type asteroids and comets. Therefore, P- and D-type asteroids and comets seem to be more plausible as parent bodies of these AMMs and an IDP than B-, G-, and C-type asteroids. If that is the case, P- and D-type asteroids and comets contain abundant GEMS. Ferromagnesian silicates with Mg#<90 in the chondrules distribute around $\Delta^{17}O$ ~0‰ in the Mg# vs $\Delta^{17}O$ diagram like those in the Stardust samples. This seems to be consistent with the hypothesis that P- and D-type asteroids were migrated from the Kuiper belt. The chondrules were formed in more oxidizing conditions than chondrules in CR chondrites because type II chondrules in them occupy only ~1%.

Keywords: chondrule, refractory inclusion, GEMS

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[J] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

Mon. May 27, 2019 10:45 AM - 12:15 PM JST | Mon. May 27, 2019 1:45 AM - 3:15 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[P-PS07] Formation and evolution of planetary materials in the Solar System

convener:Yoko Kebukawa(Faculty of Engineering, Yokohama National University), Wataru Fujiya(Ibaraki University, College of Science), Shin Ozawa(Department of Earth Science, Graduate School of Science, Tohoku University), Megumi Matsumoto(Graduate School of Science, Tohoku University), Chairperson:Yoko Kebukawa, Shin Ozawa

This session will focus on the evolution in the Solar System with interaction and co-evolution in minerals, water, organic matter, and noble gas in meteorites and interplanetary dust particles. New innovative analytical and theoretical techniques in various fields will be discussed. The developing methods are welcome to submit for the future mainstream of meteorite study. In order to explore the planetary materials and their evolution, both meteorite studies and experimental approaches are necessary. In this session, we will discuss these topics from extraterrestrial sample analyses and experimental works. Research works on undifferentiated and differentiated meteorites and parent body processes such as aqueous alteration, thermal metamorphism, shock metamorphism, volcanic activity, and core-mantle-crust differentiation are especially included in this session.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[PPS07-13] Spectral and mineralogical properties of naturally-heated carbonaceous chondrites; implication to heating processes on the surface of hydrous asteroids

★Invited Papers

*Moe Matsuoka[1], Tomoki Nakamura[2], Takahiro Hiroi[3], Nobuyoshi Miyajima[4], Naoya Imae[5,6], Akira Yamaguchi[5], Hideyasu Kojima[5,6] (1.Japan Aerospace Exploration Agency(JAXA), 2.Department of Earth and Planetary Materials Sciences, Faculty of Science, Tohoku University, 3.Department of Earth, Environmental and Planetary Sciences, Brown University, 4.Bayerisches Geoinstitut, University of Bayreuth, 5.National Institute of Polar Research, 6.Department of Polar Science, School of Multidisciplinary Science, SOKENDAI)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[PPS07-14] Heterogeneity of oxygen and carbon isotopic compositions within carbonate grains in the Yamato 791198 CM chondrite and evolution of isotope ratios during aqueous alteration

*Wataru Fujiya[1], YUTO AOKI[1], Takayuki Ushikubo[2], Ko Hashizume[1] (1.Ibaraki University, College of Science, 2.Kochi Institute for Core Sample research, Japan Agency for Marine-Earth Science and Technology)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[PPS07-15] Characteristics of Oxygen isotope ratios of chondrules and isolated olivine grains from Tagish Lake C2 chondrite

*Takayuki Ushikubo[1], Makoto Kimura[2] (1.Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology, 2.National Institute for Polar Research)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[PPS07-16] Extreme ^{16}O-rich CAIs in Isheyevo chondrite

*Naoya Sakamoto[1], Noriyuki Kawasaki[2] (1.Creative Research Institution, Hokkaido University, 2.Natural History Sciences, Hokkaido University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[PPS07-17] Variations in initial ^{26}Al/^{27}Al ratios among fine-grained CAIs in the reduced CV chondrites

*Noriyuki Kawasaki[1], Changkun Park[2], Naoya Sakamoto[1], Hisayoshi Yurimoto[1,3] (1.Hokkaido University, 2.KOPRI, 3.ISAS/JAXA)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[PPS07-18] Petrographic study of compact type A CAIs with partial melting process

*Akimasa Suzumura[1], Yusuke Seto[2], Shoichi Itoh[1] (1.Graduate school of Science, Kyoto University, 2.Graduate school of Science, Kobe University)

Spectral and mineralogical properties of naturally-heated carbonaceous chondrites; implication to heating processes on the surface of hydrous asteroids

*Moe Matsuoka[1], Tomoki Nakamura[2], Takahiro Hiroi[3], Nobuyoshi Miyajima[4], Naoya Imae[5,6], Akira Yamaguchi[5], Hideyasu Kojima[5,6]

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The parent bodies of carbonaceous chondrites are thought to be C-type asteroids based on the similarity of visible (Vis) -infrared (IR) spectra between carbonaceous chondrites and C-type asteroids [e.g., 1-5]. Several C-type asteroids are thought to have been heated and dehydrated judging from their spectra which are similar to the spectra of experimentally-heated chondrites [1,6]. The Hayabusa2 spacecraft of the Japan Aerospace Exploration Agency (JAXA) was arrived at the target C-type asteroid 162173 Ryugu in June 2018. Ryugu spectra exhibit a weak 2.72-μm OH absorption band that is present across the surface of the asteroid, and nearly always darker than values typical for carbonaceous chondrites [7,8]. The meteorites whose spectral features are most similar to Ryugu are shocked or moderately-heated carbonaceous chondrites. In this study, we performed spectral analysis in Vis-NIR range and mineralogical analysis in micro scale using carbonaceous chondrites that heated dehydrated on their parent bodies.

Spectral and mineralogical analyses were performed using nine naturally-heated and dehydrated carbonaceous chondrite samples (seven CM, one CI, and one CV chondrites), which classified into heating stages (HS) from I to IV based on X-ray diffraction results [9]. In-situ heating of samples at 120–400 ˚C was performed during spectral measurements and successfully removed absorption water and part of rehydrated water from chondrite samples. Lewis Cliff (LEW) 87022 (unheated CM), Jbilet Winselwan, and Dhofar 735 (heated at 600–900 ˚C [10]) were used for transmission electron microscope (TEM) analysis.

Reflectance spectra of HS-I samples show the positive slope in Vis- IR range and the significant 0.7- and 3-μm absorption bands. The 0.7-μm band appears in only HS-I sample spectra. With increasing heating degree, (1) Vis-IR slope decreases, (2) the 0.7- and 3-μm bands decrease, and (3) Mid-IR spectral feature (i.e. Christiansen feature (CF) and Reststrahlen bands (RB)) shifts toward longer wavelength. TEM/EDX analyses showed that the matrix of severely-heated chondrites consists of tiny olivine, low-Ca pyroxene, and fine Fe- and Ni-rich metal grains (<1 μm). It is indicated that in proportion to the heating degree, amorphization and dehydration of serpentine and tochilinite from HS-I to HS-II might cause the 0.7- and 3-μm band weakening, and spectral slope and albedo decreasing of spectra. Then, formation of secondary olivine and pyroxene, and FeNi-rich metal grains at HS-IV would be responsible for the 3-μm band depth decreasing, spectral slope and albedo increasing, CF peak shift, and RB changes of chondrite spectra.

We plan to compare other IR reflectance spectra of asteroids, such as those acquired by AKARI [11], to better interpret remotely sensed data of Bennu (NASA’s OSIRIS-REx mission target) and Ryugu. Future NIRS3 observations before/after the Small Carry-on Impactor (SCI) crater experiment and lab analyses of returned samples will reveal additional compositional properties of Ryugu.

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Keywords: carbonaceous chondrite, C-type asteroid, reflectance spectra, TEM analysis, Hayabusa2

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Heterogeneity of oxygen and carbon isotopic compositions within carbonate grains in the Yamato 791198 CM chondrite and evolution of isotope ratios during aqueous alteration

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Carbonate minerals are ubiquitous in CM chondrites and formed by aqueous alteration in their parent body [1]. Previous studies have revealed a large variation in C isotope ratios of CM carbonates with $\delta^{13}C$ values ranging from ~20 to ~90 ‰[e.g., 2,3]. However, the reason for this variability has remained poorly understood. Here, we conducted in-situ C- and O-isotope measurements by SIMS along crystal growth within single carbonate grains in Yamato 791198 (CM 2.4) to trace the change in $\delta^{13}C$ values during aqueous alteration.

First, we obtained color CL images of seven calcite ($CaCO_3$) grains with an FE-EPMA. Then, we measured O and C isotope ratios of the calcite grains with the CAMECA ims-1280HR. Typically, the isotope measurements were carried out on three different points for each calcite grain. Finally, we obtained quantitative chemical compositions and elemental maps of Mg, Si, Ca, Mn, and Fe of the calcite grains using the same FE-EPMA as that for the CL images.

All grain analysed exhibit a clear zoning of Mn, Mg, and Fe. The zoning is well correlated with CL images. The heterogeneous distribution of minor elements and CL intensity likely reflects the crystal growth of these grains.

The O isotope ratios of the calcite grains significantly vary with the $\delta^{18}O$ values ranging from ~22 to ~38 ‰. The O isotope ratios plot on a single trend line in an O three-isotope plot with a slope of ~0.61, slightly steeper than the terrestrial fractionation line, reflecting a progressive O-isotope exchange between initially ^{16}O-poor water and ^{16}O-rich rock [4,5]. The $\delta^{18}O$ values also vary within single calcite grains, demonstrating crystal growth from a relatively dark CL core to a red CL periphery.

The $\delta^{13}C$ values of the calcite grains range from 17 to 32 ‰. This range is much smaller than that observed for different carbonate grains or bulk meteorite samples by previous studies. Especially, the $\delta^{13}C$ variations within individual grains are only 4 ‰at most except for one grain. Previous studies have suggested that the observed $\delta^{13}C$ variation was produced by the Rayleigh-type isotopic fractionation by the escape of ^{13}C-poor methane [2], or equilibrium isotopic fractionation reflecting variable formation temperatures of carbonates [3]. However, the small intra-grain $\delta^{13}C$ variations associated with the large $\delta^{18}O$ change observed in this study cannot be explained by such processes. Instead, here we propose that the $\delta^{13}C$ values of dissolved carbon species in aqueous solutions were locally heterogeneous, and did not significantly change during carbonate formation.

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Keywords: Carbonate mineral, Carbonaceous chondrite, Oxygen isotope, Carbon isotope

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Characteristics of Oxygen isotope ratios of chondrules and isolated olivine grains from Tagish Lake C2 chondrite

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Recent studies on oxygen isotope systematics of chondrules show that chondrules in individual chondrite groups have characteristic distributions in their oxygen isotope ratios and Mg# (molar % of MgO/(MgO+FeO)) [1, 2]. The correlations between Mg# and $D^{17}O$ values (= $d^{17}O_{VSMOW}$ - 0.52 ×$d^{18}O_{VSMOW}$) of chondrules can be explained by mixing of ^{16}O-rich anhydrous dusts and an ^{16}O-poor oxidizing agent (most likely H_2O ice) in chondrule forming regions [3]. Based on similar Mg# - $D^{17}O$ correlations between CR chondrite chondrules and cometary silicate particles from comet Wild 2, it has been proposed that many of cometary silicate particles formed in the outer regions of the asteroid belt [e.g. 4, 5]. The Tagish Lake meteorite (ungrouped C2) is an appropriate sample to investigate the Mg# - $D^{17}O$ systematics of silicate particles formed in the outer regions of the asteroid belt because the Tagish Lake meteorite probably derived from a D-type asteroid [6]. Previous oxygen isotope studies on olivine grains from Tagish Lake and Tagish Lake-like meteorites [e.g. 7] show that their Mg# - $D^{17}O$ systematics are similar to that of CR chondrite chondrules. Here, we report new oxygen isotope data of olivine grains from the Tagish Lake meteorite for better understandings of the Mg# - $D^{17}O$ systematics of silicate particles in the outer regions of the asteroid belt.

Two polished epoxy mounts of the Tagish Lake meteorite, TL-KC-1 (8mm ×5mm) and TL-KC-2 (4mm × 3mm), were prepared for this study. Due to extensive aqueous alteration in the Tagish Lake parent body, phyllosilicates and other secondary phases such as magnetite and carbonates replace primary anhydrous phases. However, remaining olivine grains in chondrules and matrix tend to have sharp grain boundaries and no apparent evidence for the Mg-Fe exchange between olivine grains and matrix was observed. No alteration features were observed in these grains. Forty chondrules and isolated olivine grains (hereafter “ferromagnesian inclusions”) were selected for oxygen isotope measurements (34 type I [Mg#>= 90] and 6 type II [Mg#<90]). Oxygen isotope ratios of olivine grains were measured with an ion microprobe, CAMECA IMS 1280-HR at Kochi Institute. A 20 kV accelerated Cs^+ primary beam (~30 pA, ~3 um in diameter) was used. The analytical conditions were similar to those in [1].

Oxygen three-isotope ratios of ferromagnesian inclusions from Tagish Lake are distributed along the PCM (primitive chondrule minerals) line [1]. Most type I ferromagnesian inclusions are relatively ^{16}O-rich ($D^{17}O$ = -7.4 to -3.9‰) and type II ferromagnesian inclusions are relatively ^{16}O-poor ($D^{17}O$ >= -3‰). Of six type II ferromagnesian inclusions, two inclusions have $D^{17}O$ ~ 0‰, which are recognized in in Tagish Lake-like meteorites, CR chondrites, and cometary silicate particles, but are almost absent in other carbonaceous chondrites [e.g., 2-5, 7]. The present results are further evidence for the link between ferromagnesian inclusions accumulated into asteroids in the outer regions of the asteroid belt (possibly D-type asteroids) and silicate particles accumulated into cometary nuclei in the Kuiper belt. As discussed in [4, 5, 8], type II silicates are common in cometary silicate particles, which is distinct from ferromagnesian inclusions in Tagish Lake(-like) meteorites and CR chondrites. Most cometary silicate particles formed in H_2O ice enriched oxidizing regions. Such regions were probably farther than where typical ^{16}O-rich type I chondrules of carbonaceous chondrites formed.

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Keywords: Tagish Lake meteorite, Chondrule, Oxygen isotope, SIMS

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Extreme ^{16}O-rich CAIs in Isheyevo chondrite

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Oxygen in the solar system is believed to be formed by mixing of ^{16}O-rich and ^{16}O-poor reservoirs [e.g. 1 and references therein]. The ^{16}O-poor end member ($\Delta^{17}O$ = +85‰) was found from magnetite in cosmic symplectite and infers that the ^{16}O-poor reservor is H_2O [2]. Nevertheless candidates of ^{16}O-rich end member were reported from one chondrule named a006 ($\Delta^{17}O$ = -37‰) [3], 4 Ca-Al-rich inclusions (CAIs) ($\Delta^{17}O$ = -37 to -32‰) [4,5] and the Sun ($\Delta^{17}O$ = -28‰) [6] relative to other CAIs ($\Delta^{17}O$ = -23‰) [e.g. 7], characteristics of the reservoir are unclear because of the diversity of few samples. In this study, we surveyed extreme ^{16}O-rich CAIs in Isheyevo chondrites to investigate the ^{16}O-rich end menber.

Thirteenthick sections of Isheyevo chondrite were newly prepared. X-ray elemental maps were obtaind for whole sections by FE-SEM-EDS. Al-rich inclusions on the sections were picked up as many as possible for isotope analysis in order to prevent biased sample selection. Oxygen isotope analysis for the inclusions were performed by SIMS.

Oxygen isotopic compositions of 263 CAIs were measured and 4 extreme ^{16}O-rich CAIs were found. Two CAIs are composed of grossite core rimmed by spinel, melilite and Ti-rich diopside layer and others lack diopside and/or melilite. While the heterogeneous composition of grossite ($\Delta^{17}O$ = -36 to -32‰) would be affected by altered feature of grossite, the spinel grains have uniform ^{16}O-rich compsition ($\Delta^{17}O$ = -37‰). If we draw a line in 3 oxygen isotope diagram with the extreme ^{16}O-rich spinel and spinel in chondules near the CAI, the slope is in good agreement with a slope of olivine in a006 chondrule and porphiritic olivine chondrule infer that the oxygen isotopic composition of the spinel grains maintain the signature of an^{16}O-rich end member of the Solar System.

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Keywords: Oxygen isotope, Isheyevo chondrite, CAI, SIMS

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Variations in initial $^{26}Al/^{27}Al$ ratios among fine-grained CAIs in the reduced CV chondrites

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Ca-Al-rich inclusions (CAIs) are oldest solids formed in the Solar System [1] and composed of high-temperature condensates from a solar-composition gas [2]. Most of CAIs are thought to have contained detectable amounts of live ^{26}Al, a short-lived radionuclide with a half-life of ~0.7 Myr, at their formation [3]. Recent high-precision $^{26}Al–^{26}Mg$ mineral isochron studies using secondary ion mass spectrometry (SIMS) revealed detailed distributions of initial $^{26}Al/^{27}Al$ values, $(^{26}Al/^{27}Al)_0$, for individual CAIs in the reduced CV chondrites [e.g., 4–9]; coarse-grained, igneous CAIs and fluffy Type A CAIs show similar variations in $(^{26}Al/^{27}Al)_0$ respectively, which range from ~5.2 to ~4.2 $\times10^{-5}$. In this study, we obtained new $^{26}Al–^{26}Mg$ mineral isochrons of five fine-grained, spinel-rich CAIs (FGIs) from the reduced CV chondrites Efremovka, Vigarano and TIL 07007 by *in situ* measurements using a SIMS instrument (CAMECA ims-1280HR installed at Hokkaido University). Since FGIs are likely to be condensates from a solar nebular gas, $^{26}Al–^{26}Mg$ mineral isochrons of them enable a more systematic comparison of $(^{26}Al/^{27}Al)_0$ between CAIs formed by condensation and by melt crystallization than has previously been achieved. The obtained $^{26}Al–^{26}Mg$ mineral isochrons for five FGIs give $(^{26}Al/^{27}Al)_0$ of (5.19 ±0.17) $\times10^{-5}$, (5.00 ± 0.17) $\times10^{-5}$, (4.53 ±0.18) $\times10^{-5}$, (4.43 ±0.31) $\times10^{-5}$, and (3.35 ±0.21) $\times10^{-5}$. The $(^{26}Al/^{27}Al)_0$ for two FGIs are essentially identical to the whole-rock CAI value of $(^{26}Al/^{27}Al)_0$ ~ 5.2 $\times10^{-5}$ [10, 11], while those for other three FGIs are clearly lower than the whole-rock CAI value. The range of $(^{26}Al/^{27}Al)_0$ values for the FGIs, from (5.19 ±0.17) to (3.35 ±0.21) $\times10^{-5}$, corresponds to a formation age spread of 0.44 ±0.07 Myr. These variations are slightly larger than those for igneous CAIs ranging from ~5.2 to ~4.2 $\times10^{-5}$ [5, 6]. Our data imply that CAI condensation events continued for, at least, ~0.4 Myr at the very beginning of our Solar System, if ^{26}Al was distributed homogeneously in the forming region. Alternatively, the observed variations would also raise a possibility of heterogeneous distributions of ^{26}Al in the forming region, corresponding to a range over, at least, $3.4 \times10^{-5} < (^{26}Al/^{27}Al)_0 < 5.2 \times10^{-5}$.

[1] Connelly et al. (2012) *Science* 338, 651–655. [2] Grossman (1972) *GCA* 86, 597–619. [3] MacPherson et al. (1995) *Meteoritics* 30, 365–386. [4] MacPherson et al. (2010) *ApJL* 711, L117–L121. [5] MacPherson et al. (2012) *EPSL* 331–332, 43–54. [6] MacPherson et al. (2017) *GCA* 201, 65–82. [7] Kawasaki et al. (2017) *GCA* 201, 83–102. [8] Kawasaki et al. (2018) *GCA* 221, 318–341. [9] Kawasaki et al. (2019) *EPSL* 511, 25–35. [10] Jacobsen et al. (2008) *EPSL* 272, 353–364. [11] Larsen et al. (2011) *ApJL* 735, L37–L43.

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Petrographic study of compact type A CAIs with partial melting process

*Akimasa Suzumura[1], Yusuke Seto[2], Shoichi Itoh[1]

1. Graduate school of Science, Kyoto University, 2. Graduate school of Science, Kobe University

Refractory inclusions (Ca-Al-rich inclusions (CAIs)) in chondritic meteorites are the oldest substances formed in the Solar System (Connelly et al., 2012). Coarse-grained CAIs are classified into three subtypes, type A, B and C, according to their petrologic features (e.g., Grossman 1975). Compact type A CAIs (CTAs) are expected to be formed in the earliest stage of solar nebula and experienced a partial melting at least once (e.g., Simon et al., 1999). Yurimoto et al. (1998) have explained the heterogeneous oxygen isotope distributions among constituent minerals in Compact Type A CAIs have formed by the partial melting model. The indicator of partial melting is necessary to discuss the formation of the entire CAIs. However, there are only a few studies that referring to the formation processes of CTAs from the perspective of crystal growth in partial melting states (Ito et al., 2004, Park et al., 2012, Kawasaki et al., 2017). Generally, spinel in CTAs are poikilitically enclosed by melilite or fassaite, and estimated to be first crystallized mineral from CAI melt (Stolper, 1982). Namely, spinel in CTAs is expected to preserve valuable information of the thermal histories such as partial melting processes. Therefore, we focus on the petrological and mineralogical feature of spinel grains in CTAs. The studied CTA (KU-N) is included in a polished thin section of North West Africa 7865 reduced CV3 carbonaceous chondrite. Yoneyama et al. (2016) had studied the same CTA, and concluded that they experienced multiple partial melting. We have undertaken petrographic and mineralogical investigations of the CTA (KU-N-02) focusing on micro-textures resulting from partial melting (local compositional zoning, grain morphology and relationships of crystallographic orientation), using a polarizing microscope, scanning electron microscope (SEM) and electron back scatter diffraction (EBSD).

In the KU-N-02 CTA, spinel crystals are enclosed by melilite or fassaite. The former (up to 50 μm in size) is substantially euhedral but the edges are rounded, while the latter (about 10 - 100 μm in size) are almost euhedral with sharp edges. On the surfaces of both type of spinel grains, small perovskite particles with sizes of several μm are ubiquitously present.

In interior KU-N-02 CAI, single crystal melilite with spinel inclusions showed a remarkable compositional zoning Single crystal melilite show core-to-rim normal zoning, with decreasing Al and increasing Mg from core to rim. In the melilite single crystal, the area of about 10 μm wide around the spinel surfaces has Åk-rich compositions in comparison. By EBSD analyses, Åk-rich melilite crystal orientation and Åk-poor melilite crystal orientation is same. Therefore, Åk-rich melilite part (~10μm) surrounding spinel are crystallized after Åk-poor melilite. Because of these results, it is difficult to explain how Åk-rich part surrounding spinel in a melilite crystal crystallized by a single stage cooling. This texture indicates that the boundary area between spinel and melilite had eutectically melted at high temperature by some heating process, and then Mg/Al contents had been redistributed to melilite and spinel during rapid cooling. Accordingly, this partial melting probably resulted in the unique morphology and the crystallographic orientation relationship of the spinel enclosed by melilite and Local composition zoning of the melilite.

Keywords: Compact Type A CAIs, partial melting, petrographic study

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Mon. May 27, 2019 10:45 AM - 12:15 PM JST | Mon. May 27, 2019 1:45 AM - 3:15 AM UTC | 102 1F

[A-OS13] Ocean circulation and material cycle in coastal seas

convener:Kiyoshi Tanaka(University of Tokyo), Akihiko Morimoto(Ehime University), Yuichi Hayami(Saga University), Kazuhiko Ichimi(Seto Inland Sea Regional Research Center, Kagawa University), Chairperson:Kiyoshi Tanaka, Akihiko Morimoto

Coastal seas have high biodiversity and high productivity, while various environmental problems such as eutrophication, red tide, and hypoxia are caused by human activity. In order to understand material cycle and various phenomena and to maintain sustainable environment in coastal seas, interdisciplinary research is needed. In the present session, we invite researchers who are interested in physical phenomena, material cycle, biological responsive dynamics, and their interactions in coastal seas. Neither study area nor study method is confined. We welcome presentations of wide-range topics to communize our knowledge in coastal seas.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[AOS13-01] On-demand development of bay-scale models using the Japanese Coastal Ocean Monitoring and Forecasting System

*Kei Sakamoto[1], Hideyuki Nakano[1], Shogo Urakawa[1], Takahiro Toyoda[1], Hiroyuki Tsujino[1], Goro Yamanaka[1] (1.Meteorological Research Institute)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[AOS13-02] Long term measurement of the current at the bay head in the Suruga Bay, Japan. part 2

*Takaaki Katsumata[1,4], Masato Niki[2], Akihiko Tanaka[1], Hiroyuki Tan[1,3], Kyoko Takashima[2], Takashige Sugimoto (1.Liberal Arts Education Center, Shimizu Campus, Tokai University., 2.School of Marine Science and Technology, Tokai University, 3.Japan Unmanned Vehicle exploration Agency, 4.NPO, the association for the environmental conservation of the ocean)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[AOS13-03] Bottom-water intrusion and subsequent water exchange induced by Yamase around Mutsu Bay

*Satomi Fujisaki[1], Atsuhiko Isobe[1], Izumi Ogida[2], Yuki Kosaka[2] (1.Kyushu university, 2.Aomori Prefectural Fisheries Research Institute)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[AOS13-04] The Generation Process of the Bottom Intrusion in the Bungo Channel

*Kana Maetani[1], Akihiko Morimoto[2], Xinyu Guo[2], Toru Miyama[3] (1.Graduate School of Science and Engineering, Ehime University, 2.Center for Marine Environmental Studies, Ehime University, 3.Japan Agency for Marine-Earth Science and Technology)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[AOS13-05] Characteristics of bottom intrusion in the Bungo Channel

*Akihiko Morimoto[1], Shuya Fujita[1], Hidetaka Takeoka[1], Xinyu Guo[1] (1.Ehime University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[AOS13-06] Role of Kuroshio Current in fish resource variability off southwest Japan

*Yushi Morioka[1], Sergey Varlamov[1], Yasumasa Miyazawa[1] (1.Japan Agency for Marine-Earth Science and Technology)

On-demand development of bay-scale models using the Japanese Coastal Ocean Monitoring and Forecasting System

*Kei Sakamoto[1], Hideyuki Nakano[1], Shogo Urakawa[1], Takahiro Toyoda[1], Hiroyuki Tsujino[1], Goro Yamanaka[1]

1. Meteorological Research Institute

We have developed the "Japanese Coastal Ocean Monitoring and Forecasting System" (MOVE/MRI.COM-JPN) to reproduce oceanic conditions across the coastal seas around Japan, based on an ocean model with horizontal resolution of approximately 2 km and a 4-dimensional variational data assimilation system. The Japan Meteorological Agency plans to use this system as a platform for various coastal marine operations, and details of the system are explained in Sakamoto et al. (2019) and Hirose et al. (2019) (submitted to Ocean Dynamics). However, the model resolution of 2 km is a minimum necessary requirement for continental shelf regions in contact with open oceans and relatively large inland seas such as the Seto Inland Sea, and it is a future task to provide information targeting bay-scale regions which are more closely related to society, including small bays, inland seas and straits. As a solution, a model covering the entire coastal seas around Japan with a resolution of several hundred meters is planned, but a current ordinary computer cannot perform its enormous calculations. In this respect, it seems feasible to deploy an array of bay-scale models of high resolution and small domain, which are nested from MOVE/MRI.COM-JPN, but management costs of a lot of models are concerned in that case. Therefore, we are considering an approach to develop bay-scale models on demand for a future expansion of MOVE/MRI.COM-JPN. As a first step towards this, we began developing a package that can quickly build a bay-scale model. Currently, the package consists mainly of three elements. The first is our numerical model MRI.COM. In addition to an offline-nesting function, it is possible to introduce dynamics important in coastal seas of Japan, such as river runoff, sea ice, tides and the inverse barometer effect. The second is a package of pre-processing and analysis tools named "MRI.COM eXperimental Environment". This helps a model developer to easily create model configurations such as topography data. The third is analysis data of the coastal seas around Japan produced by MOVE/MRI.COM-JPN. By using this data for the initial value and lateral boundary condition of a bay model, we can start a model experiment anytime after 2008. Using this package, we have created a Nagasaki Bay model with resolution of 100 m and an Osaka Bay model with resolution of 200 m. We reproduced seiches called "Abiki" by the Nagasaki Bay model, and the storm surge caused by Typhoon Jebi in September 2018 by the Osaka Bay model. The poster presentation will also show these results.

Keywords: coastal model, operational model, Japanese coastal seas, nesting, model development

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Long term measurement of the current at the bay head in the Suruga Bay, Japan. part 2

*Takaaki Katsumata[1,4], Masato Niki[2], Akihiko Tanaka[1], Hiroyuki Tan[1,3], Kyoko Takashima[2], Takashige Sugimoto

1. Liberal Arts Education Center, Shimizu Campus, Tokai University., 2. School of Marine Science and Technology, Tokai University, 3. Japan Unmanned Vehicle exploration Agency, 4. NPO, the association for the environmental conservation of the ocean

The Suruga Bay is located on a southern coast in the main island of Japan, and the bay facing to the Kuroshio front. Fishery in the bay are strongly influenced by a variables of rivers inflows and intruding of Kuroshio water (Sugimoto et al., 2009; Tanaka et al.,2009; Katsumata, 2016). But we have a little knowledge for these variations. Therefore, we measured the profile of the current by ferry mounted ADCP, at the line of the “Suruga Bay Ferry” cruise cross the bay head from a western coast to eastern coast, i.e., Shimizu Port to Toi Port, since 2008. We currently continuing measuring the current in the bay about near 10 years. The anticlockwise circulation at the bay head of the Suruga Bay has at least 100 m thick from surface layer. The circulation in bay head has clearly seasonal variation, it is relate difference of stratified period and non-stratified one. This current data include the period of typical large meander of Kuroshio.

Keywords: Ferry mount ADCP, Suruga Bay, typical large meander path of Kuroshio

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Bottom-water intrusion and subsequent water exchange induced by Yamase around Mutsu Bay

*Satomi Fujisaki[1], Atsuhiko Isobe[1], Izumi Ogida[2], Yuki Kosaka[2]

1. Kyushu university, 2. Aomori Prefectural Fisheries Research Institute

Bottom-water intrusion in the Bungo channel, which is the cold-water intrusion onto the continental shelf from the Kuroshio intermediate layer, was studied by Takeoka et al. (2000). The bottom-water intrusion in the Bungo channel occurs when the Kuroshio Current passes along the Kyushu of the Bungo channel (Kaneda et al., 2002). In the case of Mutsu Bay, bottom-water temperature fluctuated by more than 3 degree Celsius during summer (June –September). However, Tsugaru Warm Current is not so strong compared with Kuroshio and, thus, we had to find other mechanisms for the bottom-water intrusion to occur. We here focused on Yamase which is a cold, moist and westward wind blowing from the Okhotsk Sea during summer and analyzed water temperature, current velocity and wind velocity.

Ocean buoy automatic monitoring system (hereinafter, buoy system) at three points of Mutsu Bay (Tairadate, Aomori, Higashiwan) have observed water temperature, current velocity, salinity, and so forth at a depth of 1m, 15m, 30m every single hour. An observation ship “Natsudomari” records water temperature, salinity, and so forth at eleven points of Mutsu Bay once a month. Water temperature and current velocity from 2008 to 2017 (buoy system), water temperature from 1981 to 2016 (Natsudomari), water temperature from 1981 to 2010 (Japan Oceanographic Data Center (J-DOSS)) and water temperature deviation in August from 2008 to 2017 in Tsugaru Strait (Hokkaido Research Organization) were obtained. Wind data at Oma observatory free of terrain-derived disturbances was obtained from the Japan Meteorological Agency.
A correlation analysis of time series between water temperature (5 –15 days) at Tairadate, Aomori, Higashiwan and zonal wind at Oma was performed. The days when daily average easterly (westerly) wind velocity was greater than 2 m/s was referred to as “eastern (western) wind day”. Composite maps of cross sections of water temperature in Tsugaru Strait and Mutsu Bay was created on the eastern and western wind day, respectively. The relationship between annually average bottom-water temperature at Aomori and Higashiwan and eastern winds at Oma was investigated during summer (June –September) from 2008 to 2017. Water temperature in 2011 was excluded because water temperature in Tsugaru Strait was extraordinarily low.

Long-period bottom-water temperature (about 10 days) at Tairadate and Aomori, both of which are located in western Mutsu Bay, remarkably fluctuated, that is, bottom-water intrusion occurred in the western part of Mutsu Bay. The correlation coefficients between the bottom temperature and Oma winds were 0.68 at Tairadate (a significance level of 0.05) and 0.75 at Aomori (a significance level of 0.05). Consequently, it was suggested that zonal wind induced bottom-water intrusion in western Mutsu Bay. Moreover, the composite maps stated that cold-water < 10 degree Celsius intruded onto the bottom of Mutsu Bay from Tsugaru Strait during eastern wind days. These findings suggest that westward Yamase triggers bottom-water intrusion in Mutsu Bay. However, as bottom-water temperature become lower, bottom-water intrusion was prevented even when Yamase blows continuously.

Keywords: Bottom-water intrusion, Mutsu Bay, Yamase

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The Generation Process of the Bottom Intrusion in the Bungo Channel

*Kana Maetani[1], Akihiko Morimoto[2], Xinyu Guo[2], Toru Miyama[3]

1. Graduate School of Science and Engineering, Ehime University, 2. Center for Marine Environmental Studies, Ehime University, 3. Japan Agency for Marine-Earth Science and Technology

Introduction

The Bungo Channel is one of the two channels that connect to the Pacific Ocean and the Seto Inland Sea, and located between Kyushu and Shikoku Islands. Marine environment in the Bungo Channel is strongly influenced by the disturbances from open ocean. It is known that a cold-water intrusion from open sea, called a “Bottom Intrusion”, occurs in the lower layer from summer to autumn (Kaneda *et al.,* 2002). Since the Bottom Intrusion is difficult to observe because of its occurrence position, generation mechanism and intrusion process of the Bottom Intrusion have not been revealed yet. However, recently the Bottom Intrusion has been reproduced in numerical models with high resolution and high accuracy. Therefore, there is a possibility that we can figure out its three-dimensional structure and generation processes by analyzing model outputs. However, there is a possibility that the Bottom Intrusion and the intrusion of the cold-water in the numerical model do not have the same mechanism in real ocean. At first, we compare model output and observed data that derived from a mooring system at the central part of the Bungo Channel. After conforming reproduction of the model in terms of the Bottom Intrusion, we analyze the model output to understand the intrusion process of cold-water into the Bungo Channel.

Data

The observation data used in this study were measured by ADCP (Acoustic Doppler Current Profiler), thermometer and salinometer that were moored at the central part of the Bungo Channel, from 6 July to 17 October, 2016. We also used a model output of JCOPE-T-NEDO that is developed by JAMSTEC.

Results and Discussion

We analyzed two cases of the Bottom Intrusion that occurred 14 August and 10 September in 2016 because variations in current velocity and water temperature in the model consist well with those in observation. In these two cases, the cold-water mass was supplied to the shelf slope nearby N32.72˚, E132.45˚, and was crossed the 200m isobath by the anticlockwise flow in the shelf slope. As a result, a density gradient between the cold-water mass and relatively light water in the Bungo Channel was generated. The density gradient makes a northeastward density driven current in the lower layer in the Bungo Channel, and the current advects the cold-water mass into the Bungo Channel.

Furthermore, it is found from observation data that there is a case that northward flow became stronger in not lower layer but middle layer. When the northward flows became stronger in middle layer, a northeast flow also developed in northwestern part of the Bungo Channel. When strong northward flow occurred in the middle layer, water temperature in the central part of the Bungo Channel was not always dropped. This might be because the water mass transported by the strong northward flow in the middle layer came from shallower depth in the shelf edge compared with the case of Bottom Intrusion. However, the reason why velocity increased at middle layer is not clear at the moment, so that proceeding analysis is needed in addition to the Bottom Intrusion.

Keywords: Bottom Intrusion, Bungo Channel, continental shelf

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Characteristics of bottom intrusion in the Bungo Channel

*Akihiko Morimoto[1], Shuya Fujita[1], Hidetaka Takeoka[1], Xinyu Guo[1]

1. Ehime University

Bungo Channel is located between Kyushu and Shikoku and faces to the Pacific Ocean. A cold water mass with high nutrients intermittently intrudes into the Bungo Channel from summer to autumn. The phenomenon is called “Bottom Intrusion (BI)”. According to Kaneda et al., (2002), the BI occurs in neap tide of summer with the current of 15 cm/s. However, when we analyzed moored current and water temperature data at the central part of the Bungo Channel, we could not see the relation between the BI and moon age. There is a possibility that the discrepancy between our analysis and Kaneda et al. (2002) is caused by the different year data. In the present study, we reexamine the characteristics of the BI, especially relationship between the BI and moon age, using long-term water temperature data.

At the Uchiumi in the central part of the Bungo Channel, multilayer water temperature has observed since 1995. At other five stations (Hoketsu, Yusu, Shitaba, Fukuura, Okinoshima), Ehime University has also observed multilayer water temperature since 2008. In the present study, we analyze the deepest data at each station to understand the characteristics of the BI. We defined the BI as follows. Water temperature continually drops for 30 hours and its drop range is more than 0.5 ℃. At first, we analyzed water temperature data at 60 m depth in Uchiumi from 1997 to 2011. The BI occurred evenly in every moon age, we could not recognize the relation between BI and neap tide as Kaneda et al, (2002) pointed out. In addition, such kind of relation was not seen in other stations except in Yusu. Water temperature drops in Uchiumi were from 0.5 –7.0 ℃. We thought range of water temperature drop might affect to the relation. Therefore, we divided two cases, drop range is more or less than 2 ℃. We could not see the relation of neap tide in both cases. Furthermore, we investigated the relation between the BI and neap tide in each year, but we could not recognize the relation.

From the above analysis, it was found that the BI occurs without relation of moon age. However there is the relation only in Yusu. A vertical mixing area is located west of Yusu. Therefore, the BI might be blocked by the strong mixing associated with spring tide. This is why the BI occurs in neap tide in Yusu. Kaneda et al., (2002) clearly showed the relation between BI and moon age. The relation at Uchiumi was for only two years of 17 years. We will discuss why there was the relation in 1995-1996.

Keywords: Bottom Intrusion, Bungo Channel

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Role of Kuroshio Current in fish resource variability off southwest Japan

*Yushi Morioka[1], Sergey Varlamov[1], Yasumasa Miyazawa[1]

1. Japan Agency for Marine-Earth Science and Technology

Western boundary currents in the subtropics play a pivotal role in transporting warm water from the tropics that contribute to development of highly diverse marine ecosystem in the coastal regions. As one of the western boundary currents in the North Pacific, the Kuroshio Current (hereafter the Kuroshio) exerts great influences on biological resource variability off southwest Japan, but few studies have examined physical processes that attribute the coastal fish resource variability to the basin-scale Kuroshio variability. Using the high-quality fish catch data and high-resolution ocean reanalysis results, this study identifies statistical links of interannual fish resource variability off Sukumo Bay, Shikoku island of Japan, to subsurface ocean temperature variability in the Kuroshio. The subsurface ocean temperature variability off the south of Sukumo Bay exhibits vertically coherent structure with sea-surface height variability, which originates from the westward-propagating oceanic Rossby waves generated through surface wind anomalies in the Northwest Pacific. Although potential sources of the atmospheric variability remain unclarified, the remotely-induced oceanic Rossby waves contribute to fish resource variability off Sukumo Bay. These findings have potential applications to other coastal regions along the western boundary currents in the subtropics where the westward-propagating oceanic Rossby waves contribute to the coastal ocean temperature variability.

Keywords: Kuroshio, Fish catch variability, Sukumo Bay

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Mon. May 27, 2019 1:45 PM - 3:15 PM JST | Mon. May 27, 2019 4:45 AM - 6:15 AM UTC | 102 1F

[A-OS13] Ocean circulation and material cycle in coastal seas

convener:Kiyoshi Tanaka(University of Tokyo), Akihiko Morimoto(Ehime University), Yuichi Hayami(Saga University), Kazuhiko Ichimi(Seto Inland Sea Regional Research Center, Kagawa University), Chairperson:Akihiko Morimoto, Yuichi Hayami

Coastal seas have high biodiversity and high productivity, while various environmental problems such as eutrophication, red tide, and hypoxia are caused by human activity. In order to understand material cycle and various phenomena and to maintain sustainable environment in coastal seas, interdisciplinary research is needed. In the present session, we invite researchers who are interested in physical phenomena, material cycle, biological responsive dynamics, and their interactions in coastal seas. Neither study area nor study method is confined. We welcome presentations of wide-range topics to communize our knowledge in coastal seas.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[AOS13-07] Variation in hypoxic water mass in Ariake Sea -what consumed the dissolved oxygen?-

*Yuichi Hayami[1], Naoki Fujii[1], Hiroyuki Takasu[2], Yu Umezawa[3], Minoru Wada[2] (1.Saga University, 2.Nagasaki University, 3.Tokyo University of Agriculture and Technology)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[AOS13-08] Influence of Nori aquaculture-induced change in light environment on phytoplankton dynamics

*Naoya Minamiura[1], Soichi Yamaguchi[1] (1.Kyushu University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[AOS13-09] **Enhanced West Philippine Sea intrusion diminishes hypoxia conditions in the Pearl River estuary**

*Hon-Kit Lui[1,2], Chen-Tung Arthur Chen[1], Wei-Ping Hou[2], Jian-Ming Liau[2] (1.Department of Oceanography, National Sun Yat-sen University, 2.Taiwan Ocean Research Institute, National Applied Research Laboratories)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[AOS13-10] North Pacific seawater radiocarbon recorded in abalone shells obtained from Otsuchi Bay, Japan

*Ota Kosuke[1], Yusuke Yokoyama[1,2], Yosuke Miyairi[2], Jun Hayakawa[2], Naomi Sato[2], Hideki Fukuda[2], Kiyoshi Tanaka[2] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2.Atmosphere and Ocean Research Institute, The University of Tokyo)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[AOS13-11] Spreading of Radioactive Cesium off Joban coast through Large River Discharge

*Kiyoshi Tanaka[1], Seiya Nagao[2], Yujiro Kitade[3], Masato Niki[4], Takaaki Katsumata[4], Toru Miyama[5] (1.University of Tokyo, 2.Kanazawa University, 3.Tokyo University of Marine Science and Technology, 4.Tokai University, 5.Japan Agency for Marine-Earth Science and Technology)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[AOS13-12] Development of a river-ocean seamless model for simulating river discharges around Kyushu

*Takahiro Tsutsumi[1], Shinichiro Kida[2], Ryusuke Kuroki[3], Yosuke Alexandre Yamashiki[3] (1.Interdisciplinary Graduate School of Engineering Science, Kyushu University, 2.Research Institute for Applied Mechanics, Kyushu University, 3.Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University)

Variation in hypoxic water mass in Ariake Sea -what consumed the dissolved oxygen?-

*Yuichi Hayami[1], Naoki Fujii[1], Hiroyuki Takasu[2], Yu Umezawa[3], Minoru Wada[2]

1. Saga University, 2. Nagasaki University, 3. Tokyo University of Agriculture and Technology

In the inner most area of Ariake Sea, the estuarine circulation is dominated in summer. Therefore, the suspended material is transported toward offshore in the surface layer and toward inward and accumulated in the bottom layer. Simultaneously, there is a conspicuous spring-neap variation where stratification is enhanced and bottom water hypoxia develops in neap tide and stratification is reduced and hypoxia is moderated in spring tide. However, it was not clarified that such variation in hypoxia was driven only by the physical process or affected by some biological process such as biological oxygen demand. In order to clarify the variation in mass transport and ecosystem, we made surveys in the inner most area of Ariake Sea in the summer of 2018. We made 6 transect surveys with a boat during a spring-neap cycle during continuous measurements of temperature, salinity, currents, DO and turbidity with moorings.

During the mooring observation period, as a typhoon attacked Ariake Sea on 27 July, most of the mooring instruments were once recovered. The surface mooring instruments was set again on 30 July, and other ones were set again on 1 August. Another typhoon attacked on 14 August but the mooring observation was continued. Between these 2 typhoons, transect surveys were conducted on 1, 5, 8 and 12 August during low tide. It was in neap tide on 5 August and in spring tide on 12 August. The water column was well mixed in the morning of 1 August at the mooring station (Stn. 3) due to strong tidal mixing in spring tide and wind induced mixing by the typhoon. The temperature decreased and salinity increased in the bottom layer toward neap tide. Stratification was strongest on 8 August. Then the stratification became weaker and the water column was entirely mixed again on 11 August. The bottom water DO decreased from 1 August and became lower than 3 mg/L on 4 August. The bottom DO was kept lower than 3 mg/L until 10 August. In the surface layer, the bloom of *Chattonella* sp. occurred from late July. It continued at least until 13 August. The results of the transect survey indicated that the cold and saline water intruded from offshore to enhance the stratification and formed hypoxic water mass. On 12 August, stratification weakened and the hypoxic water mass was disappeared in the coastal area. But, in the offshore area, weak hypoxic water mass was formed. High turbidity layer was formed over the bottom in the coastal area on 1 August. But the turbidity decreased on 5 and 8 August. The turbidity increased again and became highest on 12 August. The experiment to estimate the oxygen demand of the bottom water was conducted on the each survey day. The oxygen demand decreased from 1 to 5 August then increased and became maximum on 12 August. In order to estimate the contribution of bacterial respiration and chemical oxygen consumption to the total oxygen demand in water, we made incubation experiment with Chloramphenicol and formalin. Chloramphenicol was added to stop the bacterial respiration. Formalin was added to measure the chemical oxygen consumption. The bacterial respiration occupied about 80 % of the total oxygen demand on 6 August. However, almost all the oxygen demand was occupied by the respiration except for the bacterial respiration on 13 August. There was almost no chemical oxygen demand on each date. There was a high correlation between chlorophyll a concentration and oxygen demand (R=0.90). There was a correlation between turbidity and oxygen demand. But it was weaker than chlorophyll a (R=0.61).

The hypoxic water mass was generated by the cold and saline water intrusion occurred between spring

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tide and neap tide. However, the oxygen demand in the bottom water decreased in this period. It indicated that the formation of hypoxia was generated by the physical process and the change in oxygen demand did not affected. The oxygen demand in spring tide was larger than in neap tide. It would be due to the active resuspension of organic matter by the strong tidal mixing. There was a high correlation between chlorophyll a and oxygen demand of water. But most of the oxygen demand when the hypoxic water mass was formed was bacterial respiration. The contribution of the phytoplankton respiration was small. They suggested the oxygen demand was mainly generated by the decomposition of organic matter derived from phytoplankton by bacteria. The red tide of *Chattonella* sp occurred continuously during the observation period. The maximum chlorophyll a concentration reached 72.3 ug/L. The organic matter supply from the red tide would fuel the oxygen consumption in the bottom layer.

Keywords: Ariake Sea, hypoxia, spring-neap variation, water oxygen demand, Chattonella red-tide

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Influence of Nori aquaculture-induced change in light environment on phytoplankton dynamics

*Naoya Minamiura[1], Soichi Yamaguchi[1]

1. Kyushu University

In the Ariake Sea in winter, Nori aquaculture is conducted actively, and its production is the largest in Japan. On the other hand, color bleaching of Nori due to red tide occurrence has become a big problem. From previous research, it is known that the red tide occurrence involves the improvement of the light environment. At the time of Nori aquaculture season, Nori aquaculture net is set densely in the coastal area, and leaf blade is attached to the net and it grows. It can be easily imagined that such net and leaf blade have great influence on the light environment in water, but there are no examples studied so far. In this study, by continuous on-site observation of the photon quantum amount in the Nori aquaculture area and the non-Nori aquaculture area, the influence of Nori aquaculture on the light environment is evaluated, and the influence is evaluated by dynamic growth of leaf blade as a function. We investigated how phytoplankton dynamics by incorporating these results into numerical simulation changes.
We installed a photon meter (DEFI2-L by JFE Advantech Co., Ltd.) and pressure gauge (DEFI2-D10 by JFE Advantech Co., Ltd.) respectively in the sea area just under the Nori aquaculture and in the non-Nori aquaculture area possessed by the Saga Prefecture Fisheries Experiment from January 15 to 25 in 2019. This continuous observation was carried out at 5 second intervals. As a result of the observation, it was revealed that the photon quantum amount decreased by about 75% on average just under Nori aquaculture area. The reduction of this photon (light shielding factor y) was expressed as a function of the leaf length (x unit: cm), and the following equation was obtained.

$y=0.86e^{-0.1\times x}$

Next, we developed a numerical ecosystem model that takes this light shielding factor into consideration and examined how it affects phytoplankton dynamics. Calculation was carried out separately into two patterns with and without light shielding factor in Nori aquaculture area. In consideration of the light shielding factor, the phytoplankton biomass was reduced in the vicinity of the Nori aquaculture area in the inner part of Ariake sea, compared to the case without consideration. This indicates that Nori aquaculture suppresses the growth of phytoplankton by deteriorating the light environment in water.

Keywords: Aquaculture, Ariake Sea, Light environment

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Enhanced West Philippine Sea intrusion diminishes hypoxia conditions in the Pearl River estuary

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1. Department of Oceanography, National Sun Yat-sen University, 2. Taiwan Ocean Research Institute, National Applied Research Laboratories

The hypoxia condition (dissolved oxygen <2 mg/L) in the Pearl River estuary is worsening in the past decade, partly due to the rising anthropogenic activities. For instance, excess nutrients cause enhanced biological productivity in the surface ocean. Yet, dead phytoplankton sink to the bottom of the coastal zone, where they decompose and consume oxygen. If the oxygen consumption rate exceeds the supply rate, then hypoxia or even anoxia may develop, leading to so-called dead zones. Here we show that a strong invasion of high dissolved oxygen but low nutrients West Philippine Sea seawater into the South China Sea in the form of Kuroshio occurred around 2003-2004. Apparently due to the oxygen supply carried by the remnants of the intruded Kuroshio, little hypoxia developed off the Pearl River estuary, where the anoxic condition develops in some years with weak Kuroshio intrusion.

Keywords: hypoxia, Kuroshio, Pearl River estuary, West Philippine Sea, intrusion, South China Sea

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North Pacific seawater radiocarbon recorded in abalone shells obtained from Otsuchi Bay, Japan

*Ota Kosuke[1], Yusuke Yokoyama[1,2], Yosuke Miyairi[2], Jun Hayakawa[2], Naomi Sato[2], Hideki Fukuda[2], Kiyoshi Tanaka[2]

1. Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2. Atmosphere and Ocean Research Institute, The University of Tokyo

Reconstructing past ocean currents in the coastal regions is needed to better understand the relationship between oceanographic changes and coastal ecosystems. Seawater radiocarbon is a unique proxy to understand the properties of water masses. However, the knowledge of the water mass distribution is limited to the low latitude regions as the only well-established proxy for it is reef-building corals. Alternative archives are required for high latitude regions. Here we measured $\Delta^{14}C$ values of three abalone shells using accelerator mass spectrometry (AMS) and counted the shell growth checks which were made in the winter season. Abalone shells were obtained from Otsuchi Bay, where the cold Oyashio Current and the warm Kuroshio Current converge. The Oyashio Current has more depleted radiocarbon than the Kuroshio Current. We compared $\Delta^{14}C$ values of abalone shells with the sea surface temperature anomaly in Sanriku region. $\Delta^{14}C$ values of abalone shells range from 5.4 ‰to 31‰ and indicated seasonal variations. $\Delta^{14}C$ values decreased by about 5 ‰in shell growth checks that indicates winter season.We found this decrease of $\Delta^{14}C$ values of abalone shells are consistent with the significantly mixing of water brought by the Oyashio Current. $\Delta^{14}C$ value of abalone shells clearly shows the Oyashio Current inflow in 2013, 2015 and 2017 and it can be used to reconstruct fluctuations between past water masses. In addition, the $\Delta^{14}C$ values of abalone shells are possibly affected by their habitat. Abalone at 2 m to 6 m depth exhibited higher $\Delta^{14}C$ values than those in abalone at 6 m to 10 m depth. This trend resulted from cold water from the Oyashio Current having a greater influence on deeper water. These radiocarbon records indicate past seawater conditions in northern Japan, where the Oyashio and Kuroshio currents converge, can be reconstructed using abalone shells.

Keywords: Radiocarbon, AMS, Abalone, Otsuchi Bay, Oyashio Current, Ocean circulation

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Spreading of Radioactive Cesium off Joban coast through Large River Discharge

*Kiyoshi Tanaka[1], Seiya Nagao[2], Yujiro Kitade[3], Masato Niki[4], Takaaki Katsumata[4], Toru Miyama[5]

1. University of Tokyo, 2. Kanazawa University, 3. Tokyo University of Marine Science and Technology, 4. Tokai University, 5. Japan Agency for Marine-Earth Science and Technology

A hydrographic observation was conducted off the Joban coast during September 7 to 12, 2011 (six months after the 2011 Great East Japan Earthquake), using a CTD profiler and a ship-mounted ADCP (R/V Tansei-Maru cruise KT-11-22). At the same time, water-samplings for radioactive cesium measurements were conducted at a depth of 10 m. The radioactivity of cesium (134Cs and 137Cs) was measured for the AMP/Cs compound using gamma-ray spectrometry at the Low Level Radioactivity Laboratory of Kanazawa University. There was a negative correlation between the radioactive cesium and salinity in the sea surface (at the depth of 10 m), indicating more radioactive cesium was included in less saline water. Abundant freshwater is discharged from three large rivers (Tone, Naka, and Kuji Rivers) into the observational area. What is important is that several days before the observation, there was extremely heavy rainfall in the upper reaches of the rivers, which resulted in that discharge of the Tone River exceeded 2000 m^3/s on September 4. Therefore, it was suggested that the highly concentrated radioactive cesium in the sea surface originated from the land through the rivers. Moreover, it was shown that spreading of the river water and radioactive cesium is strongly influenced by the Kuroshio Current.

Keywords: radioactive cesium, river discharge, 2011 Great East Japan Earthquake, off the Joban coast

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Development of a river-ocean seamless model for simulating river discharges around Kyushu

*Takahiro Tsutsumi[1], Shinichiro Kida[2], Ryusuke Kuroki[3], Yosuke Alexandre Yamashiki[3]

1. Interdisciplinary Graduate School of Engineering Science, Kyushu University, 2. Research Institute for Applied Mechanics, Kyushu University, 3. Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University

Regional-scale torrential rainfalls cause river discharges that are capable of abruptly changing the oceanic condition over a wide area. It is necessary to simultaneously solve multiple rivers for capturing such events that are also often associated with flooding over land. Many coastal areas are also affected by multiple rivers but many of the conventional river-models to simulate the influence of rivers on a regional scale. The object of this research is to develop a river-ocean seamless model for simulating river discharges around Kyushu during and after weather events. By using an Isopycnal-Layered model following Kida and Yamashiki (2015), we developed a model that focuses on the island of Kyushu and the heavy rain event in September 2015. The model reproduces the increase in river flow due to the heavy rain and when compared to observations, we found some rivers to show slow water propagation speed from upstream to downstream, while some rivers reproduce the actual observation well. We plan to conduct a sensitively experiment to verify the cause behind this difference in the reproducibility of the model.

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Mon. May 27, 2019 3:30 PM - 5:00 PM JST | Mon. May 27, 2019 6:30 AM - 8:00 AM UTC | 102 1F

[A-OS15] Freshwater discharge through rivers and estuaries to the ocean

convener:Shinichiro Kida(Research Institute for Applied Mechanics, Kyushu University), Dai Yamazaki(Institute of Industrial Sciences, The University of Tokyo), Yosuke Alexandre Yamashiki(Earth & Planetary Water Resources Assessment Laboratory Graduate School of Advanced Integrated Studies in Human Survivability Kyoto University), Humio Mitsudera(Institute of Low Temperature Science, Hokkaido University), Chairperson:Shinichiro Kida(RIAM, Kyushu University), Humio Mitsudera(Hokkaido University, Institute of Low Temperature Science), Yosuke Yamashiki(GSAIS Kyoto University)

The water cycle from land to the ocean involves complex dynamics of rivers and buoyancy driven flows in estuaries and the ocean. Recent progress in satellite observations and numerical models are beginning to illuminate how this water cycle occurs on various time scales globally and regionally. This session welcomes various process studies that investigate the dynamics and material circulation related to the freshwater cycle from land to the ocean such as surface runoff, river transport, estuarine circulation, and coastal river plumes based on numerical, observational, or theoretical studies.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[AOS15-01] The forefront research for flow and water quality estimations in coastal area using geo-stationary and polar orbital satellites data

★Invited Papers

*Yuji Sakuno[1] (1.Graduate School of Engineering, Hiroshima University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[AOS15-02] Rainfall-Runoff-Inundation Processes and Modeling in a Humid Tropical River Basin

★Invited Papers

*Takahiro Sayama[1], Kodai Yamamoto[2], Ryoko Araki[2], Apip Apip[3], Eva Mia Siska[1], Kaoru Takara[4] (1.Disaster Prevention Research Institute, Kyoto University, 2.Graduate School of Engineering, Kyoto University, 3.LIPI, Indonesia, 4.Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[AOS15-03] Role of river inflows from Kamchatka Peninsula in the Okhotsk Sea

*Toru Miyama[1], Humio Mitsudera[2] (1.Application Laboratory, Japan Agency for Marine-Earth Science and Technology, , 2.Institute of Low Temperature Science, Hokkaido University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[AOS15-04] CHLOROPHYLL ESTIMATION OF LAKE AND COASTAL WATER USING REMOTE SENSING APPROACH

*Shweta Yadav[1], Yamashiki Yosuke[1], Junichi Susaki[1], Kanako Ishikawa[2], Yoh Yamashita[1] (1.Kyoto University, 2.LBERI)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[AOS15-05] Maritime-continent coastal region as land-sea-air triple boundary layer and bio-anthroposphere

*Manabu D. Yamanaka[1] (1.Research Institute for Humanity and Nature / Professor Emeritus of Kobe University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[AOS15-06] River-ocean interaction at the Ganges-Brahmaputra river mouth

*Shinichiro Kida[1], Dai Yamazaki[2] (1.Research Institute for Applied Mechanics, Kyushu University, 2.Institute of Industrial Sciences, The University of Tokyo)

The forefront research for flow and water quality estimations in coastal area using geo-stationary and polar orbital satellites data

*Yuji Sakuno[1]

1. Graduate School of Engineering, Hiroshima University

Continuous estimation of the flow velocity and water quality distribution in a wide area at high resolution is extremely important in order to understand the natural phenomena occurring at the interface between the river and the ocean. In recent years,satellite remote sensing is expected as a powerful tool to grasp such phenomena. In this presentation, a case study of flow velocity estimation using the stationary meteorological satellite "Himawari-8" data, which observes sea surface temperature (SST) at 10 minute intervals at first. A strong flow velocity distribution of about 0.5 m/s was detected by applying the image correlation method to continuous SST images in the southern part of the Lombok Straits of Indonesia in the study area. Such a method can measure the flow velocity distribution of wide channel at low cost, so it is particularly effective in waters where there is a remarkable water temperature difference. Meanwhile, the heavy rain in western Japan occurred in July 2018, and a large amount of sediment from the land flowed out to the Seto Inland Sea. As a result, oyster beds for aquaculture were broken or red tide damage caused by a large amount of nutrient salt was occurred. The state of such huge flood were monitored by the polar orbital earth observation satellite such as Landsat-8, Sentinel-2 (10 m to 30 m spatial resolution) and GCOM-C (250 m spatial resolution). The polar orbital satellite has lower observation frequency than geostationary satellite, but there is an advantage that detailed distribution of sediment discharge from river and red tide distribution can be visualized. Combining such stationary / polar orbital satellite data, measured data, numerical model and other technologies will make it possible to monitor coastal environments connecting the open ocean and rivers more quickly and in detail in the future.

Keywords: satellite, flow, water quality

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Rainfall-Runoff-Inundation Processes and Modeling in a Humid Tropical River Basin

*Takahiro Sayama[1], Kodai Yamamoto[2], Ryoko Araki[2], Apip Apip[3], Eva Mia Siska[1], Kaoru Takara[4]

1. Disaster Prevention Research Institute, Kyoto University, 2. Graduate School of Engineering, Kyoto University, 3. LIPI, Indonesia, 4. Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University

Large-scale plantations of palm and acacia trees have caused 50 % reduction of natural forests in the 25 years between 1985 to 2009 in Sumatra, Indonesia. Deforestation of natural forest might have changed water cycle in the area including runoff and evapotranspiration, which may lead to possible changes in flood and drought conditions. Downstream parts of river basins in Sumatra spreads wetlands with rich ecosystems, though such environment have degraded due to land cover changes over the last few decades to agricultural areas. Drying the wetlands by drainage for rice cropping and other agricultures caused various issues including peatland fire and haze in surrounding regions. In addition to the land cover change, climate change may give significant impact on the hydrologic cycle in this region. Climate change in humid tropical region in South East Asia has been difficult to be predicted due to local atmospheric cycle. Furthermore, hydrologic process understandings and their representations by simulation models are the important scientific step toward adequate assessment of land cover and climate changes. Among various hydrologic processes, rainfall-runoff processes in tropical climate conditions characterized also by deep weathered soil layers have been poorly understood. Our study is conducted based on field investigation with respect to rainfall-runoff processes in the mountainous hillslope in Sumatra to understand the fundamental characteristics of rainfall-runoff in this region, and to represent the feature particularly with a thick soil layer, in our distributed hydrologic model. After the calibration and validation of the model at the river basin scale in the Batanghari River basin, we assess the impact of the climate change by inputting the rainfall.

Some findings from the field monitoring are summarized below. According to a simple cone penetration experiment, the soil depths in the hillslope were estimated to be about 1.5 ~ 4.5 meters. Furthermore, the soil sample experiment at surface, 30 cm and 60 cm depths showed that saturated hydraulic conductivities were as high as 7,200 mm/h while the volumetric water content maintain also high (0.45~0.50) with negative suction between 1~10 m. Such characteristics should be explained due to the aggregated soil in humid tropics. In our site, the foot of the slope (SK1) has thicker soil layer (4.5 m), while it is reduced to 1.5 m about 20 m upstream along the hillslope (SK3). Groundwater table exists at the depths of about 3 ~ 4 m depth consistently at SK1 (bottom) and SK2 (middle) and the groundwater table responses rapidly to rainfall. With the high saturated hydraulic conductivity and high infiltration rate, especially in the natural forest area, we conceptualize the rainfall-runoff in this region is dominated by fairly quick vertical infiltration into the thick soil layer and the recharge to the groundwater table. Based on the above process understandings, we represent the process in the Rainfall-Runoff-Inundation (RRI) model to the entire Batanghari River basin to simulate streamflow at the river basin scale.

Keywords: Tropical Forest, Rainfall-Runoff, RRI Model, Landuse Change, Climate Change, Sumatra Island

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Role of river inflows from Kamchatka Peninsula in the Okhotsk Sea

*Toru Miyama[1], Humio Mitsudera[2]

1. Application Laboratory, Japan Agency for Marine-Earth Science and Technology, , 2. Institute of Low Temperature Science, Hokkaido University

The Okhotsk Sea is a unique ocean in that sea ice forms at the lowest latitude in the world. The sea ice formation plays important roles in water mass formations not only in the Okhotsk Sea but also in the North Pacific Ocean. The river inflows from the surrounding coasts affect the sea ice formation by changing stratification. Especially, the contribution from the river inflow from the Amur River on the western side of the Okhotsk Sea has been widely discussed. The roles of the Amur River in chemical and biological cycles have been also investigated. On the hand, the role of the river inflows from the Kamchatka Peninsula on the eastern side of the Okhotsk Sea is not well known.
In this study, we simulated the northern part of the Okhotsk Sea to investigate the roles of river inflows from the Kamchatka Peninsula. FVCOM (Finite-Volume, Primitive equation Community Ocean Model; Chen et al. 2003) was used. JRA55-do (Tsujino et al., 2018) was used for the atmospheric forcing. The river inflow dataset also came from JRA55-do based on Suzuki et al. (2017). The unstructured horizontal grid spacing was decreased from about 9.0 km at the southern boundary to about 1.4 km along the northern boundary.
The model runs with and without the river inflows from the Kamchatka Peninsula were compared. The salinity significantly increased without the river inflow along the coast of Kamchatka (by more than 1 unit at maximum). The salinity increase also spread toward the western Okhotsk Sea. With these changes in salinity, ice formation in the Okhotsk Sea was also affected.

Keywords: Okhotsk Sea, sea ice, river inflow

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CHLOROPHYLL ESTIMATION OF LAKE AND COASTAL WATER USING REMOTE SENSING APPROACH

*Shweta Yadav[1], Yamashiki Yosuke[1], Junichi Susaki[1], Kanako Ishikawa[2], Yoh Yamashita[1]

1. Kyoto University, 2. LBERI

Chlorophyll-a is an optically active compound (OAC) commonly used as a proxy for phytoplankton biomass in an aquatic environment. Retrieving the concentration of chlorophyll-a remains a challenge due to the presence of several OAC particularly in water bodies which are in proximity to the land-based activities. In this study, an effort has been made to estimate the chlorophyll-a concentration of both the freshwater Lake Biwa and the coastal water of Wakasa Bay in Japan. A spectral decomposition algorithm was used to determine the chlorophyll-a using the satellite images. The algorithm was applied to the satellite images from two different sensors namely Landsat-8 /OLI and Sentinel-2A/MSI. The satellite-derived chlorophyll-a concentration for the lake and coastal water from two different sensors were compared to assess the performance of both the sensors. The accuracy of the chlorophyll-a results derived from the images was evaluated with the in-situ measurement data of the chlorophyll-a for the Lake Biwa and the coastal water of Wakasa Bay. Both satellite sensors appear to give the best results for the coastal water ($R^2 > 0.80$) with an RMSE < 0.3 μg/L. However, slight underestimation of chlorophyll-a noted for the Landsat-8 image with an increase in chlorophyll-a concentration. For the lake water, Sentinel-2A results were relatively better ($R^2 > 0.70$) than Landsat-8, with an RMSE of < 1.0 μg/L. The obtained results will be useful to evaluate the primary productivity of both freshwater and coastal water body.

Keywords: Chlorophyll-a, Lake and Coastal Water, Satellite-Remote Sensing

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Maritime-continent coastal region as land-sea-air triple boundary layer and bio-anthroposphere

*Manabu D. Yamanaka[1]

1. Research Institute for Humanity and Nature / Professor Emeritus of Kobe University

Imbalance of radiative processes determining climate is compensated by atmospheric-oceanic circulations and latent heating. The latent heat generated mainly by equatorial cumulonimbus clouds concerns both overheating and circulation pumping. Since the equatorial atmosphere is almost free from Coriolis force making cyclones, the diurnal-cycle sea-land heat contrast is the most principal mechanism to generate cumulonimbus and thus rainfall. The earth’ s longest coastline of Indonesian maritime continent (IMC) generates the largest regional rainfall and latent heat controlling the global climate (Yamanaka et al., 2018, *Prog. Earth Planet. Sci.*, **5**(21), 1-28). Massive fresh water sustains the biosphere with biodiversity over the peatland of major islands of the IMC, which also concern the carbon cycle through making peats and coals as geologically long-term reservoirs. We homo sapiens originated from the tropical Africa and evacuated to the temperate zone, where coexistence with other species was easier and thus proliferation and civilization were achieved with making the tropics a field for grabbing both alive and fossilized bio-resources. On one hand, the human population is governed by the rain water for survival, agricultural and industrial use. On the other hand, the human activity after the industrial revolution has been consuming the fossil fuels, and has been modifying the peatland for plantations, which release massive greenhouse gases. Such interactions are being studied mainly in the eastern coast of Sumatera and the southern coast of Kalimantan, under an interdisciplinary project (RIHN Tropical Peatland Society Project, 2017-21). Based on rainfall variabilities of mesoscale (with radars, and as functions of coastal distance), intraseasonal to interannual scales (based on operational data) and interdecadal to centennial scales (by historical data rescue), we may discuss a “saturation” of anthroposphere in the tropical coastal region such as the IMC peatland.

Keywords: cosatal region, sea-land breeze and monsoon circulations , hydrologic cycle, bio-anthroposphere, maritime-continent peatland

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River-ocean interaction at the Ganges-Brahmaputra river mouth

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1. Research Institute for Applied Mechanics, Kyushu University, 2. Institute of Industrial Sciences, The University of Tokyo

The Ganges-Brahmaputra river is a major source of freshwater for the Bay of Bengal. River discharge occurs through the Ganges-Brahmaputra Delta, which consists of multiple river mouths. The seasonal cycle of this river discharge is observed with a minimum from late winter to early spring and a maximum from late summer to early fall. The seasonal cycle of the sea surface height for the Bay of Bengal, on the other hand, shows the presence of the Kelvin waves propagating from the equatorial Indian Ocean. We investigated how these two processes may interact at the river mouths based on a high-resolution numerical model that resolves the various channels of the Ganges-Brahmaputra Delta. The model simulates the basic seasonal cycle of the river discharge that is comparable to observations, with a river plume forming from the major river mouth and along the coast. Preliminary results suggest significant river-ocean interaction in narrow channels and, at times, reverse the direction of the river flow.

Keywords: River discharge, water cycle, Bay of Bengal

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Mon. May 27, 2019 3:30 PM - 5:00 PM JST | Mon. May 27, 2019 6:30 AM - 8:00 AM UTC | 303 3F

[A-OS16] Chemical and Biological Oceanography

convener:Namiha Yamada(National Institute of Advanced Industrial Science and Technology), Sayaka Yasunaka(Japan Agency for Marine-Earth Science and Technology), Hiroaki Saito(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Tsuneo Ono(Japan Fisheries Research and Education Agency), Naohiro Kosugi(気象研究所)

This session invites presentations on a wide variety of topics related to chemical and biological oceanography.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[AOS16-01] Variability of the growth rate for dissolved inorganic carbon in surface seawater along the 165°E line

*Chiho Tanizaki[1], Hisashi Ono[2], Masao Ishii[2], Atsushi Kojima[1], Shinji Masuda[1], Kazutaka Enyo[1], Daisuke Sasano[1], Toshiya NAKANO[1] (1.Japan Meteorological Agency, 2.Meteorological Research Institute, Japan Meteorological Agency)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[AOS16-02] Seasonal variations of oceanic CO_2 disequilibrium and anthropogenic CO_2 in the subarctic North Pacific

*Bofeng Li[1], Shukuta Satori[1], Kasai Hiromi[2], Hiroshi Kuroda[2], Taniuchi Yukiko[2], Daisuke Hasegawa[3], Yutaka Watanabe[1] (1.Hokkaido University, 2.Hokkaido National Fisheries Research Institute, Japan Fisheries and Education Research , 3.Tohoku National Fisheries Research Institute, Japan Fisheries and Education Research)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[AOS16-03] An evaluation of current and future ocean acidification based on pCO_2 database around Okinawa Island

*Naohiro Kosugi[1], Hiroyuki Tsujino[1], Masao Ishii[1] (1.Meteorological Research Institute)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[AOS16-04] Reconstruction of spatiotemporal change of anthropogenic fixed nitrogen in the western North Pacific

*Yutaka Watanabe[1], Kouichi Fujita[1], BOFENG LI[1] (1.Hokkaido University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[AOS16-05] On the mechanism of significant increasing trend of silicate in intermediate layer of Oyashio region

*Tsuneo Ono[1] (1.Fisheries Research and Education Agency)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[AOS16-06] Systematics of aluminum, manganese, iron, cobalt, and lead in the North Pacific Ocean observed during ocean-section study of GEOTRACES Japan

*Yoshiki Sohrin[1], Linjie Zheng[1] (1.Institute for Chemical Research, Kyoto University)

Variability of the growth rate for dissolved inorganic carbon in surface seawater along the 165˚E line

*Chiho Tanizaki[1], Hisashi Ono[2], Masao Ishii[2], Atsushi Kojima[1], Shinji Masuda[1], Kazutaka Enyo[1], Daisuke Sasano[1], Toshiya NAKANO[1]

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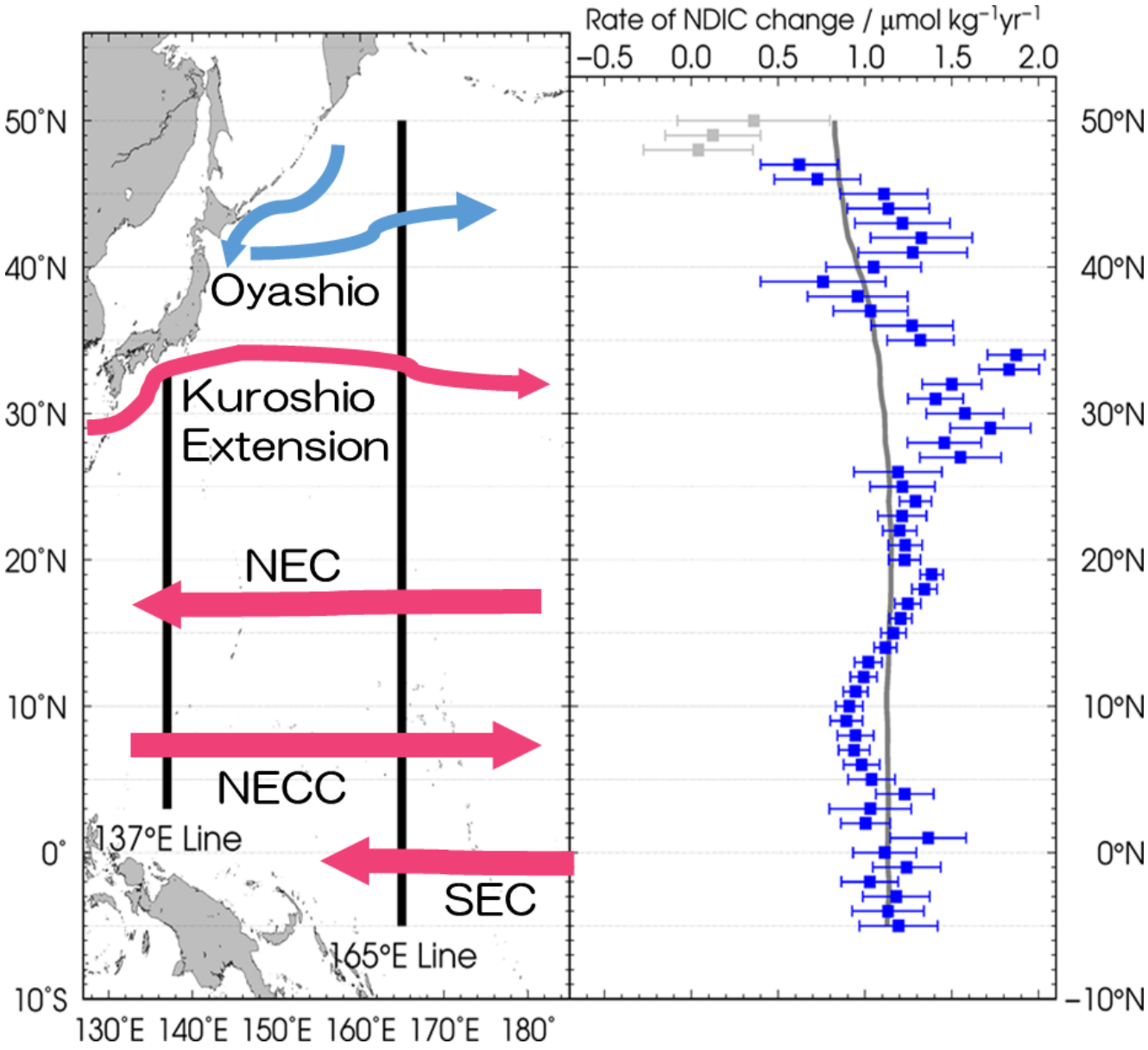
The atmospheric concentration of carbon dioxide (CO_2) has reached 146% of the pre-industrial level resulting from the increase of CO_2 emissions by human activities. On the other hand, the ocean has absorbed about 30% of the anthropogenic CO_2, which leads to the regulation of the atmospheric CO_2 increase (IPCC, 2013). Midorikawa et al. (2012) found that the increase of the partial pressure of oceanic CO_2 (pCO_2^{sea}) along 137˚E recently decelerates though that of atmospheric CO_2 accelerates. The variability of pCO_2^{sea} is affected by the changes in sea surface temperature and salinity, dissolved inorganic carbon (DIC), and total alkalinity, and the investigation of the DIC changes in the surface seawater helps us to understand the oceanic absorption of atmospheric CO_2. In this study, the variability of DIC in surface seawater is examined from subarctic to equatorial region along 165˚E, one of the repeat hydrographic sections of Japan Meteorological Agency (JMA).

Using the observation data collected by JMA’s Research Vessels in the 165˚E section and surface ocean CO_2 atlas (SOCAT) version 6, we calculated the mean trend of DIC in surface seawater during the period of 1996-2017. We found that DIC increases slower around 10˚N, and faster around 30˚N than atmospheric CO_2. Also, DIC growth rate is similar to the rate of atmospheric CO_2 increase in the equatorial region.

The variability of the DIC trend averaged for 10 years indicates that the DIC growth rate has increased in the equatorial region and decreased around 30˚N.

Keywords: 165˚E section, Dissolved Inorganic Carbon, growth rate

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Seasonal variations of oceanic CO_2 disequilibrium and anthropogenic CO_2 in the subarctic North Pacific

*Bofeng Li[1], Shukuta Satori[1], Kasai Hiromi[2], Hiroshi Kuroda[2], Taniuchi Yukiko[2], Daisuke Hasegawa[3], Yutaka Watanabe[1]

1. Hokkaido University, 2. Hokkaido National Fisheries Research Institute, Japan Fisheries and Education Research , 3. Tohoku National Fisheries Research Institute, Japan Fisheries and Education Research

Assuming that the CO_2 above the surface mixed layer depth (MLD) mixes very well with air, we used a simple and new method to estimate air-sea CO_2 disequilibrium value at the MLD (C_{diseq}) as follow [*Li et al.*, 2019];

$$C_{diseq} = C_{MLD} - C_{sat,\,MLD} - C_{soft,\,MLD} - C_{carb,\,MLD}$$

where C_{MLD} is the observed dissolved inorganic carbon (DIC); $C_{sat,\,MLD}$ is saturated DIC; $C_{soft,\,MLD}$ is derived from the remineralization of organic matter; $C_{carb,\,MLD}$ is derived from the dissolution of $CaCO_3$ in the MLD. We collected the DIC and total alkalinity (TA) samples in the subarctic North Pacific in four seasons, and measured all the DIC and TA by using semi-closed cell simultaneous method [*Li et al.*, 2016].

C_{diseq} in this region changed from −38.29 to −56.93 μmol kg^{-1} in wintertime and from −9.65 to 1.02 μmol kg^{-1} summertime, indicating a strong seasonal change in C_{diseq}. Appling these values of C_{diseq} to the approach for estimating C_{ant} in this region, we also found a strong seasonal variation in C_{ant}.

Keywords: Air-sea CO2 disequilibrium, Anthropogenic CO2, Subarctic North Pacific

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An evaluation of current and future ocean acidification based on pCO_2 database around Okinawa Island

*Naohiro Kosugi[1], Hiroyuki Tsujino[1], Masao Ishii[1]

1. Meteorological Research Institute

1. Introduction

Ocean acidification is caused by the dissolution of anthropogenic CO_2 into seawater. When CO_2 is dissolved in seawater, pH and the carbonate ion concentration decrease. A variety of marine organisms may be adversely affected since they use calcium carbonate as the main component of hard tissues such as shells and skeletons.

Coral reefs in the tropical zone are thought to be vulnerable to ocean acidification as they have a skeleton of aragonite which is a form of calcium carbonate. Ocean acidification will have adverse impacts on not only coral reefs but also whole tropical ecosystem since coral reefs are important for spawning, hatching, and habitat for many organisms.

Many coral reefs exist around Okinawa and bring a lot of benefits there by fishery and tourism. Geographically, coral reefs around Okinawa are located at the higher latitudinal area where the water temperature drops largely in winter.

In this study, we use the Surface Ocean CO_2 Atlas (SOCAT) database to evaluate the progress of ocean acidification around Okinawa from the 1980s to the present. Based on the results, we project the progress of acidification under future CO_2 concentration scenarios. This projection will reproduce seasonal variation in pCO_2 and aragonite saturation (Ω_A) there more realistically than existing predictions on a global scale.

2. Methods

The data of surface water temperature (SST), salinity (SSS) and pCO_2 around Okinawa (24-30˚N, 123-130˚E) were extracted from SOCAT database. We used the results of hydrographic observations conducted by the Japan Meteorological Agency in the same area between 2010 and 2017 in order to derive an empirical equation between salinity and total alkalinity (TA). Ω_A were calculated from pCO_2 and estimated TA using the CO2SYS program.

3. Results

In 1982-2016, pCO_2 showed a long-term trend of increase (Fig. a). At the same time, pCO_2 was high in summer and low in winter. Long-term and seasonal variation in pCO_2 was separated by using the method by Ishii et al., [2011]. As a result, the component of the long-term trend was +1.49±0.26 μatm/year (95% CI). This was as high as the rate of increase in atmospheric pCO_2 at Mauna Loa in Hawaii in the same period (+1.73±0.04 μatm/year).

TA was basically proportional to salinity (TA = 2297.1 / SSS * 35). In some areas near the shelf in the East China Sea, however, there was a positive anomaly from this relation. This may be due to the influence of river water originated from the Changjiang River. Another equation was applied (TA = 1347 + 897.6 / 34.2 * SSS) to the data to the north of 26˚N with SSS < 34.2 from July to September.

As for Ω_A, a long-term trend -0.0102±0.0018/year was calculated in the same manner as pCO_2. Previous studies showed that the coral reef habitat coincided with the area where Ω_A does not fall seasonally below 3.0 [Kleypas et al., 1999]. In the present situation, Ω_A around Okinawa island (SST > 21˚C in winter) was kept at 3.0 or more throughout the year.

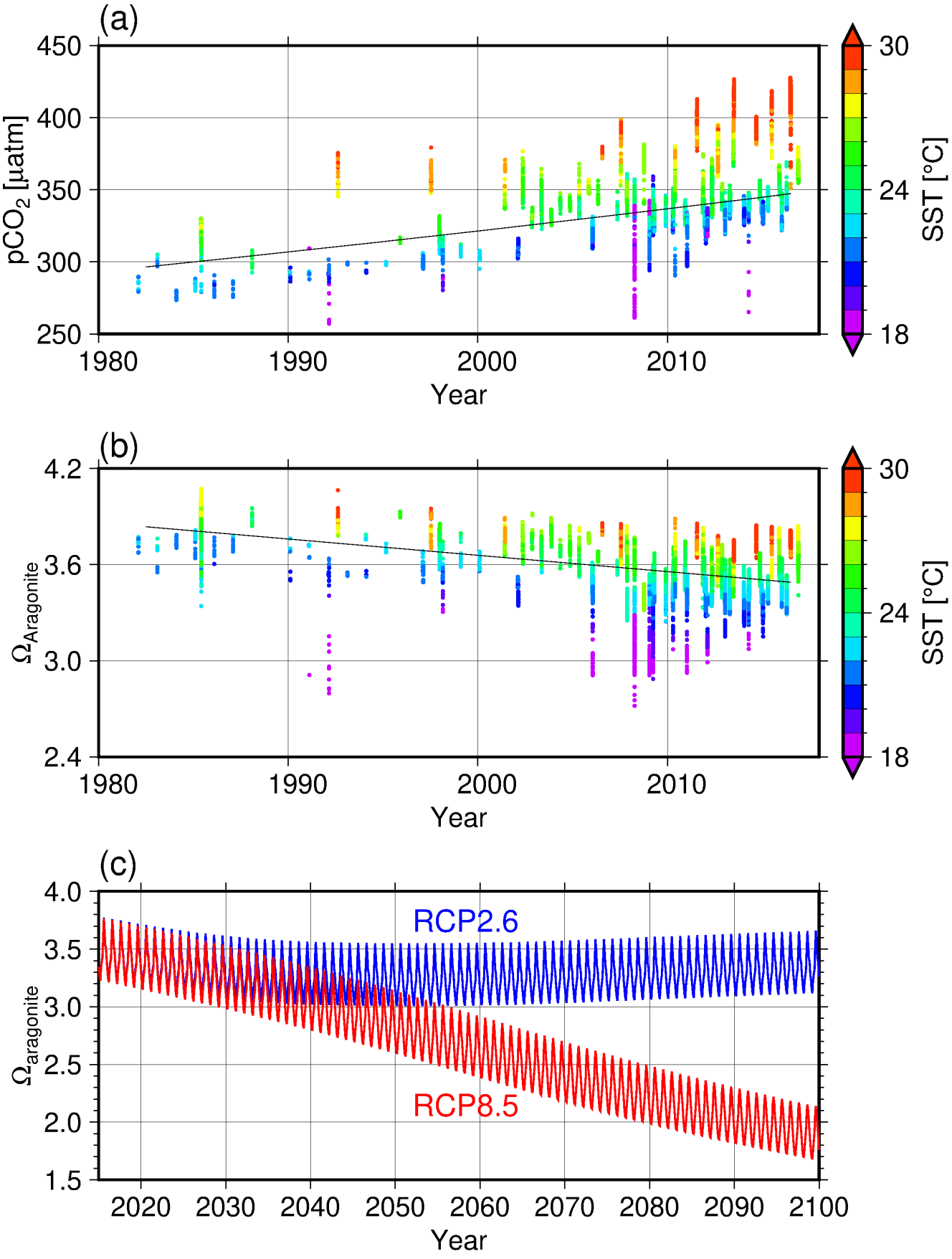
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4. Future projections
We can project the fluctuation in the ocean pCO_2 and Ω_A under future CO_2 concentration scenarios assuming that the current difference between in pCO_2 in the atmosphere and the ocean (ΔpCO_2) will not change in the future. Monthly ΔpCO_2 was averaged from the SOCAT database. CO_2 concentrations for the Representative Concentration Pathways (RCPs) were used to calculate atmospheric pCO_2 up to 2100 [Meinshausen et al., 2011]. Climatology of SST and SSS from 1982 to 2014 was calculated from Northwest Pacific Ocean Long-term Reanalysis Data Set (FORA-WNP30) and applied to the prediction. In the RCP 2.6 scenario, Ω_A will be at 3.0 or larger during this century. However, in the RCP 8.5 scenario, Ω_A will drop seasonally below 3.0 in the north of Okinawa island around 2030. In that scenario, Ω_A will be lower than 3.0 throughout the year in the 2060s (Fig. C). If the current increase in atmospheric CO_2 continues, coral reefs around Okinawa will be seriously affected by ocean acidification in the near future. On the other hand, there is a possibility that a suitable environment for coral reefs around Okinawa can be maintained under a strict emission reduction.

5. Figure captions
(a) pCO_2 around Okinawa during 1982-2016 from SOCAT database. SST is shown in color. Black line indicates the deseasonalized trend of pCO_2.
(b) Ω_A around Okinawa during 1982-2016 calculated from pCO_2 and estimated TA. SST is shown in color. Black line indicates the deseasonalized trend of Ω_A.
(c) Projected Ω_A in the coast of northern Okinawa Island (26.8˚N, 128.1˚E) during 2015-2100.

Keywords: ocean acidification, coral reef, SOCAT database, Future prediction

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Reconstruction of spatiotemporal change of anthropogenic fixed nitrogen in the western North Pacific

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1. Hokkaido University

We constructed parameterizations for the estimation of ocean fixed nitrogen (N) in the western North Pacific. Parameterizations (N_p), determined as a function of temperature (T), potential density (sigma-theta) and dissolved oxygen (DO), provided strong correlations with direct measurements for ocean nitrogen (N_p = −2.24T −4.70sigma-theta −0.0970DO + 182.2; the coefficient of determination (r^2) = 0.988; the root mean square error (RMSE) = 1.25 umol kg^{-1}). Predicted N values were consistent with previous independent hydrographic observations, generally within the above error. By applying T, sigma-theta and DO time-series data from ship observations to our parameterization, large seasonal variations in N were demonstrated in detail. Using the parameterization technique along with the time series of observed N (N_{obs}) found the significant increasing rate of oceanic anthropogenic fixed nitrogen (N_{anth}) in the past four decades in the western North Pacific subtropical region.

Keywords: anthropogenic fixed nitrogen, western North Pacific, parameterization

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On the mechanism of significant increasing trend of silicate in intermediate layer of Oyashio region

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A large multi-decadal increasing trend of Silicate was found in the intermediate later of Oyashio region [Whitney et al., 2013]. The rate of silicate increase was significantly rather than those observed in other nutrients under the asamption of normal Redfield ratio, but mechanism of such large Si increase has long remaind unknown.
Here, I demonstrate that the observed silicate increase can be exprained by the facts that 1)Rapid warming of intermediate waters of Okhotsk Sea had deepen isopycnal surfaces and 2)this causes steep increase of silicate concentration in the water that mixes with Oyashio waters on a same density surface.

Keywords: long-term trend, silicate, Oyashio, Okhotsk Sea

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Systematics of aluminum, manganese, iron, cobalt, and lead in the North Pacific Ocean observed during ocean-section study of GEOTRACES Japan

*Yoshiki Sohrin[1], Linjie Zheng[1]

1. Institute for Chemical Research, Kyoto University

Trace metals in seawater are critical parameters in oceanography as trace nutrients for organisms, tracers in the modern ocean, and proxies in paleoceanography [1]. The international study programme GEOTRACES based on intercalibrated methods is revealing global distributions and temporal variations of trace metals in the ocean (http://www.geotraces.org). We have developed a method for multielemental determination of Al, Mn, Fe, Co, Ni, Cu, Zn, Cd, and Pb in seawater using NOBIS Chelate-PA1 resin [2, 3], and revealed basin-scale and full-depth sectional distributions of the trace metals in the North Pacific during three GEOTRACES Japan cruises of R/V Hakuho Maru: a 160°W section during KH-05-2, a 165°E section (GP18) during KH-11-7, and a 47°N section (GP02) during KH-12-4. The elements showed different speciations and distributions. The fraction of labile particulate (lp) species was calculated as the difference between the total dissolvable (td) species and dissolved (d) species. The lpM/tdM ratio, where M refers to an element, is highest for Al, at 0.66 ±0.31 (average ±sd, n= 489), and lowest for Pb, at 0.02 ± 0.08 (n= 575). The distribution of each element is uniquely related to ocean circulation. We propose that the enrichment factor of dM, defined as EF(dM) = $(dM/dAl)_{seawater}/(M/Al)_{upper\ crust}$, where $(M/Al)_{upper\ crust}$ is the molar ratio in upper crustal abundance, can be a good parameter for the sources. As an example, the EF(dPb) found in this study is on the same order of magnitude as the EF values for aerosols found in the literature, suggesting that the deposition of aerosols is a major source for dPb. The lpFe dominates tdFe and is strongly correlated with lpAl: lpFe = 0.543 lpAl −0.12, r^2= 0.968, n= 510. The results also indicate that the dFe concentration corrected for lithogenic contribution improves the linear relationship with phosphate. Thus, we suggest that the mechanism controlling a scavenged element of Al significantly affects the biogeochemistry of Fe. Based on the concurrent observation of these metals, we confirm that the width of the boundary scavenging zone is approximately 500 km off the Aleutian shelf. We estimate an inventory of tdFe in the North Pacific as 1.1 ×10^{12} mol, and this is approximately four times that of dFe. The results emphasise the potential importance of lpFe in the ocean iron cycle.

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Keywords: trace metals, seawater, multielemental determination, GEOTRACES, North Pacific Ocean

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Mon. May 27, 2019 9:00 AM - 10:30 AM JST | Mon. May 27, 2019 12:00 AM - 1:30 AM UTC | 301A 3F

[A-OS19] Dynamics of oceanic and atmospheric waves, vortices, and circulations

convener:Yuki Tanaka(Graduate School of Science, The University of Tokyo), Ryo Furue(APL/JAMSTEC), Yukiharu Hisaki(University of the Ryukyus), Norihiko Sugimoto(Keio University, Department of Physics), Chairperson:Norihiko Sugimoto, Ryo Furue

Oceanic and atmospheric dynamics aims at abstracting general principles from observed phenomena and constructing a system of mathematical models, thereby leading to the understanding, prediction, and parameterization of those phenomena. It provides perspectives for the advancement of sciences in various areas such as wind waves, swells, internal waves, Rossby waves, equatorial waves, tides, eddies, meandering of jets and fronts, general circulation, boundary layers, and ocean-atmosphere coupled modes. It has also been and will continue to be benefited by new uses of ideas and methods from such theories as resonance, nonlinear interaction, spectral analysis, probability, statistics, and dynamical systems. In this session, we solicit presentations on observational, experimental, numerical, and theoretical studies of oceanic and atmospheric dynamics and on exploratory use of new ideas and methods. We also welcome presentations on interdisciplinary studies in fields such as ecosystems, climate, and environment.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[AOS19-01] Instability of Ekman pumping

★Invited Papers

*Yoshiaki Miyamoto[1], Daivd S Nolan[2], Norihiko Sugimoto[3] (1.Faculty of Environment and Information Studies, Keio University, 2.Rosenstiel School of Marine and Atmospheric Science, University of Miami, 3.Keio University, Department of Physics)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[AOS19-02] Extratropical Cyclone Structures around Japan -Comparison between Extratropical Cyclones Developing around Japan and those in Northwestern Atlantic Ocean-

*Eigo Tochimoto[1], Hiroshi Niino[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[AOS19-03] Application of a new wave energy flux formulation to assessment of tropical wave propagation dynamics: Diagnostics for the tropical synoptic-scale wave disturbances in the Maritime Continent-northern Australian region

*Fukutomi Yoshiki[1], Hidenori Aiki[1] (1.Institute for Space-Earth Environmental Reasearch, Nagoya University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[AOS19-04] Direct measurement of turbulent fluxes at sea-air interface by micrometeorological technique

★Invited Papers

*Fumiyoshi Kondo[1], Shujiro Komiya[2], Kosuke Noborio[3], Hidenori Aiki[4], Kunio Kutsuwada[5], Mitsuo Uematsu[6], Osamu Tsukamoto[7] (1.Japan Coast Guard Academy, 2.Max Planck Institute for Biogeochemistry, 3.Meiji University, 4.Nagoya University , 5.Tokai University, 6.The University of Tokyo, 7.Okayama University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[AOS19-05] Swell-Dominant Surface Waves Inherent in the Shape of the Rias Coast facing the western North Pacific

*Kosei Komatsu[1,2], Takaki Fujii[1,2], Kiyoshi Tanaka[2] (1.Graduate School of Frontier Sciences, The University of Tokyo, 2.Atmosphere and Ocean Research Institute, The University of Tokyo)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[AOS19-06] **Variabilities of the Sea Surface Height in the Kuril Basin of the Okhotsk Sea: Coherent shelf-trapped mode and Rossby wave-like mode**

*Vigan Mensah[1], Kay I. Ohshima[1] (1.Institute of Low Temperature Science)

Instability of Ekman pumping

*Yoshiaki Miyamoto[1], Daivd S Nolan[2], Norihiko Sugimoto[3]

1. Faculty of Environment and Information Studies, Keio University, 2. Rosenstiel School of Marine and Atmospheric Science, University of Miami, 3. Keio University, Department of Physics

This study derived Ekman pumping velocity without assuming that the velocity in the free atmosphere is not slow to be neglected and not homogeneous. Unlike the classic solution that is widely recognized, the solution can be unstable when the flow in the free atmosphere satisfies some conditions. The solution shows that the flow is more likely unstable when the velocity is fast and spatial variation of relative vorticity is large. One example that would be applied to Earth’ s atmosphere is secondary eyewall formation in tropical cyclone, which has been one of the hottest topics in typhoon research field in the last decades. The authors successfully showed the secondary eyewall formation in simulated cyclones is attributed to the Ekman pumping instability.

Keywords: Ekman pumping

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Extratropical Cyclone Structures around Japan -Comparison between Extratropical Cyclones Developing around Japan and those in Northwestern Atlantic Ocean-

*Eigo Tochimoto[1], Hiroshi Niino[1]

1. Atmosphere and Ocean Research Institute, The University of Tokyo

Extratropical cyclones (ECs), which have horizontal scale of several thousands and time scale of a week, develop mainly in mid-latitude. They affect daily weather and sometimes cause extreme rainfall and severe winds, which result in meteorological disasters. ECs also affect climate variability: They interact with low-frequency variability such as North Atlantic oscillation. It is also pointed out that diabatic effects associated with ECs contribute to the initiation of atmospheric blocking.

Generally, there are two major conceptual model of ECs. The first model is Norwegian model, which was proposed in the beginning of 20 century. In this model, cold fronts catch up with warm fronts, and then occluded fronts form in the mature stage of ECs. The second model is Shapiro-Keyser model, which was proposed in 1990’ s. In this model, an occluded front does not form, and bentback fronts extending rearward from the EC center develop. These two conceptual models are proposed mainly with the results of studies in the Northwestern Atlantic Ocean and Europe. Although the Northwestern Pacific is one of the major storm tracks, difference in EC structures between Northwestern Atlantic and Northwestern Pacific Oceans have not been well understood. In addition, a considerable number of ECs also passes over the Sea of Japan and Okhotsk Sea. Thus, the objective of our study is to clarify the differences in structures between ECs that develop around Japan and those develop in Atlantic Ocean

Firstly, ECs are automatically detected with the tracking method developed by Hodges (1994, 1995, 1999). Secondly, ECs that develop in Okhotsk Sea or the Sea of Japan (OJC), Northwestern Pacific (POC) and Northwestern Atlantic (AOC) were selected based on the locations where the ECs underwent the maximum deepening rate (in Bergeron; Sanders and Gyakum 1980). In the present study, only ECs with Bergeron larger than 0.5 are used to examine the structures of fully-developing ECs. In the composite analysis, physical variables are superposed with respect to the cyclone center. Furthermore, to examine differences in frontal characteristics between POCs and AOCs, atmospheric fronts are objectively detected with a method using thermal front parameter (e.g., Schemm et al. 2015).

The composite analysis shows clear differences in structures between OJCs, POCs and AOCs: OJCs have relatively strong cold fronts compared to warm fronts at KT, especially in Spring. On the other hand, both warm and cold fronts develop well for POCs and AOCs. Differences in frontal characteristics between POCs and AOCs are most notable in warm fronts. Warm fronts for AOCs tend to extend eastward or east-northeastward from the EC center, while those for POCs southeastward. It is also noted that bentback fronts for AOCs are stronger than those for POCs.

An analysis using a frontogenesis function shows that this difference in warm front is mainly due to the effect of shear deformation: the shear deformation in the southeast quadrant of POCs is larger than that of AOCs, resulting in development of the warm fronts in the southeast quadrant of the EC center for POCs, which are most notable in warm fronts.

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Keywords: Extratropical cyclones, Front, Jetstream

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Application of a new wave energy flux formulation to assessment of tropical wave propagation dynamics: Diagnostics for the tropical synoptic-scale wave disturbances in the Maritime Continent-northern Australian region

*Fukutomi Yoshiki[1], Hidenori Aiki[1]

1. Institute for Space-Earth Environmental Reasearch, Nagoya University

A two-dimensional (horizontal) wave energy flux (WEF) formulation derived by Aiki et al. (2017, PEPS) is used to diagnose the dynamics of the tropical synoptic-scale waves (TSWs) propagating across the Maritime Continent and northern Australian (MCNA) region. The new WEF vectors are considered to be useful to assess energy dispersion characteristics of various types of waves in both the tropics and extratropics. The WEF is defined by adding a rotational flux term that includes Ertel potential vorticity (EPV)-based flow to the eddy geopotential flux. We computed eddy components of EPV-based stream function and corresponding wind fields from the atmospheric reanalysis (JRA-55) data using a numerical inversion technique to estimate the additional rotational flux term. The TSWs analyzed in this study have periods of about 2-8 days and zonal wavelengths of about 3000-4000 km (Fukutomi 2018, submitted to JGR). These waves propagate westward at approximately 8 m/s along the mean monsoon westerly flow extending from the Indian Ocean to the western Pacific. Wave troughs and ridges form a well-organized wave train in the MCNA region. Eastward amplification of wave troughs and ridges due to group propagation occurs along the monsoon westerly flow. WEF diagnostics confirm that wave energy propagation facilitates the downstream development of the synoptic-scale wave train and the mean monsoon westerly flow acts as a tropical waveguide. Distribution and behavior of the WEF vectors are compared with those of traditional wave activity and energy flux vectors. Applicability of this new tool to other types of the tropical waves and extratropical waves is also discussed.

Keywords: Tropical wave disturbances, Wave energy flux, Wave enegy dispersion

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Direct measurement of turbulent fluxes at sea-air interface by micrometeorological technique

*Fumiyoshi Kondo[1], Shujiro Komiya[2], Kosuke Noborio[3], Hidenori Aiki[4], Kunio Kutsuwada[5], Mitsuo Uematsu[6], Osamu Tsukamoto[7]

1. Japan Coast Guard Academy, 2. Max Planck Institute for Biogeochemistry, 3. Meiji University, 4. Nagoya University , 5. Tokai University, 6. The University of Tokyo, 7. Okayama University

Accurate parameterizations of sea–air momentum, sensible and latent heats, trace gases (e.g. greenhouse gases including CO_2 and CH_4), and aerosol fluxes are important in sea–air interaction. Coupled ocean–atmosphere global climate models require high accuracy of the net surface heat flux for the prediction of climate change, and process–based understanding of particle formation from bubble bursting to realistically predict the climate effect of marine aerosols. Precise measurements of the CO_2 gas transfer across the air–sea interface provide a better understanding of the global carbon cycle. The eddy covariance technique is the definitive method to directly determine these sea–air fluxes, but it requires measurements of the vertical and downwind components of air velocity, air temperature, humidity, trace gases, and aerosol over a sufficiently long averaging period (> 30 min) and with sufficient frequency response (< 10 Hz). One of the greatest difficulties in measuring sea–air flux by the eddy covariance technique over the open ocean is the apparent wind velocity caused by the wave–induced platform motion. As a result, the uncorrected eddy covariance results are all strongly biased, and especially represent unrealistic momentum fluxes. Improved ship motion correction scheme with Kalman filter results in a significant reduction in both the bias and the scatter of momentum fluxes. Previous studies over the oceans have shown that the eddy covariance CO_2 flux was larger than the bulk CO_2 flux estimated by the mass balance technique. Our results suggest that the density correction due to the air pressure fluctuation, which is assumed to be negligible in the WPL correction, is required to evaluate the accurate eddy covariance CO_2 flux over the ocean.

Keywords: air-sea flux, air-sea interaction, eddy covariance technique

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Swell-Dominant Surface Waves Inherent in the Shape of the Rias Coast facing the western North Pacific

*Kosei Komatsu[1,2], Takaki Fujii[1,2], Kiyoshi Tanaka[2]

1. Graduate School of Frontier Sciences, The University of Tokyo, 2. Atmosphere and Ocean Research Institute, The University of Tokyo

Real-time monitoring of wind and surface waves in Otsuchi Bay, a ria located in the northeastern portion of Japan, had been continued over four years since October 2012, using a mooring buoy with an ultrasonic anemometer and a single-mode GPS wave sensor. The monitoring revealed that waves in the bay were dominated by swells propagated from the northeastern offshore region in all seasons. Time-lag correlation coefficient between the significant wave height in the bay and the offshore wind velocity component blowing in the direction to the bay was maximized in the region approximately 300 km northeast of the bay, from which waves developed by the local wind are accessible within the corresponding time-lag to the bay at a speed of the group velocity of the swell observed in the bay. As an interesting feature common to swell-dominant waves observed in the rias bays adjacent to Otsuchi Bay, the region of the significant correlation between the wave height and the offshore wind velocity extends to the direction that faces the bay mouth. It implies that the source region of the swell depends heavily on the coastal shape of the bay. Consequently, the relation between the offshore wind field and the decay-rate of the swells propagating to Otsuchi Bay indicates that the source region of the swell influential in the bay is located in the offshore region several hundreds of kilometers northeast of the bay, which is on the typical migration route of high and low pressures in the Northern temperate zone.

Keywords: swell, surface wave, rias coast, offshore surface wind, coastal shape

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Variabilities of the Sea Surface Height in the Kuril Basin of the Okhotsk Sea: Coherent shelf-trapped mode and Rossby wave-like mode

*Vigan Mensah[1], Kay I. Ohshima[1]

1. Institute of Low Temperature Science

Time series analysis of Sea Surface Height anomaly (SSHa) is conducted in the Kuril Basin of the Sea of Okhotsk. The mapping methodology of the satellite-derived SSHa data is optimized to mitigate the effects of sea ice on the SSHa field during winter and the early spring. In particular, we found that conducting an objective mapping of along-track SSHa data with correlation length and time scales adapted to the Kuril Basin considerably reduces the number of missing data days in this region. A Complex Empirical Orthogonal Functions (CEOF) is then used to analyze the SSHa field, and the first 3 modes, representing 54 % of the total variability are delineated here. The focus is brought on the first and third modes. The first mode mainly represents the coherent variability trapped over the shelves all along the coast and Kuril Islands. Both seasonal (high over the shelves in winter) and interannual variations are strongly correlated with the alongshore wind stress. These variations can be well explained by the arrested topographic waves. The third mode is a propagating mode, with trains of southwestward propagating anomalies. Their characteristics are consistent with those of westward propagating Rossby waves, whose energy propagates from the Kuril Straits towards the Kuril Basin.

Keywords: Okhotsk Sea, SSHa, Circulation, Interannual variability, Dynamics, Rossby Waves

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Mon. May 27, 2019 10:45 AM - 12:15 PM JST | Mon. May 27, 2019 1:45 AM - 3:15 AM UTC | 301A 3F

[A-OS19] Dynamics of oceanic and atmospheric waves, vortices, and circulations

convener:Yuki Tanaka(Graduate School of Science, The University of Tokyo), Ryo Furue(APL/JAMSTEC), Yukiharu Hisaki(University of the Ryukyus), Norihiko Sugimoto(Keio University, Department of Physics), Chairperson:Yukiharu Hisaki(琉球大学理学部), Hidenori AIKI

Oceanic and atmospheric dynamics aims at abstracting general principles from observed phenomena and constructing a system of mathematical models, thereby leading to the understanding, prediction, and parameterization of those phenomena. It provides perspectives for the advancement of sciences in various areas such as wind waves, swells, internal waves, Rossby waves, equatorial waves, tides, eddies, meandering of jets and fronts, general circulation, boundary layers, and ocean-atmosphere coupled modes. It has also been and will continue to be benefited by new uses of ideas and methods from such theories as resonance, nonlinear interaction, spectral analysis, probability, statistics, and dynamical systems. In this session, we solicit presentations on observational, experimental, numerical, and theoretical studies of oceanic and atmospheric dynamics and on exploratory use of new ideas and methods. We also welcome presentations on interdisciplinary studies in fields such as ecosystems, climate, and environment.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[AOS19-07] Dynamics of water exchange processes at a deep submarine canyon off the western coast of the Sakhaline which causes the origin of the cold water belt along the Soya Warm Current

★Invited Papers

*Humio Mitsudera[1], Hiroyuki Iida[2] (1.Institute of Low Temperature Science, Hokkaido University, 2.Graduate School of Environmental Science)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[AOS19-08] Generation Mechanism of Tropical Instability Waves in the Equatorial Pacific Ocean

*Yuki Tanaka[1], Toshiyuki Hibiya[1] (1.Graduate School of Science, The University of Tokyo)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[AOS19-09] Annual Rossby waves below the pycnocline in the Indian Ocean

*Motoki Nagura[1] (1.Japan Agency for Marine-Earth Science and Technology)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[AOS19-10] Eddies observed by Argo floats

★Invited Papers

*Katsuro Katsumata[1] (1.JAMSTEC)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[AOS19-11] Rhythmic Phenomena in Nonlinear Systems and Oceanic General Circulation

*Shinya Shimokawa[1], Tomonori Matsuura[2] (1.National Research Institute for Earth Science and Disaster Prevention, 2.University of Toyama)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[AOS19-12] Control of the ocean circulation by bottom topography and generation of mesoscale disturbances

*Yuri Kase[1], Tomonori Matsuura[1] (1.National university corporation University of Toyama)

Dynamics of water exchange processes at a deep submarine canyon off the western coast of the Sakhaline which causes the origin of the cold water belt along the Soya Warm Current

*Humio Mitsudera[1], Hiroyuki Iida[2]

1. Institute of Low Temperature Science, Hokkaido University, 2. Graduate School of Environmental Science

A cold water belt (CWB) is observed off the Soya Warm Current, the former of which appears from the west coast of the Sakhaline Island. Observations of the CWB (Kuma et al., 2016; Iida et al., 2018) indicates that the CWB, characterized by a cold and saline water (temperature 7℃, and salinity 34.0), is derived from the lower part of the thermocline in the Japan Sea basin. This implies that the cold and saline water in the Japan Sea basin should overcome the shelf break, which is not easy in general, and be transported to the vicinity of the coast of Sakhaline. The aim of this study is to elucidate mechanisms of water exchange between the Japan Sea basin (continental slope) and the continental shelf.

We first analyzed the output of a general circulation model OFES with the 1/30° resolution. It was found that the water over the continental slope enters the continental slope at a deep submarine canyon off the Kholmsk city on the west coast of the Sakhaline. Further, a barotropic model using Princeton Ocean Model (POM) with a realistic topography shows the exchange at the canyon in a similar manner to OFES, even though water exchange would not readily occur at the shelf break because of a potential vorticity (PV) barrier. We thus conducted numerical experiments using idealized topographic features mimicing the canyon off the Kholmsk in order to understand the barotropic exchange processes. The throughflow across the Soya Strait occurs owing to the adjustment of sea level difference between the Japan Sea and the Sea of Okhotsk by long shelf waves. It was found that the shelf waves are scattered into the second and third mode waves at the canyon, which have large transport over the continental slope; the scattered flow over the continental slope directed southward, and enters the continental shelf at the canyon. Further, nonlinearity is important in the vicinity of the canyon during the scattering process. Specifically: 1) nonlinearity produces a wave guide across the shelf break overcoming the PV barrier, by bringing low PV water from the continental slope to the continental shelf; 2) High-order mode waves (higher than 4^{th} mode) are retarded from propagation because of the background flow caused by 1^{st} -3^{rd} modes, making the flow over the continental slope steady. The nonlinear steady flow over the slope upwells at the canyon and connects to the flow over the shelf, and consequently flows through the strait.

Finally. hydrographic data during 1960-1985, archived at the Japan Hydrographic Data Center, was analyzed. Potential temperature and salinity from July to October was used. It was confirmed that the upwelling occurs at the canyon off the Kholmsk.

Keywords: water exchange across the shelf break, continental shelf wave, submarine canyon, cold water belt along the Soya Warm Current

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Generation Mechanism of Tropical Instability Waves in the Equatorial Pacific Ocean

*Yuki Tanaka[1], Toshiyuki Hibiya[1]

1. Graduate School of Science, The University of Tokyo

Tropical instability waves (TIWs) are prominent features observed in the eastern to central equatorial Pacific, which typically have a wavelength of ~1000 km and a period of ~25 days, propagating westward at a speed of ~0.5 m/s. Although TIWs are thought to be generated by meridional shear between the westward-flowing South Equatorial Current (SEC) and the eastward-flowing North Equatorial Countercurrent (NECC), the decisive parameter responsible for the occurrence of the instability has not yet been fully understood. Because the meridional and vertical momentum and heat transfer by TIWs are essential to drive the equatorial ocean circulation and affect the air-sea interactions related to the global climate, a better understanding of the generation mechanism of the TIWs is prerequisite for improving models' capability to predict climate variations.

In this study, we show that a linear stability analysis using a 1.5-layer shallow water model with a zonal mean flow on the equatorial beta plane can successfully predict an unstable mode whose phase speed and meridional structure are both very similar to those of the TIWs simulated in an eddy-resolving ocean general circulation model (OGCM), although the wavelength and the growth rate are somewhat larger and smaller, respectively. This unstable mode can be interpreted as resulting from a coupling between a Rossby wave propagating eastward in the negative potential vorticity (PV) gradient just north of the equator (~1°–3.5°N) while advected westward by the SEC, and a Rossby wave propagating westward in the positive PV gradient further north (~3.5°–8°N) while weakly advected eastward by the NECC. The unstable mode tends to have smaller growth rate as the negative PV gradient becomes weaker, and even disappears when it is completely absent.

The negative PV gradient just north of the equator thus plays an essential role in forming the unstable mode. Actually, the seasonal and interannual variability of the TIWs simulated in the OGCM is shown to be significantly controlled by the strength of the negative PV gradient, suggesting the possibility that it can serve as a key parameter for a dynamically based parameterization of the heat and momentum transfer associated with TIWs in coarse-resolution OGCMs.

Keywords: Tropical Instability Wave, Equatorial Pacific Ocean, Potential Vorticity Gradient, Rossby Wave, 1.5-Layer Shallow Water Model, Linear Stability Analysis

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Annual Rossby waves below the pycnocline in the Indian Ocean

*Motoki Nagura[1]

1. Japan Agency for Marine-Earth Science and Technology

In-situ observations in the Indian Ocean had long been limited to sporadic ship observations, which hampered the progress of observational research of basin-wide circulation and variability. The implementation of Argo profiling float program since 2004 dramatically improved this situation, and now abundant in-situ observations obtained from Argo floats are available. This study uses the resulting temperature and salinity observations between the sea surface and 2000 m depth and float trajectories at 1000 m depth to examine annual variability in pressure and horizontal velocity. Annual variability below the pycnocline is large in amplitude in the Arabian Sea and between 10˚S and 20˚S in the South Indian Ocean. Wavenumbers were estimated by fitting a straight line to annual harmonic phase. Results showed that vertical wavenumber tends to decrease poleward in both hemispheres, and vertical wavelength is more than tripled from about 5,000 m at 5˚N/S to 16,000 m at 20˚N/S. The inverse radius of deformation squared (defined as f^2m^2/N^2) does not show clear dependence on latitude, because poleward increase in the magnitude of the Coriolis parameter (f) compensates for poleward decrease in vertical wavenumber (m), and Brunt-Väisälä frequency (N) varies little meridionally in the analysis domain. According to the dispersion relation of linear, quasi-geostrophic Rossby waves at a rest state, these meridional structures in m and deformation radius result in steeper angle of ray trajectory at a higher latitude in the longitude-depth plane. Energy estimated from in situ observations shows a consistent pattern with this expectation. The line of constant phase of annual pressure harmonic is steeper in angle at higher latitudes, which is also expected from the uniform deformation radius and constant N. This result indicates that energy penetrates deeper at higher latitudes.

Keywords: Indian Ocean, mid-depth, Linear, quasi-geostrophic Rossby waves

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Eddies observed by Argo floats

*Katsuro Katsumata[1]

1. JAMSTEC

Eddies play an important role in the oceanic general circulation theory, specifically its meridional overturning component. Due to the limited spatial extent, however, synoptic observation of the eddy field has been difficult and its quantitative arguments have depended mostly on numerical simulation outputs. Argo floats, which revolutionalised phycical oceanographic observations, demonstrate their capability in the eddy observation (albeit at limited depths).
Under the Temporal Residual Mean framework, the most natural coordinate system for ocean circulation theories, we estimated the eddy transport above the mean 1000 dbar surface by using the hydrographic and drift velocity data from Argo floats. Eddy transport is strong in the western boundaries and in the Southern Ocean. In the midlatitude oceans, it is weaker and equatorwords. In the southern part of the Antarctic Circumpolar Current (ACC), it is larger than 10 Sv poleward.
In the Southern Ocean, we can discuss the vertical transport of zonal momentum input by the westerly wind and responses of the ACC to variable wind localised to topographic features.

Keywords: Eddy, Southern Ocean

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Rhythmic Phenomena in Nonlinear Systems and Oceanic General Circulation

*Shinya Shimokawa[1], Tomonori Matsuura[2]

1. National Research Institute for Earth Science and Disaster Prevention, 2. University of Toyama

Various oscillation phenomena such as transition between meander and non- meander paths of western boundary current such as the Kuroshio exist in the oceanic general circulation. These phenomena can be related to nonlinear rhythmic phenomena such as synchronization, stochastic resonance and stochastic synchronization. Synchronization 1) is a phenomenon for an adjustment of rhythms of two or more self-sustained oscillating systems, which have different periods. Stochastic resonance 2) is a phenomenon in which a kind of noise amplifies and elicits weak signals under detection thresholds. Both phenomena are observed in various nonlinear systems such as climate system, living system, and electric circuits. Also, the coupling of both phenomena was found and is called stochastic synchronization 3).

Thus, we investigate the responses of oceanic double-gyre to external wind forcing with and without noise using a 1.5 layer quasi-geostrophic model, and considered the possible role of nonlinear rhythmic phenomena in oceanic general circulation 4)-7). The variable parameter is the amplitude of external seasonal forcing, α, the amplitude of red noise, ε, and the Reynolds number, Re.

Synchronization at two times the period of the forcing occurs at a parameter range of α and Re without noise (ε =0). For cases with adequate (not too weak and not too strong) noise, potential signals in the system appear at the front as actual signals (i.e., stochastic resonance) such as intermittent large variations in energy. Also, by adding red noise to external forcing, synchronization (i.e., stochastic synchronization) occurs when the amplitude of external forcing is smaller than that in the case without noise. These results suggest that potential signals in the system are amplified and appear as stochastic resonance or synchronization in relation to the added noise.

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1) Kuramoto, Y., “Chemical Oscillations, Waves, and Turbulence”, (Springer, 1984), p.156.

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7) Shimokawa, S and T. Matsuura, “Chaos excitation and stochastic synchronization in an oceanic double gyre”, Theor. Appl. Mech. Jpn., Vol. 64 (2018), pp. 15-22.

Keywords: Oceanic general circulation, Nonlinear systems, Synchronization, Stochastic resonance, Stochastic synchronization

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Control of the ocean circulation by bottom topography and generation of mesoscale disturbances

*Yuri Kase[1], Tomonori Matsuura[1]

1. National university corporation University of Toyama

One of the representative ocean current in the North Pacific is the Kuroshio. The Kuroshio which is the western boundary current of the North Pacific subtropical gyre leaves off the coast of Choshi, Chiba Prefecture, and it will be the eastward Kuroshio extension. At about 160° E, the Kuroshio-extension current encounters the Shatsky rise extending north and south, and fluctuation of flow path and generation of mesoscale disturbances due to flow-topography interaction is seen around this topography. We study the mechanism of phenomena as geophysical fluid dynamics in the North Pacific, mainly generation of mesoscale disturbances due to flow-topography interaction in rotating stratified fluid, by modeling which is target of the North Pacific.

We simulated four cases with different ocean bottom topography using the eddy resolving 3-layer QG model (Hogg et al., 2010) based on the quasi-geostrophic vorticity equation for the generation of the mesoscale disturbances accompanied the main flow path variation.

In Figure 1, the strong flow in each case is seen near the west-coast and mid-latitudes, and in case 1 where no topography is given, the most noticeable double gyre and the zonal strong flow as the gyre's front are seen. It can be inferred that this double gyre corresponds to the North Pacific subtropical gyre / subpolar gyre, and the flow on the front corresponds to the Kuroshio extension because we give the wind stress corresponding to the North Pacific about this time. On the other hand, in case 2, 3, and 4, which topography is given in each case, the strong flow near the mid-latitude is obstructed or meandered depending on the topography, and there is the long-lived eddy as an anticyclonic eddy over the topography. Especially, paying attention to the meandering flow behind the topography, and comparing case 3 and case 4, we can see that the addition of "corn" to "kamaboko" strengthens the flow of two wavelengths behind "kamaboko" (in case 4 of Figure 1).

Figure 2 shows the spatial patterns of the 10 years mean values of the squared disturbances of the potential vorticity in layer 1. The higher value area has the stronger and finer mesoscale disturbances. The development of the mesoscale disturbances in each case is seen at the west-coast, the mid-latitude area and the area surrounding the topography, corresponding to the strong flow as seen in Figure 1. In addition, when comparing case 3 and case 4, the addition of "corn" to "kamaboko" strengthens the meandering flow which has two wavelengths behind "kamaboko" (in case 4 of Figure 1), and the mesoscale disturbances are developed along the flow (in case 4 of Figure 2). From these results, it is suggested that the baroclinic instability is strengthened around the topography. We think the mechanism as described later; flow is disturbed by the influence of the topography, and the interface (of two layers) height anomaly increases, so the potential energy becomes large (strengthened baroclinic instability), and then the enlarged potential energy is released as kinetic energy (resolution of the baroclinic instability), and the mesoscale disturbances develop. It was suggested that how to change the flow and the degree of strengthened its baroclinic instability depend on the shape, arrangement and combination of the topography. And it was found that the bottom topography plays an important role in the generation of mesoscale disturbances.

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Hereafter, by modeling which is given “kamaboko”, “corn” as a bottom topography imitating the Izu Ridge and the Shatsky rise (Tam massif) in the North Pacific, respectively, and simulating in some cases which have defferent positions (latitude / longitude) and heights of the topography, we presume that it is possible to realize the application of the mechanism of phenomena from the simulation results to the real phenomena.

Keywords: mesoscale disturbance, bottom topography, western boundary current, Kuroshio, Kuroshio extension

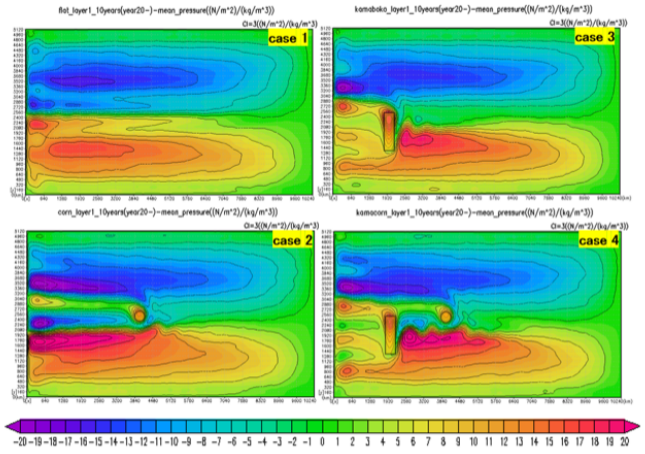


Figure 1: the four cases' spatial patterns of the 10 years mean values of the pressure in layer 1 ($\overline{p_1}(10)$) (superimposed the horizontal section of the bottom topography in each case)

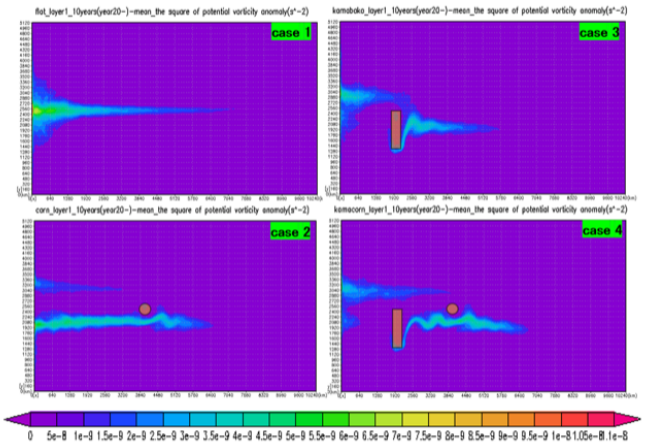


Figure 2: the four cases' spatial patterns of the 10 years mean values of the squared disturbances of the potential vorticity in layer 1 ($\overline{(q_1')^2}(10)$) (superimposed the horizontal section of the bottom topography in each case)

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-HW Hydrology & Water Environment

Mon. May 27, 2019 9:00 AM - 10:30 AM JST | Mon. May 27, 2019 12:00 AM - 1:30 AM UTC | 105 1F

[A-HW24] Isotope Hydrology 2019

convener:Masaya Yasuhara(Rissho Univ.), Kohei Kazahaya(Geological Survey of Japan, AIST), Shinji Ohsawa(Institute for Geothermal Sciences, Graduate School of Science, Kyoto University), Kazuyoshi Asai(Geo Science Laboratory), Chairperson:Masaya Yasuhara(Rissho Univ.), Noritoshi Morikawa(産業技術総合研究所活断層・火山研究部門)

The purpose of the session is to review the present state of knowledge of isotope hydrology,
by bringing together hydrologists, geologists, volcanologists, geochemists, agronomists, ecologists, engineers and so on.

9:00 AM - 9:30 AM JST | 12:00 AM - 12:30 AM UTC

[AHW24-01] The use of natural abundances of stable isotopes to elucidate the nitrogen dynamics in plant-soil systems

★Invited Papers

*Keisuke Koba[1] (1.Center for Ecological Research, Kyoto University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[AHW24-02] Reconstruction of local temporal variation on atmospheric sulfur hexafluoride concentration in the Kyoto Basin by multiple environmental tracer and mass transport analyses

*Koki Kashiwaya[1], Taishi Hori[1], Ryuta Hazama[2], Yoichi Sakuma[3], Katsuaki Koike[1] (1.Kyoto University, 2.Osaka Sangyo University, 3.Tokyo Institute of Technology)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[AHW24-03] Quantitative reconstruction of the humidity in the moisture source region based on the ^{17}O-excess in precipitation on a subtropical island

Yuina Uechi[1], *Ryu Uemura[1] (1.University of the Ryukyus)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[AHW24-04] Identification of deep groundwater recharge system in an intermontane basin

*Takashi Nakamura[1], Kei Nishida[1], Naim Mohamad[2], Bijay Man Shakya[1], Kazuyoshi Asai[4], Sresh Das Shrestha[3] (1.ICRE, University of YAMANASHI, 2.University of Yamanashi, 3.CDG, Tribhuvan University, 4.Geo-Science Laboratory)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

Discussion

The use of natural abundances of stable isotopes to elucidate the nitrogen dynamics in plant-soil systems

*Keisuke Koba[1]

1. Center for Ecological Research, Kyoto University

Nitrogen (N) dynamics in terrestrial ecosystems are quite complex because of its high turnover due to the high biological N demand by plants and microbes. The uses of the natural abundance of stable N and oxygen (O) isotopes have been carried out in many ways to elucidate the N dynamics in intact terrestrial ecosystems. The methodological progress ("denitrifier method") can allow us to measure not only N but also O isotope ratios with samples with low N amounts. We applied this analytical method to elucidate the fate of nitrate. Among many fates of nitrate in terrestrial ecosystems, plant nitrate uptake is quite difficult to evaluate. In this talk, I will introduce our results on the uptake of the soil nitrate by tundra plants where soil net nitrification rates are quite low.

Keywords: stable isotopes, soil nitrate

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Reconstruction of local temporal variation on atmospheric sulfur hexafluoride concentration in the Kyoto Basin by multiple environmental tracer and mass transport analyses

*Koki Kashiwaya[1], Taishi Hori[1], Ryuta Hazama[2], Yoichi Sakuma[3], Katsuaki Koike[1]

1. Kyoto University, 2. Osaka Sangyo University, 3. Tokyo Institute of Technology

Groundwater is a valuable water resource and understanding groundwater flow regime is indispensable to maintain its quantity and quality at favorable conditions and to achieve its sustainable use. Residence time is an indicator reflecting flow regime of groundwater and various environmental tracers can be used to estimate residence time. Sulfur hexafluoride (SF_6) is one of such dating tracer and is frequently used to estimate residence time of relatively young groundwater. SF_6 residence time is estimated by comparing temporal variation curve of atmospheric SF_6 concentration with concentration obtained from measurement of groundwater sample. Groundwater dating with SF_6 is sometimes difficult in urban areas because of locally elevated atmospheric SF_6 concentration and/or contamination. If local temporal change of atmospheric SF_6 concentration can be reconstructed, and if contaminated samples can be detected, they help to increase accuracy of groundwater dating with SF_6. Therefore, we tried to estimate local temporal change of atmospheric SF_6 concentration in the Kyoto Basin. Groundwater samples were collected from 47 wells in the basin and concentrations of tritium and SF_6 were determined. Air samples were also collected at three points to reconstruct the variation curve. Additionally, groundwater flow and mass transport analyses were conducted using MODFLOW and MT3DMS. The groundwater flow and mass transport models were calibrated by comparisons with actually measured water levels and tritium concentrations. Several temporal variation curves of local temporal variation on atmospheric SF_6 concentration were considered, and using these curves, mass transport analysis of SF_6 was conducted. Finally, the calculated and actually measured SF_6 concentrations in groundwater were compared and the temporal variation curve with which error between the calculated and measured values was minimum was selected. In the presentation, residence time of groundwater in the Kyoto Basin is presented and plausibility of the selected temporal curve is discussed.

Keywords: Groundwater, Residence time, Sulfur hexafluoride, Tritium, Mass transport analysis

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Quantitative reconstruction of the humidity in the moisture source region based on the ^{17}O-excess in precipitation on a subtropical island

Yuina Uechi[1], *Ryu Uemura[1]

1. University of the Ryukyus

A high-precision analysis of the triple oxygen isotope composition of water provides a new tracer denoted as ^{17}O-excess. In theory, the ^{17}O-excess can be interpreted as variations in the relative humidity in moisture source regions for precipitation. However, recent studies on ^{17}O-excess in the precipitation in polar and dry regions suggest the importance of snow formation and raindrop re-evaporation processes. To date, whether humidity in the moisture source region can be quantified based on observations of ^{17}O-excess in precipitation has not been proven. Here, we show a 2 year record of the ^{17}O-excess in precipitation on a maritime island in the East Asian monsoon region, Okinawa, Japan. We demonstrate that the reconstructed relative humidity is quantitatively consistent with observations in the oceanic moisture source region. This result suggests that the ^{17}O-excess in precipitation on the subtropical island is determined largely by diffusional fractionation during evaporation in the ocean. These results suggest that the ^{17}O-excess in precipitation in tropical and subtropical regions is a unique quantitative tracer for the relative humidity in oceanic moisture source regions and thus will be a useful tracer and proxy for hydrological and paleoclimate studies.

Reference:
Uechi, Y. and R. Uemura, Dominant influence of the humidity in the moisture source region on the ^{17}O-excess in precipitation on a subtropical island, Earth and Planetary Science Letters, in press.

Keywords: 17O, stable isotope, monsoon, precipitation

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Identification of deep groundwater recharge system in an intermontane basin

*Takashi Nakamura[1], Kei Nishida[1], Naim Mohamad[2], Bijay Man Shakya[1], Kazuyoshi Asai[4], Sresh Das Shrestha[3]

1. ICRE, University of YAMANASHI, 2. University of Yamanashi, 3. CDG, Tribhuvan University, 4. Geo-Science Laboratory

This study focuses on identifying the deep groundwater recharge system in Kathmandu Valley, Nepal using various environmental tracers. The Kathmandu Valley is one of the largest intermontane basin that covers an area of 625 km^2. The average altitude of the valley floor is 1350 m above sea level and is surrounded by the hills rising more than 2800 m. Rainfall in the basin is mostly seasonal with roughly 80% of the 1755 mm average annual total arriving between June and September during monsoon season. Groundwater samples were collected from 10 deep tube wells covering almost all parts of the valley and 2 shallow dug wells located at the central part of the valley. All the collected samples were then subjected to the analysis of major dissolved ions, hydrogen and oxygen stable isotopes and radiocarbon.

Groundwater ion composition using Hexa-diagram showed that the deep groundwater of the Kathmandu Valley tends to be relatively young in the outer peripheral area. Meanwhile for the groundwater located in the central area tends to be older. However, for the shallow wells located at the central area, the higher values of ion composition were derived from the effect of human activities. Relatively high pMC values obtained from radiocarbon were detected from the shallow groundwater at central part of the valley and from the deep groundwater samples those were collected from the peripheral area. On the other hand, the deep groundwater at the central part of valley was observed with low pMC values.

Relatively heavier stable isotopes of hydrogen were observed from both the deep groundwater and the shallow groundwater in the central part of the valley. Along with the pMC values, these results also suggests the possibility of vertical groundwater recharge from the shallow groundwater to the deep groundwater in central part of the valley. However, isotopically depleted groundwater recorded from the peripheral areas also concludes the recharge in this basin occurs from the mountain areas.

AKNOWLEDGMENTS: This study was supported by the JSPS KAKENHI Grant Number is 18K11617. It was also partly supported by the Science and Technology Research Partnership for Sustainable Development Program (SATREPS, Project Manager: Professor Narendra Man Shakya and Professor Futaba Kazama) of the Japan International Cooperation Agency (JICA)/Japan Science and Technology Agency (JST).

Keywords: Groundwater recharge, water quality, Hydrogen and oxygen stable isotope, Radiocarbon, Kathmandu Valley, Nepal

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-HW Hydrology & Water Environment

Mon. May 27, 2019 10:45 AM - 12:15 PM JST | Mon. May 27, 2019 1:45 AM - 3:15 AM UTC | 105 1F

[A-HW24] Isotope Hydrology 2019

convener:Masaya Yasuhara(Rissho Univ.), Kohei Kazahaya(Geological Survey of Japan, AIST), Shinji Ohsawa(Institute for Geothermal Sciences, Graduate School of Science, Kyoto University), Kazuyoshi Asai(Geo Science Laboratory), Chairperson:Noritoshi Morikawa(産業技術総合研究所活断層・火山研究部門), Kazuyoshi Asai(Geo-Science Laboratory), Kohei Kazahaya(Geological Survey of Japan, AIST)

The purpose of the session is to review the present state of knowledge of isotope hydrology,
by bringing together hydrologists, geologists, volcanologists, geochemists, agronomists, ecologists, engineers and so on.

10:45 AM - 11:15 AM JST | 1:45 AM - 2:15 AM UTC

[AHW24-05] The discharge rate of the Arima-type deep brine discharge in Ooshika-mura, Nagano Prefecture

★Invited Papers

*Fumitake Kusuhara[1] (1.Central Research Institute of Electric Power Industry)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[AHW24-06] Sublacustrine hydrothermal system of the active crater lake, Yudamari of Aso Volcano inferred from Mg budget of the lake

*Shinji Ohsawa[1], Takeshi Saito[2], Kazuhiro Amita[3] (1.Institute for Geothermal Sciences, Graduate School of Science, Kyoto University, 2.Academic Assembly School of Science and Technology, Shinshu University, 3.Graduate School of Engineering Science, Akita University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[AHW24-07] Spatial distribution of chemical compositions, hydrogen and oxygen isotopic ratios of stream water of the Shimanto River area, southwestern Japan

*Masaaki Takahashi[1], Hinako Shimizu[1], Kohei Kazahaya[1], Masaya Yasuhara[2,1] (1.The National Institute of Advanced Industrial Science and Technology, 2.Rissho University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[AHW24-08] An isotopic study on shallow groundwater origins in a densely-populated area in Shinagawa, central Tokyo, Japan

*Masaya Yasuhara[1], Akihiko Inamura[2], Takashi Nakamura[3], Kazuyoshi Asai[4] (1.Rissho Univ., 2.Geological Survey of Japan, AIST, 3.Yamanashi Univ., 4.Geo Science Laboratory)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

Discussion

The discharge rate of the Arima-type deep brine discharge in Ooshika-mura, Nagano Prefecture

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1. Central Research Institute of Electric Power Industry

Arima-type hot spring water is thought to originate from the dehydration from the hydrous minerals in a subducting slab. In the present research, this dehydrated saline water is called “ADB (Arima-type Deep Brine)”. It is important to estimate the amount of the discharge of ADB in order to understand the water circulation in subduction zones. Few studies, however, have been conducted on such estimation because the chemical and isotopic compositions of the ADB is unknown.Ooshika-Mura is located at the southern part of Nagano prefecture, central Japan. It is thought that the ADB is diluted by local meteoric water, gushes out at several points (e.g. the Kashio hot spring, famous as the Arima-type hot spring), and flows into the 4 rivers in the region. In the present research, the flow rate and Cl- concentration of river water is measured at several points along each river. The flow rate of the ADB is estimated at each observation point, based on the results of above measurements and the previous study on the chemical and isotopic composition of the ADB in the researched region. These estimated flow rate values are regarded as the discharge rate of the ADB discharge inside the upstream watershed areas. The ADB discharge rate over the whole area of Ooshika-Mura is estimated approximately 0.8 L/s, by summing up each flow rate at the most downstream point of each river. The estimation is consistent with previous calculation of the dehydration rate from subducting slabs. More than 50% of the discharged ADB in the whole area concentrates within a few kilometers of the confluence of Kashio River and Shiokawa River. The fault plane of the MTL intersects with the Shiokawa River at the area, which is consistent with the ADB discharging model in Kii peninsula, shown by the previous study.

Keywords: slab-derived fluid, discharge rate, Median Tectonic Line, geologic structure, Kashio

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Sublacustrine hydrothermal system of the active crater lake, Yudamari of Aso Volcano inferred from Mg budget of the lake

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The crater lake, Yudamari, formed in the first crater of Mt. Nakadake, Aso Volcano, contains a large amount of dissolved components such as chloride ion (Cl) and magnesium ion (Mg), without the surface outflow of the lake. This kind of water quality is formed under the influence of subaqueous volcanic gas flowing into the lake. From analysis of the isotope composition of the Yudamari water samples (δ D and δ^{18}O), it was found that a large change occurred in the water isotope composition when the lake which became extremely acidic caused the dissolution of chemical components from rocks (oral presentation in the same session last year). In the period when the lake became extremely acidic, the volume of the lake and the water budget were demanded in detail (Saito et al., 2008). We calculated the Mg balance of the lake including the hydrological parameters reported there, and found that a large amount of Mg from 5 to 10 tons per day was eluted from the rock to the lake. Assuming chemical composition and density of the original rock subjected to the acid leaching and converting the Mg leaching amount to the volume of the rock, it is 50 to 200 cubic meters. This is an amazing phenomenon in which a cubic rock from 3 to 6 m is completely altered in one day. The elution of such a large amount of rock components is not caught up in the dissolution reaction only on the bottom surface of the lake. It strongly supports the existence of the subaqueous hydrothermal system that the lake water circulates continuously and reacts with the rock, for example, it is often assumed under the lake of a high temperature and strongly acidic crater lake called active crater lake similar to Yudamari.

Keywords: Aso volcano, active crater lake, magnesium budget, acid leaching, sublacustrine hydrothermal system

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Spatial distribution of chemical compositions, hydrogen and oxygen isotopic ratios of stream water of the Shimanto River area, southwestern Japan

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109 river water samples were collected from 101 locations in the Shimanto River system and adjacent streams in the western part of Kochi Prefecture and southern part of Ehime Prefecture in December 2007, November 2008, and December 2009, for the purpose of understanding how the distribution of δD and δ^{18}O can be explained by geographical parameters (latitude (LAT), altitude (ELV) and inland degree (Distance from the nearest seashore; DS)) and meteorological parameters (mean annual temperature (MAT) and mean annual precipitation (MAP)), and what is the difference in those explanatory variables of the distribution of δD and δ^{18}O compared to the national level. As a result, it was found that the spatial distribution of δD, δ18O of stream water in the Shimanto area can be shown in detail by using ELV and DS as geographical parameters and MAP as meteorological parameters as explanatory variables.

Keywords: stream water of the Shimanto River, hydrogen and oxygen isotopic ratio, altitude effect, amount effect, inland effect

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An isotopic study on shallow groundwater origins in a densely-populated area in Shinagawa, central Tokyo, Japan

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Stable isotopes (δ D and δ^{18}O) and hydrochemical tracers (electric conductivity, NH_4^+, NO_3^-, Cl^-) of water were applied to quantify 1) rainfall infiltration (natural recharge), 2) water supply leakage, and 3) sewage leakage in a shallow aquifer in a densely-populated area in Shinagawa, central Tokyo, Japan. Despite of a quite small area about 0.5 km (E-W) by 1 km (N-S), shallow groundwater took on a wide range of values: 28 ~70 mS/m electric conductivity, 0.0 ~9.1 mg/L NH_4^+, 0.1 ~ 36.2 mg/L NO_3^-, 4.8 ~46.6 mg/L Cl^-, and -8.7 ~-7.4‰ δ^{18}O. A ternary mixing model was used based on the Cl^-concentration and d^{18}O of three plausible origins of groundwater to estimate fractions of each component in shallow groundwater in the study area. As a result, a fraction of sewage leakage in groundwater proved large for one well as much as 70%, while for some wells rainfall infiltration contributed more than 80% of water to the formation of groundwater. These remarkable differences in contribution of urban leakage to the shallow aquifer may result from the different state of the water infrastructure in the vicinity of the respective wells.

Keywords: Tokyo, shallow groundwater, origins of groundwater, water leakage, sewage leakage, isotope

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[J] Oral | H (Human Geosciences)：H-DS Disaster geosciences

Mon. May 27, 2019 10:45 AM - 12:15 PM JST | Mon. May 27, 2019 1:45 AM - 3:15 AM UTC | 106 1F

[H-DS14] Geohazards in humid, tectonically active countries and their precursors

convener:Masahiro Chigira(Disaster Prevention Research Institute, Kyoto University), Hiroshi YAGI(Faculty of Art, Science and Education, Yamagata University), Satoru Kojima(Department of Civil Engineering, Gifu University), Taro Uchida(National Institute for Land and Infrastructure Management), Chairperson:Satoshi Ishimaru

This session covers mass movements of landslide, slope failure, debris flow, and gravitational slope deformation in tectonically active, humid countries, and aims to discuss on their mechanisms, characteristics of occurrence sites, the significance in geological time scale, and the methodology to mitigate their affects by researchers with various related research fields. In particular, papers about 2017 northern Kyushu rainstorm, 2018 Osaka earthquake, 2018 Western Japan rainstorm, and 2018 Hokkaido earthquake are welcome

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[HDS14-01] The sources of landslides occurred by the 2018 Hokkaido Eastern Iburi Earthquake

*Satoshi Ishimaru[1], Wataru Hirose[1], Gentaro Kawakami[1], Ryo Takahashi[1], Yoshihiro Kase[1], Ken'ichi Koshimizu[1], Hiromichi Koyasu[1], Masahiro Chigira[2], Jun Tajika[3] (1.Geological Survey of Hokkaido, 2.Kyoto University, 3.Docon Co., Ltd.)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[HDS14-02] Feature of landslide of pyroclastic fall deposits induced by 2018 Hokkaido Eastern Iburi Earthquake, and its relation with damage

*Jun Tajika[1], Kazuo Amemiya[2], Masahiro Chigira[3], Satoshi Ishimaru[4], Akio Koike[1], Hidetoshi Kon[1], Kenji Kizaki[5], Nobuo Yamane[6] (1.Docon Co.,Ltd., 2.Bousai Chishitsu Kogyo Co.,Ltd., 3.Kyoto University, 4.Geological Survey of Hokkaido, HRO, 5.Kizaki PE Office, 6.Terre Research Co.)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[HDS14-03] Influence of slope cutting on failures induced by the July heavy rain, and the Iburi-tobu earthquake, 2018.

*Hidehisa Nagata[1] (1.Fu-Sui-Do Company Limited)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[HDS14-04] Slope failures occurred in the southwest part of the Izu-oshima Island in geological time, NE Japan

*Takehiko Suzuki[1], Masahiro Chigira[2] (1.Faculty of Urban Environmental Sciences, Tokyo Metropolitan University, 2.Disaster Prevention Research Institute, Kyoto University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[HDS14-05] The strain rate observation by the borehole inclinometer on the bedrock creep slopes in Akadani-west area

*Atsuhiko Kinoshita[1,2], Yasutaka Tanaka[2], Wataru Sakurai[1], Taro Uchida[1], Koichiro Hayashi[3], Yasuuchi Kubota[3], Katsushi Kawato[4] (1.National Institute for Land and Infrastructure Management, 2.Sediment Disaster Prevention Technology Center, Kinki Developing Regional Bureau, Ministry of Land, Infrastructure, Transport and Tourism , 3.OYO Corporation, 4.NIPPON ENGINEERING CONSULTANTS CO., LTD.)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[HDS14-06] Assessing Potential Landslide Areas Due to Earthquake Using Three-Dimensional Resistivity Datasets from Across a Wide Area

*Yusuke Sakai[1], Taro Uchida[1], YASUMASA FUJIWARA[2] (1.National Institute for Land and Infrastructure Management , 2.Eight-Japan Engineering Consultants)

The sources of landslides occurred by the 2018 Hokkaido Eastern Iburi Earthquake

*Satoshi Ishimaru[1], Wataru Hirose[1], Gentaro Kawakami[1], Ryo Takahashi[1], Yoshihiro Kase[1], Ken'ichi Koshimizu[1], Hiromichi Koyasu[1], Masahiro Chigira[2], Jun Tajika[3]

1. Geological Survey of Hokkaido, 2. Kyoto University, 3. Docon Co., Ltd.

An earthquake of M6.7 was occurred at 37km depth in East Iburi, Hokkaido, on September 6, 2018. This earthquake caused numerous landslides in Azuma town with seismic intensities of 7 or 6+. The number of landslides reached 8000 in area of 20km by 20km. The type of these landslides is almost debris slide on the base of tephra layers, excluding rock slide and rock fall near the epicenter.

1 Distribution of tephra layers

Thick tephra layers interleaved with kuroboku, cover on hill slopes in the area of numerous landslides. The tephras derived from Shikotsu caldera and surrounding volcanoes, about 50 km west of Atsuma town. Main tephra layers in the hillslope are Spfa1 pumice of 48ka from Shikotsu caldera, En-a pumice of 20ka from Eniwa volcano, and Ta-d pumice of 9ka, Ta-c pumice of 3ka, Ta-b pumice of AD1667, and Ta-a pumice of 1739 from Tarumai volcano. En-a layer is thick, 1m more, in the northern area with numerous landslides, and Ta-d layer is thick, 1m more, in the southern area. These tephra layers are the main parts of landslides by this earthquake.

2 Tephras on hillslope with geomorphological evolution

Slope surficial deposit moved active affected by solifluction due to freeze-thaw cycles in the last glacial period, more than 10ka. For the reason, Spfa1 and En-a could not remain on hillslopes, except for valley head slopes and the foot of the slope accumulated surficial deposits, or crest slopes. On the other hand, the lower part of slopes was eroded by increased fluvial activity related to warmer and wetter during the late glacial period. Therefore, Spfa1 and En-a from the last glacial period do not cover on the lower valley-side slopes, but Ta-d covers on slope deposits on weathered rock there.

En-a covering the slope, for example valley head slope, is underlain by the reworked Spfa1. The volcanic soil with Spfa1 contains easily water and has slippery. On the other hand, Ta-d often is underlain by reworked En-a on the lower valley-side slope. These reworked tephras and the unit of the base of Ta-d layer with high absorbability, described below, would be slide layers in this earthquake.

3 Cases of landslides

Cases of landslides of thick Ta-d in the southern area of the disaster area and of thick En-a in the northern area are shown below.

3.1 The southern part covered thick Ta-d

A landslide at Asahi, located at the west side of Yoshino at the most severe disaster, was occurred on a flat slope at the lower valley-side slope. The collapse was occurred from the lower convex break of slope. It is 35m high, 35m wide, and 90m long. The vertical surface of the 3m thick soil layers with tephras, is exposed at the both sides of the landslide. Pale yellowish water-rich volcanic ash with striations adhere to the slip surface on thin slope deposit on weathered rock. The sliding surface was in a fine-pumice layer containing much moisture at the lowest part of Ta-d layer, according to outcrop observation of both sides of this failure. The upper part of Ta-d layer of 130cm thick, is redish brown pumice with weathered clay, and the lower part of it is dull gray coarse pumice with high permeability. The moving body slid and deposited as almost kept stratigraphic structure.

3.2 The northern area covered thick En-a

A landslide at the right bank of the upper Abira river is at 80m high, 45m wide, and 230m long. The collapsed debris buried the Abira river. The landform of the slope was divided into upper and lower parts

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by a break line of inclination. The source of collapse was mainly the upper, a valley head slope, shaped shallow flat slope which is covered by En-a. The lower part was a V-shaped valley before the earthquake. The moving body run on the upper of V-shaped slope along the valley and deposited over the Abira river. Acording to observation of the exposed outcrops by the failure, thin Ta-d and the above layers cover on En-a of 130cm thick. En-a is pumice of 1-2mm diameter with rich-pyroxene. The sliding surface was on the lower volcanic ash, mixed glassy Spfa1, beneath En-a.

4 Shapes of slope failures in each southern and northern area of the disaster area

In the southern part of the disaster area, almost slopes except of steep are covered thick Ta-d. The main source of collapses is thick Ta-d by the earthquake. Therefore, the collapses were occurred numerous on the slope covered by thick Ta-d, especially the lower valley-side slope, which is steep. On the other hand, in the northern area of disaster area, because Ta-d layer is thin, even though it is on the lower valley-side slope, the collapse of Ta-d is rare. The collapses of thick En-a on the valley head slopes are unevenly distributed. Because each geomorphological unit at the source of collapses in the northern and the southern is different, their shapes are different in each region.

Keywords: the 2018 Hokkaido Eastern Iburi Earthquake, tephra layer, valley head slope, lower valley-side slope

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Feature of landslide of pyroclastic fall deposits induced by 2018 Hokkaido Eastern Iburi Earthquake, and its relation with damage

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1. Docon Co.,Ltd., 2. Bousai Chishitsu Kogyo Co.,Ltd., 3. Kyoto University, 4. Geological Survey of Hokkaido, HRO, 5. Kizaki PE Office, 6. Terre Research Co.

Many landslides occurred by the 2018 Hokkaido Eastern Iburi Earthquake around Atsuma-cho . Rapid landslide consisting of Holocene pyroclastic fall deposit (Debris slide by the classification of Varnes, 1978) gave the human damage of 36 above all. We show the topographical and geological cause and morphological characteristic of the landslides and discuss about relations with the human damage.

Tephra mainly derived from Shikotsu, Eniwa and Tarumai volcanos cover on sedimentary rocks for Neogene of the base in Atsuma area. Among these tephra, the Tarumai d pyroclastic fall deposit (Ta-d: 9ka) thickly distributes in this area as a central axis of distribution. Ta-d (thickness 1-2m), the tephra (Ta-c,-b,-a) and black soil (total thickness approximately 1.5-3m) which did mantle bedding was translationally sliding as landslide body. The sliding layer was formed in several centimeters above from the base of the Ta-d pumice at the slope where Ta-d directly covered the mudstone and mudstone rubble. The thickness of the layer was 1-3cm and is made of creamy clay including the halloysite. In addition, the sliding layer was formed in the weathered volcanic soil including pumice derived from Eniwa a and Shikotsu 1 Tephra in the area where the Ta-d covers up the volcanic soil.

The landslides in Atsuma area into following 7 types based from form and another feature of the slide, i.e. 1) Type Gv: Extremely gentle, shallow valley from, 2) Type Sv: Gently shallow valley form. 3) Type Dv: Deep valley form with alluvial cone or landslip lobe 4) Type Hv: Hanging valley form, 5) Type Ps: Planer slope, 6) Type Cf: Complex of Some valley form collapses along the small stream, and 7) type Ol: Gently landslide caused by overlapping of other slides.

Although there is difference in some clarity, the cutting of the layered bedding of Ta-d is often seen at the slope end in these slopes. The valley wall slope that Ta-d covers is eroded by small stream in the Type Cf. Because the thinning and omission of Ta-d occur at an exit of the hanging valley in the Type Hv , it is in a near condition for "lower part cutting". In addition, the convex break of slope angle and a man-made small cut is often observed in the foot of the collapse scarp with the Types Sv, Dv and Ps.

The landslide body of each type was moved with mostly maintaining of bedding form from the source area to the depositional area. The terminal form of slides has many variations, i.e. from stacking of plural sliding bodies which make thrust on the front, to separating and crushed into many blocks. Fluidized slide material such as the Type Cf made depositional lobes like a debris-avalanche or a debris-flow deposit in the terminal area. The distance from the base of slope to the tip of the sliding body of Types Cf, Hv and Dv were generally longer than the type Ps. The thickness of landslide body was about 1.5-3m which was reflected from the total thickness of stratified Ta-d and other tephra and black soil, and reaches 3-5m in the part which some bodies stacked at the terminal. The damaged buildings were located at the mouth of small stream and were located in the accumulation area of the landslides. Height of the first floor of the house is almost about 3m.

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The geological cause of landslide is that The Ta-d tephra distributes widely with the mantle bedding. The pumice of Ta-d is weathered and halloysite formed in it. Furthermore, the tephra was cutting in the foot of slope in many places by natural and artificial process. On the other hand, the Eastern Eburi Earthquake showed that a landslide will occur by all means in the sloping ground including extremely gentle area that pyroclastic fall deposit cover with mantle bedding when the large-scale inland earthquake occurs. Because it is impossible to predict earthquake, inhabitants of the slope area cannot evacuate beforehand. The preventive measures construction is not necessarily realistic. It is necessary to avoid building house at the mouth of small valley and to make a bedroom in the places more than second floor for reducing human damage.

Keywords: landslide induced by earthquake, tephra, landslide body, Lower cutting, weathering

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Influence of slope cutting on failures induced by the July heavy rain, and the Iburi-tobu earthquake, 2018.

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Many cases of failure induced by slope cutting have been also reported in the past. Some examples are added here by the July heavy rain from June 28 to July 8 and the Hokkaido Iburi-tobu earthquake on September 6, 2018. In the July heavy rain, many slope failures occurred widely main in western part of Japan including Hiroshima, Ehime and Gifu Prefectures. The Iburi-tobu earthquake caused collapses in high density in the hilly area around at Atsuma Town, Hokkaido.

Case A (Hokkaido): a failure that 20 m in width and 50 m in length caused by the Iburi-tobu earthquake. It is smaller scale one in the many failures by the earthquake. Similar to many other cases, sliding surface is the base of Tarumai-d tephra (9ka) lying under 2.5 m from the earth surface. The slope toe has been cut about 3 m in height for a hut. As a result, inclined weak layer became to daylight in the cutting slope.

Case B (Ehime Prefecture): a 30 m wide failure occurred on an orange grove slope by the July heavy rain. It is initially surface failure 0.5 m in depth, although the secondary 2 m deep failure continued on the left side. A trail for working passes at the top of the failure, and a pipe for sprinkling was buried along the trail. Leaked water from the pipe might cause the initial failure, so many small gullies run from the top. Otherwise, groove into strongly weathered Cretaceous sandstone is possible factor of the failure.

Case C (Gifu Prefecture): a forest road shoulder composed of highly weathered Jurassic Hida Granite was collapsed 25 m in width. The failure occurred on a shallow valley slope and the road passes through the upper part of the slope in up-hill grade. Although this valley has only small catchment area originally, rain water was drained from upper neighboring valley through the road and flowed out to the road shoulder along small undulations on the road. This large quantity of water caused the failure. Involving catchment area was enlarged at least 8.5 times than before the road opened.
There are many sites needed slope cutting for architecture and civil structure and dense network of forest road is required for proper management of forestry and agriculture. However, any slope cutting causes hydrological and geomorphological changes despite of its scale. When large impacts like heavy rain or earthquake occur, modified landforms can be a factor of landslide. Slope failures are induced by daylighting of weak layer in the case A, and by flowing water in the upper part of slope in the cases B and C. Moreover, construction of the forest road made drainage area increase by capture of the upper neighboring valley in the case C. On the planning of slope cutting, appropriate design, construction and maintenance should be taken considering microlandforms, subsurface geological properties and structures.

Keywords: 2018 July heavy rain, 2018 Iburi-tobu earthquake, slope failure, cutting

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Slope failures occurred in the southwest part of the Izu-oshima Island in geological time, NE Japan

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So-called “loam” composed of primary fall-out tephras and tephric soil deposits (tephric loess) is one of the factors cause earthquake-induced landslide. To evaluate potential of slope failure by this combination in the Japanese Island, earthquake-induced landslides potential assessment should be examined in relevant areas, considering frequency of landslides in geological time. To estimate this, we examined unconformities within “loam” on the Izu-oshima Island, Tokyo, where thick loam has been formed during last 19 ka. We identified at a maximum six unconformities suggesting possibility of occurrences of landslides during the period between 19-1.8 ka.

Keywords: Slope failure, Tephric soil deposits, Izu-oshima Island

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The strain rate observation by the borehole inclinometer on the bedrock creep slopes in Akadani-west area

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In the disaster around Kii Peninsula in 2011, many deep-seated landslides were occurred. In order to reduce the damage, it is necessary to establish the method of the extracting dangerous slopes and to consider the countermeasures in advance. So far, the method of reading the micro topography from the topographic map such as the laser profiler, the method of judging the degree of danger from geological / topographical overview have been proposed. On the other hand, there are few cases where the strain rate was observed at the landslide dangerous slope such as the bedrock creep slope. For this reason, the validity of the past method has not been fully verified. In this study, we conducted the boring survey and observed the strain rate by borehole inclinometer on two slopes of Akadani-west area. Also, based on this observation value, the validity of the risk method by the past study was examined.

First, we calculated the strain rate (the value obtained by dividing the length of the landslide scarp by the slope length) from the topographical data obtained by the laser profiler at the two slopes in Akadani-west area. We also evaluated the risk of the two slopes using the method to evaluate the risk from geology and topography by Chigira et al. In addition, we conducted the airborne electromagnetic survey, and the degree of strain was also investigated from the resistivity distribution of the ground. By these methods, after evaluating the degree of risk, two boring investigations were conducted on each of the two slopes. At the borehole location, the strain rate was observed by the borehole inclinometer. Through these, the consistency of the observed data and the risk assessment results was verified.

The strain rate of Akadani-west I district was 4.1%, and the risk by the method by geology / topography was IV. The strain rate of Akadani-west II district was 2.7%, and the risk by the method by geology / topography was II. From this, we have found that the degree of the risk in the Akadani-west I district is higher than that of II by the risk assessment by the past research. In addition, the strain rate by the borehole inclinometer was 0.6mm/year, 1.0mm/year in Akadani I and II districts, respectively. For this reason, we have found that the danger level in the Akadani-west II district is higher by the observed data. On the other hand, in the resistivity distribution by the airborne electromagnetic survey, a large change in resistivity was seen in Akadani-west II area, and it was found that the consistency with the actual observed data was obtained. From this, we have found that there is a possibility that the degree of the risk can be accurately evaluated by combining the plural methods.

Keywords: Bedrock creep, Borehole inclinometer, Strain rate

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Assessing Potential Landslide Areas Due to Earthquake Using Three-Dimensional Resistivity Datasets from Across a Wide Area

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In recent years, sediment disasters due to earthquake have often occurred, including in the 2011 Great East Japan Earthquake, the 2016 Kumamoto Earthquake, the 2018 Hokkaido Eastern Iburi Earthquake. Measures for preventing and reducing the damage of sediment disaster due to earthquake are an urgent issue, because Nankai Trough Earthquakes are expected in the future. A variety of methods for assessing seismic landslide susceptibility have been proposed and their accuracy verified. In those methods, topographic parameters such as inclination of slope, curvature of slope, and relief are commonly used as controlling factors.

It has also been reported that underground structure has a large impact on seismic landslide occurrence, as in the case of the landslide that occurred around the Aso Volcanological Laboratory of Kyoto University in the 2016 Kumamoto Earthquake. Therefore, underground structure can be considered critical information for improving the predictability of potential landslide areas. However, geological maps only plot spatial patterns of the underground condition, and boring is required to obtain point information of underground structure in the depth direction. This lack of three-dimensional information of underground structures is one of key obstacles to evaluating potential landslide areas due to earthquake across a wide area.

Therefore, we used resistivity spatial patterns measured by airborne electromagnetic survey (AES). Airborne electromagnetic survey Based on electromagnetic induction, AES is an exploration technique for obtaining three-dimensional resistivity across a wide area by measuring the response to an induced electromagnetic field with an electromagnetic sensor from a helicopter.

The purpose of this study was to test the applicability of three-dimensional resistivity data to assessing seismic landslide susceptibility. We used three-dimensional resistivity data from the central cone of Aso Volcano measured before the 2016 Kumamoto Earthquake and landslide distribution maps made from airborne laser scanner datasets and orthoimages from before and after the earthquake. We identified the three-dimensional resistivity patterns in seismic landslide areas before landslide occurrence. Based on our findings, we argue the applicability of three-dimensional data for assessing seismic landslide susceptibility.

Keywords: resistivity, airborne electromagnetic survey, landslide, earthguake

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[J] Oral | H (Human Geosciences)：H-DS Disaster geosciences

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[H-DS14] Geohazards in humid, tectonically active countries and their precursors

convener:Masahiro Chigira(Disaster Prevention Research Institute, Kyoto University), Hiroshi YAGI(Faculty of Art, Science and Education, Yamagata University), Satoru Kojima(Department of Civil Engineering, Gifu University), Taro Uchida(National Institute for Land and Infrastructure Management), Chairperson:Chigira Masahiro, Taro Uchida

This session covers mass movements of landslide, slope failure, debris flow, and gravitational slope deformation in tectonically active, humid countries, and aims to discuss on their mechanisms, characteristics of occurrence sites, the significance in geological time scale, and the methodology to mitigate their affects by researchers with various related research fields. In particular, papers about 2017 northern Kyushu rainstorm, 2018 Osaka earthquake, 2018 Western Japan rainstorm, and 2018 Hokkaido earthquake are welcome

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[HDS14-07] Prediction of shallow landslides and debris flow by rainstorm: dynamic hazard mapping toward disaster mitigation

*Yuki Matsushi[1] (1.Disaster Prevention Research Institute, Kyoto University)

2:00 PM - 2:30 PM JST | 5:00 AM - 5:30 AM UTC

[HDS14-08] Land slide warning judgment mesh information of the Meteorological Agency using the Soil Water Index

★Invited Papers

*KENJI OKADA[1] (1.Japan Meteorological Agency)

2:30 PM - 3:00 PM JST | 5:30 AM - 6:00 AM UTC

[HDS14-09] A future direction of remedial measures for sediment disaster reduction from the viewpoint of enhancing a workable early warning system

★Invited Papers

*Masaru Kunitomo[1,2,3,4], Shigetaka Takiguchi[1,2,3,4], Fumiaki Akazawa[1,2,3,4], Kazuyuki Imai[1,2,3,4] (1.Ministry of Land, Infrastructure, Transport and Tourism, 2.Water and Disaster Management Bureau, 3.Sediment and Erosion Control Department, 4.Sediment and Erosion Control Planning Division)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

Discussion

Prediction of shallow landslides and debris flow by rainstorm: dynamic hazard mapping toward disaster mitigation

*Yuki Matsushi[1]

1. Disaster Prevention Research Institute, Kyoto University

This study demonstrates a strategy for predicting location, timing, and magnitude of rainfall-induced shallow landslides and areas affected by subsequent debris flows. Spatial distribution of soil layers was modeled for evaluating thickness of sliding material on hillslopes, which provides a basis for predicting source area and volume of shallow landslides and simulating subsurface hydrological processes. Soil accumulation in hollows was calculated on a geographic information system using a 1 m-meshed digital terrain model with soil production by bedrock weathering and transport by soil creep. The output was validated by a ground-based survey in the actual terrain in a selected watershed. The shear strength of the bulk soil was evaluated by direct shear tests using undisturbed specimens, and quantification of soil reinforcement by tree roots through an in-situ survey at soil pits. Hydrological monitoring was carried out at representative hillslopes for modeling fluctuation in subsurface pore-water pressure by rainwater infiltration. By coupling all of those data and modeling, we analyzed the hillslope instability, and then compared the output with a landslide inventory map to confirm the accuracy and precision of the prediction. Time-series change in areas of debris flow runout was estimated based on assumed equivalent coefficient of friction as a function of hillslope wetness in the watershed. Such dynamic mapping of geohazard fills a demand in disaster mitigation in local communities for increasing events of heavy rainfall.

Keywords: Soil thickness, Tree roots, Pore-water pressure, Slope stability, Equivalent coefficient of friction

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Land slide warning judgment mesh information of the Meteorological Agency using the Soil Water Index

*KENJI OKADA[1]

1. Japan Meteorological Agency

Soil Water Index shows the risk of land slide disasters caused by rain in real time and the land slide warning judgment mesh information released by the Japan Meteorological Agency using it.
Most of the dead due to land slide disasters in the last two decades occurred with the Soil Water Index value updating the maximum value in the last 10 years.

Keywords: land slide, Soil Water Index, Land slide warning judgment mesh information

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A future direction of remedial measures for sediment disaster reduction from the viewpoint of enhancing a workable early warning system

*Masaru Kunitomo[1,2,3,4], Shigetaka Takiguchi[1,2,3,4], Fumiaki Akazawa[1,2,3,4], Kazuyuki Imai[1,2,3,4]

1. Ministry of Land, Infrastructure, Transport and Tourism, 2. Water and Disaster Management Bureau, 3. Sediment and Erosion Control Department, 4. Sediment and Erosion Control Planning Division

Due to “Heavy rain of July 2018”, more than 2500 sediment disasters occurred mainly in the western part of Japan. The number is equivalent to approximately 2.3 times of the annual average. Why were such a lot of people killed in this disaster, despite various measures for precaution?

The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) established a committee in order to take remedial measures for sediment disaster reduction from the view point of enhancing a workable early warning system, after not only revealing the facts on cause of the disaster but reviewing our measure have been taken.

With understanding that the lack of residents’ awareness of sediment disaster risk may be a major cause of this disaster, on the other hand, mutual assistance plan among local community may work well for evacuation at the sites with no victim, the committee proposed the MLIT to;
Build the early warning system nationwide based on a community mutual assistance plan for evacuation, Get residents to aware of their risk on sediment disasters, Enhance the national and prefectural support system to build the capacity of municipalities and residents, Improve the accuracy of sediment disaster alert to encourage residents at risk to evacuate precautionary, Build disaster-prevention facilities such as debris basins to reduce evacuation risk and to prevent crucial infrastructures from debris flows as well as sediment-rich flood, with the object of climate change adaptation. As a remedial measures for sediment disaster reduction from the viewpoint of enhancing a workable early warning system.

Keywords: Sediment Disasters, Early Warning

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[J] Oral | S (Solid Earth Sciences)：S-GD Geodesy

Mon. May 27, 2019 1:45 PM - 3:15 PM JST | Mon. May 27, 2019 4:45 AM - 6:15 AM UTC | 304 3F

[S-GD03] Geodesy General Contributions/Global Geodetic Observing System

convener:Koji Matsuo(Geospatial Information Authority of Japan), Yusuke Yokota(Institute of Industrial Science, The University of Tokyo), Takahiro Wakasugi(Geospatial Information Authority of Japan), Chairperson:Kensuke Kokado(GSI of Japan), Yusuke Yokota

In this session, general contributions from all areas of geodesy are welcomed. Topics of interest will include but not limited to recent advances in measurement techniques, reference frame realization, earth rotation or earth tide. In addition, this session also provides a forum for discussing GGOS (Global Geodetic Observing System) related observation programs, advancement of geodetic techniques, collaboration among various organizations in the world. Topics will include improvements of observing system and data analysis, participations in global programs, global reference frames and geodesy's contributions to society.

1:45 PM - 1:50 PM JST | 4:45 AM - 4:50 AM UTC

Introduction

1:50 PM - 2:05 PM JST | 4:50 AM - 5:05 AM UTC

[SGD03-01] Activities and future perspective of GGOS Working Group Japan

*Basara Miyahara[1] (1.GSI of Japan)

2:05 PM - 2:20 PM JST | 5:05 AM - 5:20 AM UTC

[SGD03-02] Discussion

*Koji Matsuo[1] (1.Geospatial Information Authority of Japan)

2:20 PM - 2:35 PM JST | 5:20 AM - 5:35 AM UTC

[SGD03-03] VLBI-GNSS Co-location Survey at the Ishioka Geodetic Observing Station

*Saho Matsumoto[1], Michiko Umei[1], Haruka Ueshiba[1], Shinobu Kurihara[1], Tadao Kikkawa[1], Takahiro Wakasugi[1] (1.GSI of Japan)

2:35 PM - 2:50 PM JST | 5:35 AM - 5:50 AM UTC

[SGD03-04] **Research of Crustal Deformation Model for Next Version of Japanese Geodetic Datum**

*Kensuke Kokado[1] (1.GSI of Japan)

2:50 PM - 3:05 PM JST | 5:50 AM - 6:05 AM UTC

[SGD03-05] Construction of a laser-strainmeter network for accurate seismic and geodetic observations

*Akito Araya[1], Akiteru Takamori[1], Wataru Morii[2], Akio Katsumata[3], Akio Kobayashi[3], Takeo Ito[4], Takashi Okuda[4], Makoto Okubo[5] (1.Earthquake Research Institute, University of Tokyo, 2.Disaster Prevention Research Institute, Kyoto University, 3.Meteorological Research Institute, Japan Meteorological Agency, 4.Graduate School of Environmental Studies, Nagoya University, 5.Natural Science Cluster, Kochi University)

3:05 PM - 3:15 PM JST | 6:05 AM - 6:15 AM UTC

Discussion

Activities and future perspective of GGOS Working Group Japan

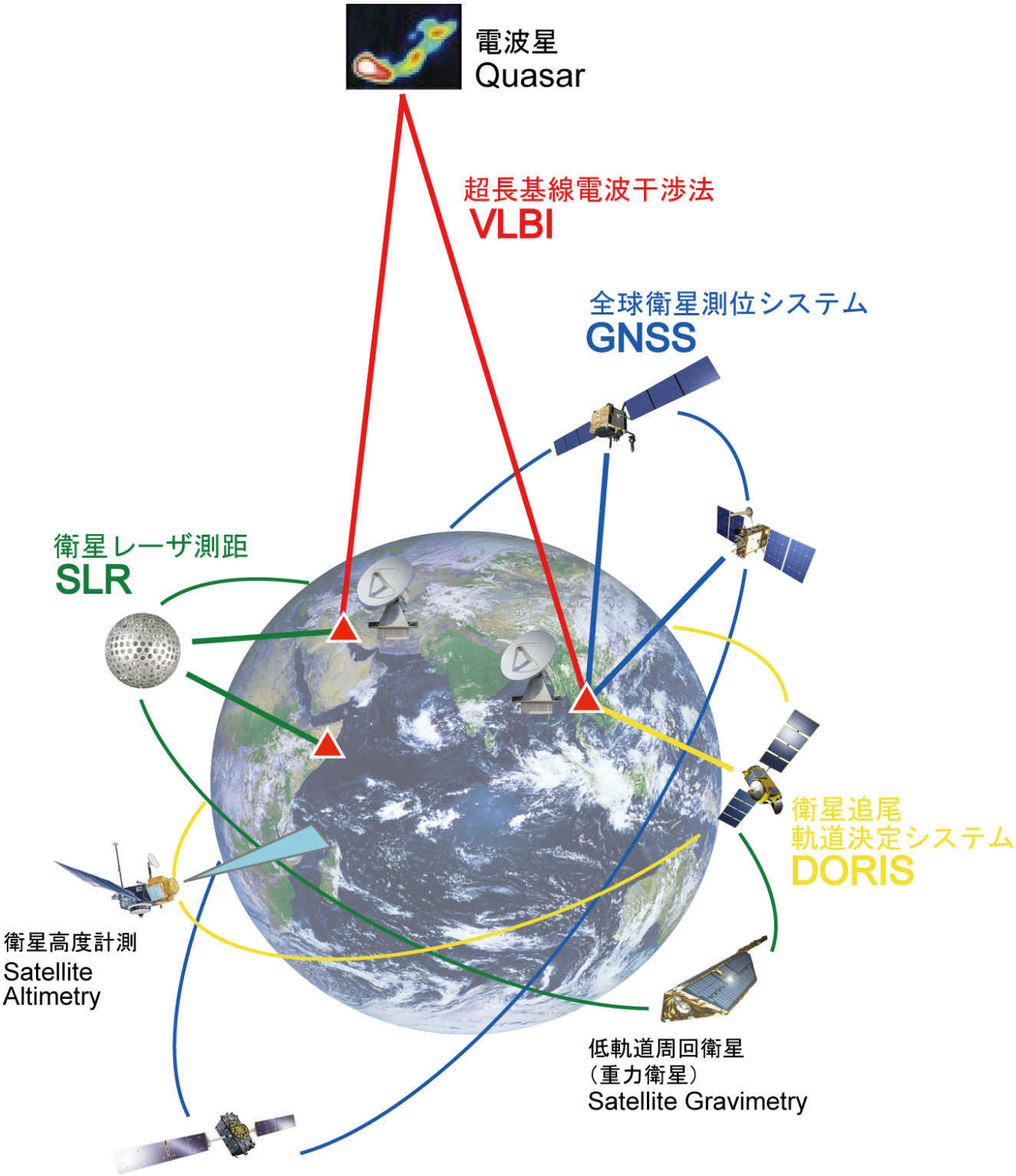
*Basara Miyahara[1]

1. GSI of Japan

Global Geodetic Observing System (GGOS) is a fundamental framework for integration of global geodetic observations such as GNSS, VLBI, SLR, DORIS, gravity measurements and so on. The main objective of the system is to measure and monitor shape, rotation, gravity field of the earth and its changes. GGOS integrates various international organizations related geodetic observation such as International GNSS Service (IGS), International VLBI Service for Geodesy and Astrometry (IVS), International Laser Ranging Service (ILRS) and so on in order to coordinate and promote global geodetic observations. International Terrestrial Reference Frame (ITRF) which is a de-facto standard for Global Geodetic Reference Frame (GGRF), reference frame for earth’s shape and variation which was endorsed by the United Nations General Assembly in 2015, is also one of the main achievements of GGOS observation. GGOS is essential basic infrastructure for measuring and monitoring of earth’s shape and its change.
The objective of GGOS, that is to continue to measure and monitor earth’s shape and its change can be possible only with continuous global geodetic observation with high quality and enough spatial coverage. Such observation cannot be possible without continuous geodetic observation by countries all over the world. Therefore, several agencies in Japan such as Geospatial Information Authority of Japan (GSI), Japan Coast Guard, National Institute of Information and Communications, National Astronomical Observatory of Japan, National Institute of Polar Research, and Japan Aerospace Exploration Agency have been individually conducting geodetic observation such as GNSS, VLBI and SLR in Japan and Antarctica, and participating in global geodetic observation through international organizations such as IGS, IVS, and ILRS and so on. Several researchers with universities have also participated in the organizations as chairs and board members. In addition, we established a working group on GGOS, GGOS-WG of Japan under IAG Subcommittee in Science Council of Japan in 2013 in order to facilitate information sharing and strengthen collaboration between the agencies for further contribution to GGOS. The WG submitted a status report of geodetic observatories of Japan to GGOS in 2014 and updated it in 2017. The WG has also held a session on GGOS at annual meetings of Japan Geoscience Union (JpGU) since 2015. The theme of GGOS has also added in annual meeting of the Geodetic Society of Japan since 2018. Furthermore, GGOS invited the WG as the first GGOS Affiliate, which is a regional component of GGOS aiming to strengthen regional participation to GGOS and the WG has participated in and contributed to activities of GGOS from regional and national perspectives. As the first GGOS Affiliate, the WG hosted the GGOS annual meeting, GGOS Days 2018 in Tsukuba, Japan and discussed the future activities of GGOS for more strengthened collaboration between GGOS and the WG. In the meeting, current status and issues of network, observation, products and standard were discussed activities of three of four Focus Areas, 1. Unified Height System, 2. Geohazards, 4. Geodetic Space Weather were reported. Some members also reported the possibility of establishment of new GGOS affiliates in DACH countries, Scandinavia, Latin America and North America. The members agreed on the new WG in GGOS which will work on DOI of geodetic data. An update of GGOS guide book was also discussed in the meeting. In addition to the above activities, the WG organized special issue on GGOS in Journal of the Geodetic Society of Japan and also developed a Japanese brochure of GGOS in 2018 to facilitate understanding of the role and significance of GGOS for science and society. In 2018, some members of the WG participated in several international conferences related to GGOS and facilitated exchange of the latest information on geodetic observation. In 2019, we will continue sharing of information and strengthening collaboration in Japan and strengthen collaboration between GGOS and GGOS-WG of Japan.

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Keywords: GGOS, GGRF



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Discussion

*Koji Matsuo[1]

1. Geospatial Information Authority of Japan

We provide a forum for discussion on today's presentation and any topics related to geodesy and GGOS.

Keywords: Discussion

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VLBI-GNSS Co-location Survey at the Ishioka Geodetic Observing Station

*Saho Matsumoto[1], Michiko Umei[1], Haruka Ueshiba[1], Shinobu Kurihara[1], Tadao Kikkawa[1], Takahiro Wakasugi[1]

1. GSI of Japan

The International Terrestrial Reference Frame (ITRF) is realized by a combination of four space geodetic observing techniques (VLBI, SLR, GNSS and DORIS), where VLBI contributes in determining scale and EOP, and SLR contributes in determining scale and the center of mass. To perform this combination, it is necessary that relative coordinates between these space geodetic observing stations are precisely known at co-location sites.

The Ishioka Geodetic Observing Station operates the two space geodetic observing stations, VLBI and GNSS. Ishioka station is a fundamental site on a geodetic perspective since the VLBI station is one of the VGOS (VLBI Global Observing System) stations which is promoted by IVS (International VLBI Service for Geodesy and Astrometry) as the next-generation standards, and the GNSS station "ISHI" is registered as one of the IGS (International GNSS Service) sites. To measure the relative coordinate between the VLBI invariant point (IVP) and the GNSS reference point, we conducted the co-location survey in November 2018 in Ishioka station. In this survey, we adopted two methods to determine the IVP. One is "outside method" where we observe the target attached on the antenna movable part (near the counterweight) with "Total Station" at the reference pillars installed around the antenna. The other is "inside method" where we observe the targets attached near the IVP from the inside of the antenna cabin. "Inside method" was adopted for the first time in Ishioka station so we discussed the way of observation, computation and evaluation of error.

In this talk, we will report a co-location survey result in November 2018 and discuss details on two different methods.

Keywords: VLBI, Co-location survey, Local tie vector, ITRF, GNSS

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Research of Crustal Deformation Model for Next Version of Japanese Geodetic Datum

*Kensuke Kokado[1]

1. GSI of Japan

Geospatial Information Authority of Japan (GSI) maintains the Japanese horizontal and vertical datum reference system and provides the accurate positions of control points including GNSS CORSs (Continuously Operating Reference Stations) as basic survey result based on the reference system. By utilizing the survey results as the reference position of various surveys and maps, people can receive location information service which positions are aligned with each other nationwide. Along with the progress of Global Navigation Satellite System (GNSS) and the satellite positioning techniques in recent years, it is expected that location information service will be developed using the high accuracy GNSS positioning.

However, there is some gaps due to the crustal deformation between the position of the survey results such as map and the measurement position of the GNSS positioning, which will be used in location information service. Therefore it is necessary to correct the crustal deformation that occurred between the reference date of map and the measurement date of the GNSS positioning in order to match the measurement position by GNSS with the map.

In order to properly correct the above gaps due to the crustal deformation, GSI plans to develop advanced correction system instead of the existing semi-dynamic correction system. For the system development, we have been researching the crustal deformation model considering not only steady crustal deformation but also postseismic deformation of the 2011 Tohoku-Oki earthquake or coseismic deformation of the other earthquakes caused along an active inland faults.

In this presentation, we will focus on the postseismic deformation of 2011 Tohoku-Oki earthquake among the contents of the research, and report the progress of the research to create the crustal deformation model in the Tohoku region.

Keywords: Geodetic Datum, Crustal Deformation, Deformation Model, GNSS positiong

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Construction of a laser-strainmeter network for accurate seismic and geodetic observations

*Akito Araya[1], Akiteru Takamori[1], Wataru Morii[2], Akio Katsumata[3], Akio Kobayashi[3], Takeo Ito[4], Takashi Okuda[4], Makoto Okubo[5]

1. Earthquake Research Institute, University of Tokyo, 2. Disaster Prevention Research Institute, Kyoto University, 3. Meteorological Research Institute, Japan Meteorological Agency, 4. Graduate School of Environmental Studies, Nagoya University, 5. Natural Science Cluster, Kochi University

Laser interferometers are widely used for precise measurements of displacement with reference to wavelength of light. As their geophysical application, a laser strainmeter is used for measuring deformation of the ground by sensing distance between two separated points, enabling to detect small strain changes over wide frequency range [1]. The advantages of the laser strainmeter over conventional strainmeters using mechanical references are high resolution with a long baseline, resonance-free response of optical reference, and low-drift detection using stabilized laser wavelength. Apart from the instrumental detectability, local noise sources, such as changes in temperature, air pressure, and ground water level, will affect both the instrument and the ground, and should be properly evaluated to examine the measured strain data. For this purpose, we constructed a network of laser strainmeters deployed at three underground sites in Japan: Kamioka (Gifu Pref.), Inuyama (Aichi Pref.), and Tenryu-Funagira (Shizuoka Pref.). These strain data are analyzed to evaluate performance of instruments installed at these sites as well as to identify common geophysical signals.

At Kamioka site, two laser strainmeters with baselines of 100m and 1500m are in operation [2, 3]. At Inuyama and Tenryu-Funagira sites, a 30-m strainmeter and a 400-m one are installed, respectively [4]. These strainmeters clearly detect earth tides, and their amplitudes are consistent with the calculation based on the tidal force, the standard Earth's model, and the topographic effects around the sites. Using the site effects, coseismic strain steps observed by the strainmeter network are compared with fault parameters estimated from seismic observations and the detectability of the fault mechanisms using the strainmeter network is estimated. For long-term strain changes, local disturbances of the sites and detectability of the network are estimated using GNSS data. In the presentation, we discuss detectability of the strainmeter network for seismic and geodetic signals and prospects for monitoring crustal activities using long-baseline laser strainmeters.

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Keywords: strainmeter, laser, crustal deformation, Kamioka, Inuyama, Tenryu-Funagira

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[J] Oral | S (Solid Earth Sciences)：S-GD Geodesy

Mon. May 27, 2019 3:30 PM - 5:00 PM JST | Mon. May 27, 2019 6:30 AM - 8:00 AM UTC | 304 3F

[S-GD03] Geodesy General Contributions/Global Geodetic Observing System

convener:Koji Matsuo(Geospatial Information Authority of Japan), Yusuke Yokota(Institute of Industrial Science, The University of Tokyo), Takahiro Wakasugi(Geospatial Information Authority of Japan), Chairperson:Yuji Harada(Macau University of Science and Technology), Koji Matsuo

In this session, general contributions from all areas of geodesy are welcomed. Topics of interest will include but not limited to recent advances in measurement techniques, reference frame realization, earth rotation or earth tide. In addition, this session also provides a forum for discussing GGOS (Global Geodetic Observing System) related observation programs, advancement of geodetic techniques, collaboration among various organizations in the world. Topics will include improvements of observing system and data analysis, participations in global programs, global reference frames and geodesy's contributions to society.

3:30 PM - 3:35 PM JST | 6:30 AM - 6:35 AM UTC

Introduction

3:35 PM - 3:50 PM JST | 6:35 AM - 6:50 AM UTC

[SGD03-06] UNAVCO GNSS Data: Real-time High-rate Streams, Geodetic Earthquake Magnitudes, Cloud Computing and Future Machine Learning Frameworks

*David A Phillips[1], Kathleen Hodgkinson[1], David Mencin[1], Charles Meertens[1], Thomas Herring[2], Walter Szeliga[3], Timothy Melbourne[3], Mark Murray[4], Glen Mattioli[1], Christine Puskas[1] (1.UNAVCO, Inc. Boulder, 2.Massachusetts Institute of Technology, 3.Central Washington University, 4.USGS)

3:50 PM - 4:05 PM JST | 6:50 AM - 7:05 AM UTC

[SGD03-07] **On application of GNSS-techniques for early tsunami warning in the Sea of Japan**

*Grigorii Viktorovich Nechaev[1,2,3], Nikolai Shestakov[2,3], Hiroaki Takahashi[1], Mako Ohzono[1] (1.Institute of Seismology and Volcanology, Graduate Schooll of Science, Hokkaido University, 2.Far Eastern Federal University, 3.Institute for Applied Mathematics FEB RAS)

4:05 PM - 4:20 PM JST | 7:05 AM - 7:20 AM UTC

[SGD03-08] Measurements of occurrence of solar conjunction with the orbits of Asian QZSS/IGSO satellites

Cancelled

*Fujinobu Takahashi[1] (1.Yokohama National University)

4:20 PM - 4:35 PM JST | 7:20 AM - 7:35 AM UTC

[SGD03-09] Sea level evaluation in northern Australian coast

*Yuta Tokui[1], Kosuke Heki[1] (1.Hokkaido University)

4:35 PM - 4:50 PM JST | 7:35 AM - 7:50 AM UTC

[SGD03-10] Implications from geomagnetic observation for the interannual fluctuations of Earth rotation

*Seiki Asari[1], Masanori Kurihara[1], Kenji Morinaga[1], Shingo Nagamachi[1] (1.Kakioka Magnetic Observatory, Japan Meteorological Agency)

4:50 PM - 5:00 PM JST | 7:50 AM - 8:00 AM UTC

Discussion

UNAVCO GNSS Data: Real-time High-rate Streams, Geodetic Earthquake Magnitudes, Cloud Computing and Future Machine Learning Frameworks

*David A Phillips[1], Kathleen Hodgkinson[1], David Mencin[1], Charles Meertens[1], Thomas Herring[2], Walter Szeliga[3], Timothy Melbourne[3], Mark Murray[4], Glen Mattioli[1], Christine Puskas[1]

1. UNAVCO, Inc. Boulder, 2. Massachusetts Institute of Technology, 3. Central Washington University, 4. USGS

UNAVCO provides a diverse suite of geodetic data, derived products and cyberinfrastructure services to support the geodetic community, Earth science research and education. We present here an overview of recent developments related to real-time GNSS data streams, GNSS earthquake magnitude estimation, a new project focusing on machine learning for geoscience and hazards research, and cloud based GNSS data analysis experiments. UNAVCO operates the National Earth Science Geodetic Facility through a cooperative agreement with the U.S. National Science Foundation (NSF) and NASA.

Real-time (<2 seconds) high-rate (1 Hz) GNSS (RT-GNSS) data streams are now provided from ~900 UNAVCO sites. Streams include raw data in BINEX and RTCM3, and PPP solutions in ITRF2008 via Trimble PIVOT RTX software. Most UNAVCO RT-GNSS sites are within the Network of the Americas (NOTA). NOTA, which includes the historic Plate Boundary Observatory (PBO) network, is an extensive network of GNSS reference stations and other geophysical instruments in the United States, Mexico, Central America, the Caribbean and parts of South America. The network advances research into Earth systems from the core to the atmosphere. Recent advances include improved plate tectonic models, understanding earthquakes and slow slip/episodic tremor, measuring surface water load, deciphering ionospheric dynamics and measuring changes in permafrost. Beyond research the network provides information for earthquake and tsunami early warning systems (EWS), severe weather and space weather forecasts, volcanic activity alerts, drought and flood monitoring and other risk assessments. UNAVCO data are open access; an objective of the geodetic community is to enhance data access and data use for global hazard risk reduction.

Following an earthquake, RT-GNSS data streams can record peak ground displacement (PGD) measurements from long-period surface waves and provide a source-scaling relation that does not saturate with event magnitude. “Geodetic magnitudes” derived from RT-GNSS data can be estimated within seconds to minutes after an earthquake, and can improve earthquake and tsunami EWS. Dynamic displacements estimated in real time show reasonable agreement with post-processed estimates. And while individual position estimates have large errors, RT-GNSS solutions offer excellent operational potential for EWS, including the use of PGD to directly invert for finite-fault solutions. We will show PGD and geodetic magnitude estimate results from recent earthquakes including the 2018-11-30 Mw 7.0 Anchorage, Alaska earthquake. PGD’s from this earthquake were calculated automatically from the RT-GNSS displacement traces, which were large enough and recorded by enough sites to determine that, using GNSS data only, the event was ~M7 within 120s.

As the number of RT-GNSS sites increases, the volume of data and the complexity of automated analysis increase as well. When other data streams are factored in, such as seismic, ocean bottom pressure and satellite radar, the shear volume and complexity of these data streams, coupled with the need to model, analyze and assess hazards in a matter of only minutes, makes geophysical applications to hazards early

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warning a Big Data problem. To address this, UNAVCO is collaborating in an NSF project called “GeoSCIFramework: Scalable Real-time Streaming Analytics and Machine Learning for Geoscience and Hazards Research.” This project unites computer scientists and geoscientists to develop a data framework for generalized real-time streaming analytics and machine learning for geoscience and hazards research. The goals of this project, which was just initiated, will be presented.

In addition to real-time products, UNAVCO also provides post-processed position time series and velocities from 2000+ GNSS stations. These products are based on daily solutions generated using GIPSY PPP and GAMIT/GLOBK double-difference network software. This software is currently run on local computing clusters. As part of an NSF funded project called GeoSciCloud, we are testing our GIPSY and GAMIT workflows in two cloud computing environments: Amazon Web Services and NSF’s Extreme Science and Engineering Discovery Environment (XSEDE). The IRIS seismic data facility is a collaborative partner on this project and conducted similar experiments using seismic software and data. We summarize our latest findings from these cloud computing experiments including performance and cost relative to local systems.

Keywords: Geodesy, GNSS, Real-Time Data, EWS

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On application of GNSS-techniques for early tsunami warning in the Sea of Japan

*Grigorii Viktorovich Nechaev[1,2,3], Nikolai Shestakov[2,3], Hiroaki Takahashi[1], Mako Ohzono[1]

1. Institute of Seismology and Volcanology, Graduate Schooll of Science, Hokkaido University, 2. Far Eastern Federal University, 3. Institute for Applied Mathematics FEB RAS

Tsunami hazard threatens an extensive coastlines located in the seismically active areas. About 250000 persons were killed by tsunami only with the beginning of 21th century. Thus, the problem of reliable early tsunami warning is very important nowadays.
The most of working tsunami early warning systems (TEWS) are based on seismic methods that often cannot provide a reliable and accurate warning due to different reasons. The GNSS-based TEWS recently has been developed and they are free of many shortcomings of seismic methods. Such systems utilize coseismic shifts measured by onshore GNSS-networks for tsunami modeling. The TEWS operating now, for example, REGARD [Kawamoto S. et al., 2017], are mainly focused on detection of huge Mw8-9 class subduction zone earthquakes. They are not designed to process relatively small events, which can produce coseismic displacements less than 10 cm, despite on RTX-techniques or recently developed methods [Fratarcangeli F. et al., 2018], which can detect site position changes of 1-2 cm in horizontal and 3-4 cm in vertical components. However, devastating tsunamis regularly appear in the Japan Sea. They are caused by shallow thrust seismic events with magnitudes Mw6.2-7.8. These quakes generate tsunamis more effectively than Pacific ones with the same magnitude.The epicenters of tsunamigenic earthquakes are distributed along the western coast of Honshu, south-west of Hokkaido and Sakhalin Islands. Nevertheless, tectonics and seismicity of the Japan Seahaven't been sufficiently investigated still and tsunamigenic seismic events can occur along the north-western margin of the sea. For example, the potentially tsunamigenic Mw~6 shallow seismic event occurred near the northeastern coast of Primorye on Nov. 11, 1990.
In this work we explored: 1) the capacity of GNSS-based TEWS application using data about historical Mw 6.2-7.8 Japan Sea crustal seismic events. The appropriate coseismic displacement fields were calculated and analyzed. Possible hypothetic tsunamigenic seismic sources were also considered; 2) the optimal GNSS-site distribution for earthquake source parameters obtaining based on existing and prospective GNSS-networks configuration in the region.
We obtained, that historical tsunamigenic earthquakes occurred along the eastern margin of the Japan Sea induced coseismic displacements ranging from 1 cm to a few decimeters through the northern Honshu and western Hokkaido. Even 1964 Oga-oki, Mw7.0 event caused up to 4 cm surface offsets on the Honshu Island coast. Southwestern Sakhalin Island are also might be affected by centimeter level coseismic movement invoked by the shallow Mw 6.2-7.3 earthquakes appeared in the north of the Sea of Japan and Tatar strait. Hypothetical events with Mw > 7.5 and located in the north-west of the sea may excite displacement varying from 1 to 4 cm in Russian Primorye and Hokkaido Island. A set of inversion tests lead us to a conclusion that GEONET GNSS-network might be used to model tsunamigenic earthquake sources with Mw>7.0-7.8 distributed along the eastern margin of the Japan Sea. Working and prospective GNSS-networks located along the western coast of the sea and Sakhalin Island might be involved into processing of seismic events with Mw ≧ 7.3 appeared in the northern part of the sea.

This work was partially supported by the RFBR grant No. 17-55-53110 and JREX Fellowship.

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Keywords: tsunami early warning, GNSS

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Measurements of occurrence of solar conjunction with the orbits of Asian QZSS/IGSO satellites

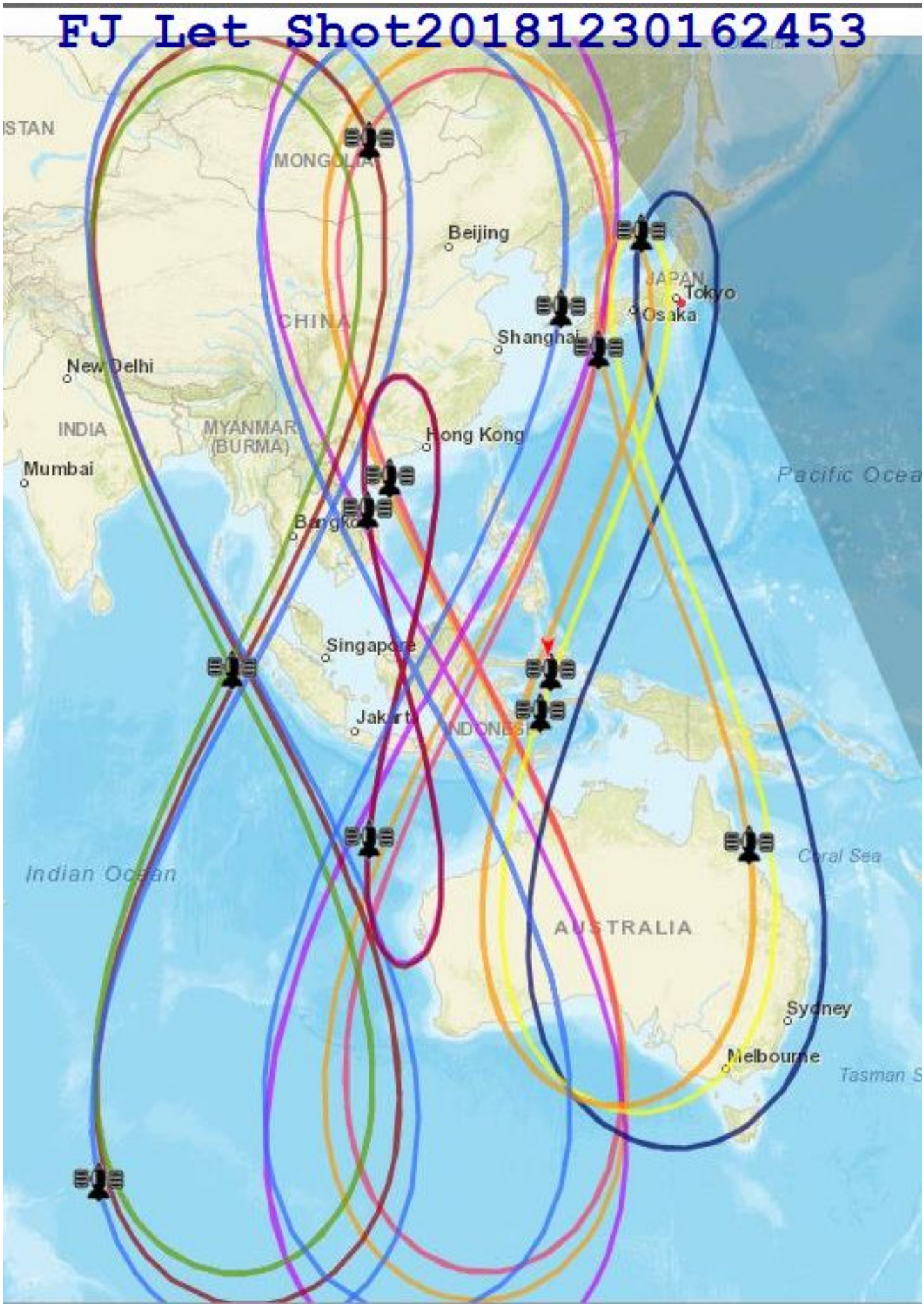
*Fujinobu Takahashi[1]

1. Yokohama National University

On the space PNT in the 20th century, the MEO satellite system represented by GPS space segment of USA has played a major role. In the 21st century, Japan's QZSS (Michibiki) satellite system and IGSO space segment of China and India are now appearing. The feature of the MEO satellite system is a scheme that the positioning accuracy is determined by randomly selecting MEO satellites above the elevation limit and by the satellites combination of smaller DOP. This is one of the stochastic based on the group of the randomly selected satellites, rather than the orbital theory of the satellite. Meanwhile the orbital motions of QZSS/IGSO of new 21st century are very slow over the respective earth regions. The more theoretical methods using satellite orbit models are available and the more reproducible analytic methods are possible. The author will report the measuring results of the orbital motion and the solar conjunctions of Asian QZSS/IGSO satellites over more than a year.

Keywords: QZSS, IGSO, PNT

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Sea level evaluation in northern Australian coast

*Yuta Tokui[1], Kosuke Heki[1]

1. Hokkaido University

Sea surface heights (SSH) are observed by satellite ocean altimetry, and it changes by two major causes. They are barystatic changes e.g. inflow of melt water from land ice, and thermal expansion of sea water, and they can be observed by GRACE and Argo floats, respectively. The three quantities behave differently from region to region, and their mutual link is important to understand regional characteristic of oceans. Here we study sea level changes in northern Australian coast (consisting of the Arafura, Timor, and Solomon Seas and the Gulf of Carpentaria). This region is characterized by large seasonal changes in SSH and gravity, and influenced by multiple climate changes such as ENSO (El Nino and Southern Oscillation) and IOD (Indian Ocean Dipole). First, we compare three changes (altimetric, thermosteric and gravity) to evaluate sea level budget. We found that SSH changes mainly come from steric changes excluding Gulf of Carpentaria where barystatic changes prevail. Next, we use the Empirical Orthogonal Functions (EOF) approach to identify the major modes of the seasonal and interannual variability. Seasonal changes in SSH are strong in Gulf of Carpentaria. The 1 st EOF of gravity indicates that main seasonal change occur in phase in the land and the sea. We also found that long-term precipitation variability appears as the 2nd EOF. The EOF analysis further showed that non-seasonal altimetric and gravity changes are driven mainly by climate changes, mainly ENSO in SSH and PDO in gravity.

Keywords: Altimeter, GRACE, Argo float, SSH, ENSO

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Implications from geomagnetic observation for the interannual fluctuations of Earth rotation

*Seiki Asari[1], Masanori Kurihara[1], Kenji Morinaga[1], Shingo Nagamachi[1]

1. Kakioka Magnetic Observatory, Japan Meteorological Agency

Kakioka Magnetic Observatory has a history of magnetic observation over as long time as more then a century. It has supported a progress of scietific researches and industry by providing accurate data, developing observation technology, certifying measurement instruments, as well as playing a geodetic role as a magnetic reference station of Japan. The observatory is even increasingly expected to stay as one of world's principal observatories, with the increase of demands for prompt data issuance to serve as reference for the recent satellite magnetic observations.

Geomagnetic variations consist of different components with varying sources and timescales. The accumulation of enormous amount of data from the recent satellite observations in the late years have drawn attentions to the interannual variations of the geomagnetic main field originating in Earth core. These variations had not been well recognised, with their tiny signals hidden by the magnetic perturbations from the magnetosphere. If these signals are resolved more clearly, they can be a precious key to reveal the interannual phenomena in Earth fluid core such as hydromagnetic waves. Imaging of the core fluid flow relies entirely on mangetic observations, as the seismic and gravitational observations do not provide high enough sensitivity, while the net fluctuations of the core may be analysed by using Earth rotation variation.

Currently, monthly mean database for the past half century has been under construction at Kakioka Magnetic Observatory such that they are optimised for better identifying the interannual main field variations. It has been found that approximately 70 percent of the external field perturbations can be eliminated from monthly data at any observatories at low- and mid-latitudes. A better mapping of the fluid core flow may be possible for even longer period. In this presentation, a report for the progress and prospect is given, together with discussion on implications for the interannual Earth rotation fluctuations through the core flow map imaged from magnetic observations. A spatiotemporal features of the westward core fluid jet at the polar region in the northern hemisphere, which may be responsible for both the rapid changes in both the geomagnetic main field and the length-of-day.

Keywords: Earth rotation, Geomagnetic field, Interannual variation, Angular momentum, Core

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Mon. May 27, 2019 1:45 PM - 3:15 PM JST | Mon. May 27, 2019 4:45 AM - 6:15 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-SS11] Seismic wave propagation: Theory and Application

convener:Kiwamu Nishida(Earthquake Research Institute, University of Tokyo), Kazuya Shiraishi(Japan Agency for Marine-Earth Science and Technology), Takao Nibe(JAPEX), Kaoru Sawazaki(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Tsutomu Takahashi(JAMSTEC)

Seismic wave propagation provides rich information of earth's heterogeneities and the excitation sources. In order to extract the information, integrated studies are needed among mathematical/numerical studies based on the wave theory, miniature physical experiments using rock specimens, and practical data analyses. Furthermore, it is greatly beneficial to conduct comparative studies of various kinds of waves, such as elastic, acoustic, traveling ionospheric disturbances, and oceanic waves. This session widely invites presentations about the theories and applications related to seismic and other geophysical waves.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SSS11-01] Power Spectrum of Random Heterogeneity of the Solid Earth

*Haruo Sato[1] (1.Tohoku Unvieristy)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SSS11-02] Estimation of spatio-temporal changes of seismic scattering property associated with the 2008 Iwate-Miyagi Nairiku earthquake from sparse modeling of seismic ambient noise CCFs

*Takashi Hirose[1], Hisashi Nakahara[1], Takeshi Nishimura[1], Michel Campillo[2] (1.Graduate School of Science, Tohoku University, 2.University Grenoble Alpes, CNRS, ISTerre)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SSS11-03] Surface roughness of the Philippine Sea plate at Nankai subduction zone

*Tsutomu Takahashi[1], Ayako Nakanishi[1], Shuichi Kodaira[1], Yoshiyuki Kaneda[2] (1.JAMSTEC, 2.Kagawa University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SSS11-04] Source location of volcanic earthquakes and tremors at Sakurajima volcano based on seismic correlation

*Theodorus Permana[1], Takeshi Nishimura[1], Hisashi Nakahara[1] (1.Solid Earth Physics Laboratory, Department of Geophysics, Graduate School of Science, Tohoku University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SSS11-05] **Crustal Structure Investigation in Northern Taiwan - Localized Wavefield Inversion of TAIGER T6 Wide Angle Refraction/Reflection Data**

*Fandy Adji Fachtony[1], How-wei Chen[1] (1.Institute of Geophysics, National Central University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SSS11-06] Self-organized criticality induced by randomness in block-spring models and the Gutenberg=Richter law

*Hidetsugu Sakaguchi [1] (1.Kyushi University)

Power Spectrum of Random Heterogeneity of the Solid Earth

*Haruo Sato[1]

1. Tohoku Unvieristy

Recent observations focusing on scattering of seismic waves revealed the existence of random heterogeneities in the solid earth medium. The radiative transfer theory (RTT) has been often used for the study of the propagation and scattering of wavelet intensities. For the statistical characterization of the power spectral density function (PSDF) of the random fractional fluctuation of velocity inhomogeneities in a 3-D space, we use von Karman type with three parameters: the RMS fractional velocity fluctuation, the characteristic length, and the order of the modified Bessel function of the second kind. This model leads to a power-law decay of PSDF at wavenumbers higher than the corner.

We compile reported statistical parameters of the lithosphere and the mantle based on various types of measurements. Reported exponents of wavenumber are distributed between -3 and -4, where many of them are close to -3. Reported RMS fractional fluctuations are of the order of 0.01 -- 0.1 in the crust and the upper mantle. Reported characteristic lengths distribute very widely. In order to grasp the spectral characteristics, eliminating strong heterogeneity data and the lower mantle data, we have plotted all the reported PSDFs of the crust and the upper mantle against wavenumber for a very wide range.

We find that the envelope of those PSDFs is well approximated by the -3rd power of wavenumber. In theory, we need to re-examine the applicable range of the Born approximation in the RTT when the wavenumber of a wavelet is much higher than the corner. In observation, we will have to measure carefully the PSDF on both sides of the corner. It is interesting to study what kinds of geophysical processes created the observed power-law spectral envelope in different scales and in different portions of the solid earth medium.

Keywords: Seismic waves, Velocity structure, Crust, Mantle, Random media, Scattering

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Estimation of spatio-temporal changes of seismic scattering property associated with the 2008 Iwate-Miyagi Nairiku earthquake from sparse modeling of seismic ambient noise CCFs

*Takashi Hirose[1], Hisashi Nakahara[1], Takeshi Nishimura[1], Michel Campillo[2]

1. Graduate School of Science, Tohoku University, 2. University Grenoble Alpes, CNRS, ISTerre

In recent years, spatial distributions of seismic velocity and/or seismic scattering property changes associated with volcanic activities and earthquakes have been investigated by linear least-squares inversions using seismic ambient noise cross-correlation functions (CCFs) and sensitivity kernels (e.g., Obermann et al., 2013; Obermann et al., 2014). However, spatial distributions of medium changes are not easily estimated in the regions where only a small number of stations are set up. Here, we use sparse modeling (L_1 norm regularization) to estimate model parameters for a small data set (e.g., Tibshirani, 1996), and evaluate the minimum number of stations for these studies. We apply the sparse modeling to the 2008 M_w 6.9 Iwate-Miyagi Nairiku earthquake that occurred on 14 June 2008, and estimate the spatial distribution of seismic scattering property changes from decoherence (waveform changes) data of seismic ambient noise CCFs. Since we have enough seismic stations, we can compare the results from the sparse modeling and those from an ordinary linear least-squares inversion with L_2 norm regularization which has been widely used to solve linearized problems.

Seismic ambient noise CCFs were calculated at 0.5-1 Hz band for the pairs among 17 Hi-net stations during the years of 2007 and 2008. We firstly calculate decoherence values between reference CCFs (Jan-Dec, 2007) and target CCFs in two time periods of May 1 to June 13 (Period I) and June 15 to July 31 (Period II) in 2008, respectively. We then calculate the differences of decoherence values of Period I and Period II, and use them as observed decoherences. Totally, 450 observed decoherence values are analyzed. Finally, we divide the study area into 63 small cells with a size of $0.15^\circ \times 0.15^\circ$ and estimate scattering coefficient changes, Δg, for each small cell by comparing the observed and synthesized decoherence values. Here, we estimate synthesized decoherence values using 2-D decorrelation kernels (Margerin et al., 2016).

The result from the linear least-squares inversion with L_2 norm regularization shows that large Δg values are estimated around the epicenter of the main shock. The region of the largest Δg value is located at the south of the epicenter also from the sparse modeling. The maximum Δg value is about 0.035 km^{-1}, which is almost equivalent to the total scattering coefficient at this region. To know a minimum number of stations for the estimation, we selected the stations which locate within 30 km, 40 km, and 50 km from the epicenter (5, 7, and 13 stations, respectively), and conducted the same estimations for each case using the sparse modeling. We confirmed that 7 stations were necessary to recover the similar result.

The regions with large Δg values are well correlated with the region where large peak ground acceleration and large seismic velocity decreases are obtained (Takagi et al., 2012; Hobiger et al., 2014). This consistency suggests that strong motion by the main shock introduce not only large seismic velocity decreases but also large seismic scattering property changes in the shallow medium at the south of the epicenter. The sparse modeling will be useful to locate a change region of seismic scattering property changes from a sparse seismic network with several seismic stations.

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Acknowledgements: We would like to thank the High Sensitivity Seismograph Network (Hi-net), NIED for providing the waveform data used in the present study.

Keywords: sparse modeling, seismic scattering property change, Iwate-Miyagi Nairiku earthquake, seismic interferometry

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Surface roughness of the Philippine Sea plate at Nankai subduction zone

*Tsutomu Takahashi[1], Ayako Nakanishi[1], Shuichi Kodaira[1], Yoshiyuki Kaneda[2]

1. JAMSTEC, 2. Kagawa University

Seismic fault surfaces have roughness over a broad spatial scale range. In this study, we measured surface roughness of subducting Philippine Sea plate along several seismic survey lines at Nankai trough. Surface geometry of the subducting plate have been estimated by analyzing both the wide-angle refraction and high-resolution seismic-reflection surveys by Nakanishi et al. (2018). They estimated velocity structures from the former data with consideration for travel times of reflected waves from the top of the Philippine Sea plate of the latter data. Uncertainties of their geometry of the Philippine Sea plate can be examined by the uncertainties of velocity structures in the overriding continental plate.
First, we examined the P-wave velocity structures in the continental plate. Power spectra of the velocity fluctuations obey a power-law at small wavenumbers. We also find a clear decrease of power spectral density at larger wavenumbers. Cutoff wavenumber of this change almost corresponds to the inverse of receiver interval. Such decrease of power spectral density is probably caused by a spatial smoothness constraint of velocity estimation. Then, we examined the surface geometries at wavenumbers smaller than the cutoff wavenumber. Power spectra of surface geometries shows self-affine property. We applied bandpass filters for geometry data and mapped the root mean squared amplitudes of filtered geometries as surface roughness. Roughness is large at Hyuga-nada, and becomes small near the trough-axis off south of Shikoku. The small roughness area off Shikoku shows low activity of regular and slow earthquakes. Meanwhile, Hyuga-nada area shows high activity of low frequency earthquakes (Yamashita et al. 2015). Since surface roughness is relevant to a small-scale stress concentration on faults, this result implies an importance of surface roughness for seismicity.

Acknowledgement
This study was supported by “Research Project for Compound Disaster Mitigation on the Great Earthquakes and Tsunamis around the Nankai Trough Region” of the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan.

Keywords: surface roughness, Philippine Sea plate, velocity inhomogeneity, self-affine

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Source location of volcanic earthquakes and tremors at Sakurajima volcano based on seismic correlation

*Theodorus Permana[1], Takeshi Nishimura[1], Hisashi Nakahara[1]

1. Solid Earth Physics Laboratory, Department of Geophysics, Graduate School of Science, Tohoku University

Precise source locations of volcanic tremors and earthquakes are one of the most basic information that is important to understand the volcanic process. The spatio-temporal changes of these source locations may provide insights into the eruption mechanism and the movement of volcanic fluids. However, the determination of those source locations is quite challenging due to the difficulties to distinguish their seismic phases and precisely measure the arrival times. Recently, we developed a hypocenter determination method for volcanic earthquakes and tremor, which adopts seismic interferometry processing technique for calculating cross-correlation functions (CCFs) and the source-scanning algorithm (SSA) (Permana et al., in preparation). Here, we apply our method to observed data recorded at Sakurajima volcano. We first locate volcano-tectonic earthquakes (VTs) and evaluate the location errors by comparing the results with the hypocenters determined by a phase-picking method. Then, we locate volcanic tremors and discuss their source locations, which cannot be obtained from phase-picking methods due to indistinguishable phase arrivals.

We analyze VTs that occurred during a rapid dike intrusion on August 15, 2015. Our result shows the hypocenters are distributed beneath the Mt. Minamidake mainly at 0-4 km depths. Our source locations are consistent with the hypocenters obtained by using the method of Hirata and Matsuura (1987), and the errors are estimated to be 2 km or less.

We determine the source locations of two kinds of tremors occurred on August 22-25, 2017. The first is a 13.5 hours long continuous tremor accompanying Strombolian eruptions on August 22-23. The second is a series of intermittent tremors that are recorded following the explosion earthquakes associated with Vulcanian eruptions which followed the continuous tremor. We calculate the CCFs at 1-3 Hz by using 20 s time windows with 19 s overlap for these tremors and stacked them to obtain average CCFs. Our results show that the source locations of the first 6 hours of continuous tremor, which are determined every 10 minutes, are located beneath Mt. Minamidake at depths from about 3 km to below the active crater. The sources of the following continuous tremor are located at shallower depths, from about 2 km depth to the ground surface on the southern flank of Mt. Minamidake. The sources of 61 segments of the intermittent tremors are densely distributed at 0-2 km depth beneath Mt. Minamidake.

The observed tremors are related to the eruptive activities at Sakurajima volcano and their sources are expected to be located at the eruptive conduit. Our estimated sources are distributed at the shallow depths beneath the active craters within the estimated errors. Therefore, our results show the prospect of our method as an alternative for tremor source location determination and volcano monitoring. The depth range of our results for continuous tremor also coincides with the previous studies on the generation depth of volcanic earthquakes.

Keywords: volcanic earthquakes, volcanic tremor, source location, cross-correlation, hypocenter

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Crustal Structure Investigation in Northern Taiwan - Localized Wavefield Inversion of TAIGER T6 Wide Angle Refraction/Reflection Data

*Fandy Adji Fachtony[1], How-wei Chen[1]

1. Institute of Geophysics, National Central University

TAIGER T6 transects is one of the four crustal-scale Wide Angle Refraction/Reflection (WARR) survey lines under **TA**iwan **I**ntegrated **GE**odynamics **R**esearch (TAIGER) project conducted in 2008 in Taiwan. The north main array consist of four shot points (N1, N2, N3, and N4) across northern Taiwan from west to east. A total of 456 geophones deployed with receiver interval of ~200m on average. However, the recorded data suffers from crooked survey line geometry, uneven shot energy, noise level and currently available poorly defined 3D reference velocity model. Near-surface static effects caused by the irregular source and receiver spacing, strong lateral velocity variations and rapid topography changes produce apparent 3D wave propagation so that the standard seismic data processing or travel-time inversion could not be fully applied. To compensate above-mentioned drawbacks, Localized Slant Stack Transformation (LSST) for data pre-processing was applied to separate signal from interfering noise that has big amplitude and minor T-X curve difference. LSST is slowness and offset range-based plane wave destruction and construction techniques. The pros and cons of LSST will be discussed for TAIGER-T6 line.
For stable wavefield inversion, sufficient spatial sampling and events enhancement is essential. Wavefield inversion utilize the complete-cycle of wavelet information without picking compared to tomography study that rely on the travel time picks with potential reading errors. Velocity estimation is performed via wavefield transformation from τ-p data domain to τ-p-z solution domain through downward continuation and the application of imaging condition ($\tau = 0$). Ray tracing is performed for quality control and to quantify the separated static effects produced from source, receiver and velocity changes. Feasibility studies of three crustal scale synthetic models containing: (1) flat layers without topographic, (2) flat layers with topographic, (3) laterally varying topographic velocity models. Synthetic data is produced from Specfem2D computations. Effects of source and/or receiver static, velocity variation, and the combination of all were studied. Wavefield inversion is stable for all test models. Inverted 1D velocity becomes less smooth when static effects are included with and without static corrections. Real data implementation for all shots were cross-checked through numerical travel-time curve with acceptable error bound. Furthermore, the bottoming point of each ray through seismic ray tracing can be mapped along with the velocity information to construct quasi-2D velocity model. Inverted velocity depth profile from wavefield inversion provide higher resolution compared to the existing tomography velocity model across northern Taiwan area.

Keywords: Localized Slant Stack, TAIGER Project, Wiechert-Herglotz Inversion, Vespagram

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Self-organized criticality induced by randomness in block-spring models and the Gutenberg=Richter law

*Hidetsugu Sakaguchi [1]

1. Kyushi University

The Block-spring model is a simple mathematical model for earthquakes proposed by Burridge and Knopoff. Later, Carlson and Langer performed numerical simulations of a uniform block-spring model with velocity-weakening friction. They found that the slip-size distribution obeys a power law in a small scale. Their model exhibits a kind of spatio-temporal chaos and the slip size distribution is dur to the chaotic behavior. Many authors studied a variety of block-spring models. In this presentation, we will show numerical results of a block-spring model with quenched randomness in the velocity-strengthening friction. When the pulling force is stationary, there is a continuous transition from a state pinned by the quenched randomness to a sliding state. When the external force is applied through a spring, the pinning and sliding repeat randomly. The effective pulling force fluctuates around the critical value of the pinning-depinning transition. The phase transition is self-organiized even if the parameter is not controlled. As a result of the criticality, the slip size distribution obeys a power law. We consider that the power law is caused by the self-organized criticality to the pinning-depinning transition in the random media. Our model is related to the asperity theory in that the spatial inhomogeneity is important.

Keywords: block-spring model, power law, pinning transition, self-organized criticality

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Mon. May 27, 2019 3:30 PM - 5:00 PM JST | Mon. May 27, 2019 6:30 AM - 8:00 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-SS11] Seismic wave propagation: Theory and Application

convener:Kiwamu Nishida(Earthquake Research Institute, University of Tokyo), Kazuya Shiraishi(Japan Agency for Marine-Earth Science and Technology), Takao Nibe(JAPEX), Kaoru Sawazaki(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Kiwamu Nishida(東京大学地震研究所)

Seismic wave propagation provides rich information of earth's heterogeneities and the excitation sources. In order to extract the information, integrated studies are needed among mathematical/numerical studies based on the wave theory, miniature physical experiments using rock specimens, and practical data analyses. Furthermore, it is greatly beneficial to conduct comparative studies of various kinds of waves, such as elastic, acoustic, traveling ionospheric disturbances, and oceanic waves. This session widely invites presentations about the theories and applications related to seismic and other geophysical waves.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SSS11-07] Land-Atmosphere Interaction in the low-frequency seismic band and inversion for shallow elasticity structure

*Toshiro Tanimoto[1], Jiong Wang[1] (1.Department of Earth Science, University of California, Santa Barbara, CA93106, USA)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SSS11-08] Noise correlation analysis of S-net records

*Ryota Takagi[1], Genti Toyokuni[1], Mare Yamamoto[1] (1.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SSS11-09] Atmospheric waves from the gas explosion in Sapporo on December 16, 2018, recorded by seismometers

*Kazunori Yoshizawa[1] (1.Faculty of Science, Hokkaido University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SSS11-10] Time-lapse monitoring of seismic velocity associated with the 2011 Shinmoedake eruption using seismic interferometry

*Kiwamu Nishida[1], Yuta Mizutani[1] (1.Earthquake Research Institute, University of Tokyo)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SSS11-11] Temporal variations of seismic velocity and azimuthal anisotropy in near-surface rock and soil at KiK-net downhole array sites

*Taka'aki Taira[1], Li-Wei Chen[1], Hiroe Miyake[2] (1.Berkeley Seismological Laboratory, University of California, Berkeley, 2.The University of Tokyo)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SSS11-12] **Denoising Ambient Seismic Field Correlation Functions with Deep Autoencoders**

*Loic Viens[1], Chris Van Houtte[2] (1.Disaster Prevention Research Institute, Kyoto University, 2.GNS Science)

Land-Atmosphere Interaction in the low-frequency seismic band and inversion for shallow elasticity structure

*Toshiro Tanimoto[1], Jiong Wang[1]

1. Department of Earth Science, University of California, Santa Barbara, CA93106, USA

For frequencies below 0.05 Hz, except for the hum signals generated by ocean waves, the atmosphere is the main source of seismic noise. Some characteristics of atmosphere-generated seismic noise have been reported (e.g., Zürn et al., 2007; Zürn and Wielandt, 2007) but recent data from co-located pressure and seismic sensors allow us to improve our understanding of this interaction. We report our analysis of data from the EarthScope Transportable Array (TA) and some global permanent stations that are equipped with pressure and seismic sensors.

We first point out that coherence between surface pressure and vertical seismic data shows two broad peaks, a lower frequency one that rises below about 0.002 Hz and a higher frequency peak that reaches its maximum about 0.02 Hz. There is a minimum of coherence between them at about 0.003-0.004 Hz.

We noted that there is basically no phase-shift between pressure and vertical seismic displacement for the lower frequency peak while there is a 180-degree phase shift between pressure and vertical displacement for the higher frequency peak at about 0.02 Hz. Two peaks show a completely opposite relationship between pressure and vertical displacement. The zero phase-shift for the lower frequency peak is consistent with the mass-attraction effect due to density perturbations in the atmosphere and the 180-degree phase shift for the peak about 0.02 Hz is consistent with elastic deformation caused by surface pressure.

They suggest that these are two competing forces generated by the atmosphere, one that tends to attract the sensor mass upward by density perturbations in the atmosphere and the other that tends to push down the ground due to high pressure. The mass-attraction effect wins for the lower frequency peak and the ground deformation effect wins for frequencies above 0.01 Hz. The existence of the minimum between the two peaks indicates that relative size of these forces switches at about 0.003-0.004 Hz (already pointed out by Zürn and Wielandt, 2007).

The size of the higher frequency peak (at about 0.02 Hz) is strongly influenced by the elasticity of near-surface materials; at many sites with STS-1 sensors, this high frequency peak is often hard to identify as the sites are mostly at hard-rock sites, meaning there is little deformation due to atmospheric pressure. On the other hand, some EarthScope TA sites are at soft sediment sites and show a large (and dominant) peak at about 0.02 Hz. For such soft sites, we can derive shallow structure from pressure and seismic data.

We will present an inversion scheme to invert data from this higher frequency peak. Basic data are the ratios between vertical seismic data to pressure data and also between horizontal seismic data to pressure data for frequencies between 0.005 Hz and 0.05 Hz. The method is an iterative nonlinear inversion from a starting model using depth sensitivity kernels that are computed at each iteration step. The framework of inversion is similar to surface-wave phase velocity inversion. The product is a layered elasticity structure beneath a co-located station.

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Keywords: Land-Atmosphere Interaction, Shallow elasticity structure, Inversion of pressure and seismic data

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Noise correlation analysis of S-net records

*Ryota Takagi[1], Genti Toyokuni[1], Mare Yamamoto[1]

1. Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University

We applied noise correlation analysis to continuous records of Seafloor Observation Network for Earthquakes and Tsunamis along the Japan Trench (S-net) to estimate crustal structure beneath the offshore region of northeast Japan. We used three-component records from 2017 to 2018 provided by National Research Institute for Earth Science and Disaster Resilience (NIED) and converted wavefoms from XYZ to UNE components. We analyzed accelerometer records because signal-to-noise ratio of accelerometer is higher than that of velocity sensor in the periods longer than a few seconds. The noise cross-correlation functions show periodic pulses every 60 seconds and a single pulse at zero lag. The periodic pulses and zero lag pulse can be attributed to coherent periodic noise and random noise, respectively, due to electric perturbation in instruments. The periodic noise depends on station, component, and time period. The random noise appears to be common only within stations along the same cable lines. We removed the periodic noise by computing cross-correlation functions of the difference waveforms between the records of one day and the records of one day before. The cable-dependent random noise was removed by fitting an empirical function to cross-correlation functions in the frequency domain. The noise reduction and staking within station separation bins enable us to extract Rayleigh and Love waves up to about 30 seconds. In the shorter period than 10 seconds, we found multiple modes of Rayleigh waves with group velocities of about 1.5 km/s and 0.3 km/s, which may have energy in ocean layer and sediment. In addition, we found Rayleigh waves propagating from coastal stations to deep offshore stations at the period around 4 seconds, whereas Rayleigh waves mainly propagate from deep offshore stations to coastal stations at the period around 8 seconds. The extracted surface waves may be useful to estimate crustal structure beneath the offshore region along the Japan trench.

Acknowledgement: We used continuous records of S-net managed by NIED. We thank NIED for providing the data.

Keywords: S-net, Seismic interferometry, Ambient noise, Noise correlation, Surface wave, Japan trench

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Atmospheric waves from the gas explosion in Sapporo on December 16, 2018, recorded by seismometers

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A large gas explosion occurred in Hiragishi, Sapporo, on December 16, 2018, which blew up a two-story building in the hypocenter with more than 50 injured, although no casualty was reported miraculously. Damages to window glasses of neighboring buildings were reported in the radius of about 100 meters around the hypocenter due to strong blast waves from the explosion.

The infrasound waves from this explosion have been recorded in several seismometers installed on the ground surface of Ishikari Lowland (including the one in the campus of Hokkaido University) even at stations more than 60 kilometers away from the hypocenter, which has traveled with a speed of about 330 m/s. It is well known that atmospheric infrasound waves from large volcanic eruptions and/or meteor blast can travel very long distances, which can be observed with broad-band seismometers. Although this explosion in Sapporo is much smaller than such natural phenomena, the observed seismic records are likely to be caused by the air-earth coupled ground motions due to the infrasound waves from the explosion.

The observed infrasound/acoustic signals from this explosion cannot be observed in seismometers installed underground in and around Sapporo. Also, we cannot see any clear elastic wave (P-wave or surface waves) from this explosion. Only several seismometers installed on the ground surface have recorded the infrasound signals that are characterized by strong spectral peaks in a frequency range between 5 and 30 Hz. We can also identify the directional dependence of the observed waveforms; i.e., the amplitudes of infrasound signals are more attenuated and scattered in the north of hypocenter. This may be affected by winds and/or propagation paths, in particular, the urban area of Sapporo with tall buildings spared over the north of hypocenter.

Keywords: infrasound, atmospheric wave, seismometer, gas explosion

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Time-lapse monitoring of seismic velocity associated with the 2011 Shinmoedake eruption using seismic interferometry

*Kiwamu Nishida[1], Yuta Mizutani[1]

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In recent years, the number of applications of seismic interferometry is increasing. In the analysis, the cross-correlation function between ambient noise records of a pair of stations can be regarded as a virtual seismic waveform recorded at one station when the source is placed at the other station. Since, in any time period, the seismic velocity around the station pair can be estimated from the cross-correlation function calculated without an earthquake, the seismic interferometry has been applied in many studies to monitor the temporal change of the seismic velocity. A number of studies have monitored the seismic velocity change in the volcanic region with seismic interferometry and detected the temporal change in seismic velocity associated with the eruption (Brenguier et al., 2008; Rivet et al., 2015). Inferred seismic velocity changes in the volcanic region frequently show the seasonal variations, which were caused by precipitation. The amplitude of seasonal fluctuation has the same order of magnitude of velocity change associated with the eruption. Therefore, in order to detect the transient velocity change accompanying the eruption, it is important to evaluate the seasonal fluctuation due to precipitation quantitatively and remove it appropriately from the estimated seismic velocity change. In this study, seismic interferometry was applied to a seismic array around Shinmoedake to monitor the seismic velocity change, aiming at detecting the velocity change associated with the Shinmoedake eruption in 2011. First, a cross-correlation function was calculated for each pair of stations using continuous ambient noise data for 8 years from May 2010 to April 2018. The stretching method (Sens-Schönfelder and Wegler, 2006) was applied to the calculated cross-correlation function to estimate the temporal change of the seismic velocity. From the estimated seismic velocity change by the stretching method, the seasonal variation affected by precipitation was detected as in the previous study (Wang et al., 2017). Therefore, the effect of precipitation was quantitatively evaluated using pore pressure model (Roeloffs, 1988; Talwani et al., 2007). After the effect of precipitation was subtracted, the seismic velocity change associated with the eruption was detected in several pairs. In order to constrain locations of the seismic velocity change in space, the horizontal and depth sensitivity kernel was calculated. The kernels suggested that structural changes would not occur in the depth of 1-3 km in the southeastern side and in the depth of 1-2 km in the northwestern side of Shinmoedake.

Keywords: seismic interferometry

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Temporal variations of seismic velocity and azimuthal anisotropy in near-surface rock and soil at KiK-net downhole array sites

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1. Berkeley Seismological Laboratory, University of California, Berkeley, 2. The University of Tokyo

Measuring stress and damage induced seismic velocity and anisotropy in crustal structure and their temporal behaviors provide insights into the underlying mechanisms of healing processes and its evolution, which would lead to a better understanding of earthquake cycle. We analyze three-component surface and borehole seismic data collected by KiK-net (Kiban-Kyoshin Net) to explore temporal variations in P- and S-wave velocity and S-wave azimuthal anisotropy (strength of anisotropy and polarization direction of the fast S wave) through coda wave interferometry. Our preliminary focus is on Hokkaido sites that experienced ground motion from the 2003 magnitude (M) 8.3 Tokachi-Oki and the 2018 M 6.0 Hokkaido Eastern Iburi earthquakes. Following Chen et al. (2017, EPSL), we analyzed all available KiK-net seismic waveforms in a frequency band of 1-15 Hz from 1997 through 2018 (more than 700 events) and evaluated seismic velocity and azimuthal anisotropy between surface and borehole sensors at 22 KiK-net sites. Median P- and S-wave velocity stacked by all measurements at each site are good agreement with them obtained from borehole logging data provided by NIED (National Research Institute for Earth Science and Disaster Resilience). We find that a number of KiK-net sites recording peak ground acceleration (PGA) higher than ~500 cm/s^2 (at surface sensor) exhibit clear S-wave velocity reductions following the 2018 Hokkaido Eastern Iburi mainshock. Station IBUH03 (located at Atuma town) also shows a sudden decrease of S-wave velocity following the 2003 Tokachi-Oki earthquake (PGA = ~350 cm cm/s^2 at station IBUH03). Reductions of S-wave velocity were about 6.5% for both mainshocks. However, there are a number of differences between two earthquakes. Our preliminary analysis suggests that the polarization direction of fast S-wave was systematically changed from 50 degrees to 10 degrees (measured clockwise from the north) following the 2018 earthquake and no notable change of P-wave velocity was observed. On the other hand, for the Hokkaido earthquake case, station IBUH03 appears to have a large variability in the polarization direction and displays a P-wave velocity reduction of about 4.5%. Our observation suggests a temporally increase of randomly oriented fractures following the 2003 Tokachi-Oki earthquake and also may suggest that the stress changes from the 2018 Hokkaido Eastern Iburi earthquake created water-saturated cracks oriented at ~10 degrees from north.

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Denoising Ambient Seismic Field Correlation Functions with Deep Autoencoders

*Loic Viens[1], Chris Van Houtte[2]

1. Disaster Prevention Research Institute, Kyoto University, 2. GNS Science

In the last decade, seismic interferometry has become an established technique for monitoring the temporal changes of the Earth’s physical properties. This technique relies on measuring time shifts of seismic waves present in Green’s functions, which are generally approximated by cross-correlating 1-h long ambient seismic field records at two stations. To increase the accuracy of the phase information of hourly cross-correlation functions, pre-processing is generally applied to the recorded ambient seismic field, such as 1-bit normalization and/or pre-whitening. Despite this, hourly cross correlation functions often need to be stacked over a few hours/days to increase their signal-to-noise ratio and measure reliable phase shifts. We introduce a new technique for improving the time resolution of seismic monitoring, which denoises cross-correlation functions using deep autoencoders. Autoencoders are composed of an encoding function, which computes a compressed representation of the input data, and a decoding function which reconstructs a simplified representation of the input data. Both the encoder and decoder parts are composed of a stack of densely-connected neural network layers. Such an algorithm can be trained to denoise corrupted versions of their inputs, which in our case are correlation functions with low signal-to-noise ratio. We apply our deep denoising autoencoder on synthetic and real single-station cross-correlation functions computed from a few MeSO-net stations located in the Tokyo Metropolitan area. The denoised waveforms allow us to compute more precise relative velocity change (dv/v) than with the raw waveforms. The great advantage of this technique is that the algorithm can be trained within a few seconds and can be used to denoise near-real-time data, which could be useful for volcano monitoring.

Keywords: Seismic noise, Deep Autoencoders, Green's function

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Mon. May 27, 2019 9:00 AM - 10:30 AM JST | Mon. May 27, 2019 12:00 AM - 1:30 AM UTC | Convention Hall A 2F

[S-SS13] Strong Ground Motion and Earthquake Disaster

convener:Masayuki Kuriyama(Central Research Institute of Electric Power Industry), Kazuhiro Somei(Geo-Research Institute), Chairperson:Nobuyuki Morikawa(National Research Institute for Earth Science and Disaster Resilience), Ryoichi Nakamura(Earthquake Research Institute, The University of Tokyo)

Strong ground motion has social impacts as it induces earthquake disasters. We solicit contribution on any seismological topics related to strong ground motion that includes, but are not limited to, source processes, wave propagation, and site effects. We also welcome contribution on earthquake related disaster mitigation.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SSS13-25] Determination of dynamic characteristics of existing buildings at various site conditions in Eskisehir, Turkey

*Onur Kaplan[1], Seiji Tsuno[2], Hiroaki Yamanaka[3], Mehmet Safa Arslan[4], Oguz Ozel[4] (1.Eskisehir Technical University, 2.Railway Technical Research Institute , 3.Tokyo Institute of Technology , 4.Istanbul University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SSS13-26] ICDP DSeis 10: Near-field Observations for the M5.5 Orkney, South Africa Earthquake

Tatsunari Yasutomi[1], *James Mori[1], Hiroshi Ogasawara[2] (1.Earthquake Hazards Division, Disaster Prevention Research Institute, Kyoto University, 2.Ritsumeikan University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SSS13-27] Number of earthquakes from seismic activity model of the national seismic hazard maps for Japan

*Nobuyuki Morikawa[1], Junichi Miyakoshi[2], Hiroyuki Fujiwara[1] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Ohsaki Research Institute, Inc.)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SSS13-28] Comparative examination of the Probabilistic Seismic Hazard Maps in Japan with observed maximum seismic intensities for various periods

*Takamoto Muneta[1], Kazuki Koketsu[1] (1.Earthquake Research Institute, The University of Tokyo)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SSS13-29] A Study on the Ground Motion Characteristics close to the Basin Edge

Ryota Hamabe[2], *Shinichi Matsushima[1], Takashi Azuma[3], Florent De Martin[4] (1.Disaster Prevention Research Institute, Kyoto University, 2.Graduate School of Engineering, Kyoto University, 3.National Institute of Advanced Industrial Science and Technology, 4.French Geological Survey)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SSS13-30] Spectrum Characteristics of MeSO-net seismograms – Effect of Underground Installation -

*Ryoichi Nakamura[1], Hiroshi Tsuruoka[1], Aitaro Kato[1], Shin'ichi Sakai[1], Naoshi Hirata[1], Takahiro Shiina[1] (1.Earthquake Research Institute, The University of Tokyo)

Determination of dynamic characteristics of existing buildings at various site conditions in Eskisehir, Turkey

*Onur Kaplan[1], Seiji Tsuno[2], Hiroaki Yamanaka[3], Mehmet Safa Arslan[4], Oguz Ozel[4]

1. Eskisehir Technical University, 2. Railway Technical Research Institute , 3. Tokyo Institute of Technology , 4. Istanbul University

The fundamental vibration period of a building is a crucial parameter for earthquake engineering. The equivalent seismic lateral force is determined from a design spectrum in most static design methods. Accordingly, the earthquake force is a function of the fundamental vibration period of the building. The fundamental period of an existing building can be determined by both forced and ambient vibration measurements. In this study, ambient vibration measurements were conducted at 17 existing buildings including different structural styles (masonry and reinforced concrete) and heights (7 to about 65 meters) which are located at different site conditions in Eskisehir, Turkey. In ambient vibration measurements, two accelerometers were placed on the top of the buildings and one accelerometer was placed on the ground. The fundamental vibration periods and the dampings of the measured buildings were evaluated. The fundamental vibration periods of the buildings were evaluated by picking the peaks of the spectral ratios of Fourier spectra on the top floor of buildings to those on the ground. The dampings of the measured buildings were estimated by fitting the spectral ratios calculated using a single degree of freedom system to the spectral ratios observed, in the process of trial and error (Iwata and Tsuno, 2013). In order to understand the site conditions near the buildings, array microtremor observations by small-scale arrays of 1.5 to 16 meters were performed on the free field. SPAC method was used to obtain the phase velocities of Rayleigh waves and the S-wave velocity profiles were estimated using those phase velocities in the inversion technique. Tsuno et al. (2018) derived an equation of T=0.016H from 10 building measurements carried out in Eskisehir, Turkey. In this study, 7 more measurements were added to the previous measurements of Tsuno et al. (2018) thus, according to findings of this study, the equation of T=0.0165H was proposed to estimate the fundamental vibration period (T, in seconds) of an existing building in Eskisehir, Turkey with respect to its height (H, in meters). This equation is still in need to improve with additional measurements, which could represent most of the building heights in the Eskisehir building inventory. The calculated dampings of the measured buildings have a general tendency that the higher the buildings, the smaller the dampings.

Acknowledgment

This study is supported by the Joint Research Project under the Bilateral Program of the Japan Society for the Promotion of Science (JSPS) and The Scientific and Technological Research Council of Turkey (TUBITAK) under Grant TUBITAK 116Y524.

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Tsuno, S., Yamanaka, H., Kaplan, O., Arslan, M. S. and Ozel, O. (2018). Characteristics of building vibrations estimated in various site conditions in Eskisehir, Turkey. In *Proceedings of the 13th SEGJ International Symposium, Tokyo, Japan, 12-14 November 2018.*

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Keywords: Ambient Vibration Measurement, Fundamental Vibration Period, Damping, Array Microtremor Observation

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ICDP DSeis 10: Near-field Observations for the M5.5 Orkney, South Africa Earthquake

Tatsunari Yasutomi[1], *James Mori[1], Hiroshi Ogasawara[2]

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We examined the near-field records for the 2014 Orkney earthquake (M5.5) to infer source properties for this moderate-sized earthquake. The event was the largest recent earthquake associated with the deep gold mines of the region. Different from usual normal-faulting events that are induced on known structures of the mines, the M5.5 earthquake took place significantly below the mining horizon with a strike-slip mechanism on an unknown geologic structure. Seismic activity close to the Moab Khotsong and Great Noligwa mines is very well monitored by instruments installed on the surface and in the mine tunnels. The high sample-rate (6 khz) geophones installed in the mine at depths of 1 to 3 km provide high-quality recordings of the mainshock and aftershocks.

The waveforms show that there is a small foreshock (about M1.8) located 1.6 km south of the mainshock hypocenter and at 0.6 sec before the mainshock. There is no evidence of any unusual character of the foreshock, or any significant deformation between the foreshock and mainshock.

Using lower frequency (<2.0 hz) data, the nearfield waveforms can be modeled using a finite fault slip inversion. The results show a slip distribution with two main patches of larger slip, which are located a few kilometers to the north and to the south of the hypocenter. The area of the fault plane is relatively large for a M5 earthquake and this gives a rather small static stress drop.

Keywords: Orkney earthquake, South Africa, slip inverstion

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Number of earthquakes from seismic activity model of the national seismic hazard maps for Japan

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1. National Research Institute for Earth Science and Disaster Resilience, 2. Ohsaki Research Institute, Inc.

In this paper, as a part of the verification of the probabilistic national seismic hazard maps for Japan, we compare the earthquake occurrence ratio from seismic activity model in the national seismic hazard maps for Japan and that from earthquake catalog data.
As the number of earthquakes from seismic activity model of the national seismic hazard maps for Japan 2018 version, the expected value in 30 years is calculated for each magnitude and expressed by the cumulative number of earthquakes. The procedure is as follows.
1. For earthquakes with nonstationary seismic activity model adopted, set the probability of occurrence of earthquake in 30 years from January 2018 as the expected value of the number of earthquakes.
2. Earthquakes in Nankai Trough (M8-9 class), in Sagami Trough (M8-class), Mega-earthquake along the Kuril trench, and large plate-boundary earthquakes in Tokachi-oki and Nemruo-oki, the whole 30 years of the earthquake occurrence probability by the weight of each occurrence pattern as the expected value of the earthquake number in 30 years, respectively.
3. For the earthquakes in which the Poisson process is adopted, use the 30 year earthquake number based on the occurrence frequency of earthquakes.
Here, we prepare three datasets of cumulative earthquake number. The first is based on the “average case”, the second is based on the “maximum case”, and the third is based on the “averaged hazard” models.
For the earthquake catalog to be compared, we combine earthquakes with M 6.0 or more from 1885 to 1925 by Utsu (1982) and Japan Meteorological Agency earthquake data of M 5.0 or more from 1926 to 2010. At this time, aftershocks are removed according to the same rules as the national seismic hazard maps for Japan.
For shallow crustal earthquakes, the number of earthquakes from the model and the catalog are consistent at less than M 7.0 for the “average case”, and are consistent at less than M 7.7 for the “maximum case”. However, on a larger magnitude, there is a tendency for the model to have a smaller number of earthquakes. For earthquakes in Philippine Sea Plate, the number of earthquakes from the model and the catalog are consistent at M 8.0 and below. However, on a larger magnitude, the number of earthquakes in the model is extremely large. This is caused by the modeling of the large occurrence probability based on the time predictable model for the Nankai Trough earthquake. The number of earthquakes from the “average hazard” model decreases at M 8.0 or more. For earthquakes in the Pacific plate, the number of earthquakes from the model and the catalog are consistent at less than M 7.0. However, on a larger magnitude, the number of earthquakes from the model is somewhat larger. For M 7.8 and more, the model has changed based on the new long-term evaluation of earthquakes along the Kuril Trench by Headquarters for Earthquake Research Promotion of Japan, and the increase in number of earthquakes is also affecting.
On the other hand, when the period of the earthquake catalog is expanded until 2015, after the 2011 great Tohoku earthquake, the number of earthquakes from the model becomes smaller than that from the catalog for earthquakes in the Pacific and Philippine Sea plates. This is due to a large number of aftershocks and induced earthquakes of the 2011 Tohoku earthquake. How to incorporate the earthquake catalog after the great Tohoku earthquake into the seismic activity model in the seismic hazard assessment is a very important task.

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Keywords: National seismic hazard maps for Japan, Seismic activity model, Earthquake catalog, The 2011 great Tohoku earthquake, Verification

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Comparative examination of the Probabilistic Seismic Hazard Maps in Japan with observed maximum seismic intensities for various periods

*Takamoto Muneta[1], Kazuki Koketsu[1]

1. Earthquake Research Institute, The University of Tokyo

The accuracy of the Probabilistic Seismic Hazard Maps in Japan (PSHMJ), which is being published by the Headquarters for Earthquake Research Promotion of the Japanese government, was examined by comparing the observed maximum seismic intensities with the PSHMJ. Miyazawa and Mori (2009) compared those only for about 500 years from 1498, and Kondo (2017) compared those for 30 years from 1890, 1920, 1950, or 1980. However, in this study, we compared those for 30, 60, 90, and 120 years from 1890, to show how the accuracy varies for various periods.

Following Kondo (2017), for synthetic seismic intensities, we combined the hazard curves in the engineering bedrocks for PSHMJ (Miyakoshi et al., 2016), the site amplification factors (Wakamatsu and Matsuoka, 2013), and the relationship of seismic intensities and peak ground velocities (Midorikawa et al., 1999; Fujimoto and Midorikawa, 2005). As in Miyazawa and Mori (2009), the Poisson distribution was assumed, and phenomena of return periods of 30, 60, 90, and 120 years were related to those with probabilities of exceedance in 30 years of 64, 45, 28, and 22%, respectively. Observed seismic intensities were derived from the JMA seismic intensity database (Ishigaki and Takagi, 2000; Ishigaki, 2007) and the reports of large earthquakes between 1944 and 1964 (Usami, 1985; Harada et al., 2016). The derived dataset consists of observed seismic intensities at 110 points. This observed dataset was compared with the synthetic seismic intensities at the corresponding points in PSHMJ.

As an index of the comparison, we first calculated the root mean square of differences between observed and synthetic seismic intensities. The results are 1.2, 0.8, 0.7, and 0.7 for return periods of 30, 60, 90, and 120 years, respectively. Since large earthquakes, which can lead to large seismic intensities, are phenomena happening once in several hundred years (plate boundary earthquakes) or once in several thousand years, it is expected that a smaller root mean square is obtained for a longer return period. The above results mostly meet this expectation, but they do not approach 0.4 to 0.5 for a return period of 500 years (Miyazawa and Mori, 2009) being saturated at 0.7 for 90 and 120 years. We secondly performed regression analyses, and similar saturation was also found. For example, the small number of observed seismic intensities can cause this problem, and therefore it will be considered further.

Acknowledgments: J. Miyakoshi provided the hazard curves, and T. Kondo provided computer codes etc. Discussion with J. Miyakoshi and H. Fujiwara is helpful for this study.

Keywords: probabilistic seismic hazard map, observed maximun seismic intensity, return period

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A Study on the Ground Motion Characteristics close to the Basin Edge

Ryota Hamabe[2], *Shinichi Matsushima[1], Takashi Azuma[3], Florent De Martin[4]

1. Disaster Prevention Research Institute, Kyoto University, 2. Graduate School of Engineering, Kyoto University, 3. National Institute of Advanced Industrial Science and Technology, 4. French Geological Survey

The 1995 Kobe Earthquake brought significant damage around the Kobe area in Japan. It was notable that a “Damage Belt” with an area with a width of 1km and length of 20km was formed. The main cause of this phenomenon was called the “Basin-Edge Effect”, which is a result of the constructive interference of seismic waves owing to the basin edge structure, i.e. the interference between the direct S-wave propagating upward and the basin-induced/diffracted surface waves propagating laterally. Therefore, this phenomenon should not limited to the Kobe area. In this study, we conduct a ground response analysis at sites close to the basin edge, assuming various types of basin structures, to understand the influence of the subsurface structure to the characteristics of the ground motion close to the basin edge. Also, the observed microtremor Horizontal-to-Vertical spectral ratio (MHVR) will be used to understand the relation between the shape of the MHVR and the basin edge shape. A method to estimate the region of amplification of ground motion due to the Basin-Edge effect at the basin edge estimated from MHVRs will be introduced.

Keywords: Basin-Edge effect, Basin edge, Amplification factor, Horizontal-to-Vertical spectral ratio

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Spectrum Characteristics of MeSO-net seismograms –Effect of Underground Installation -

*Ryoichi Nakamura[1], Hiroshi Tsuruoka[1], Aitaro Kato[1], Shin'ichi Sakai[1], Naoshi Hirata[1], Takahiro Shiina[1]

1. Earthquake Research Institute, The University of Tokyo

1. Introduction

In the Kanto district, high-density seismographs with about 300 accelerometers by MeSO-net have been deployed, and records from 2008 have been accumulated. By analyzing the MeSO-net records integrating with those obtained in K-NET and KiK-net, which is operated near the ground surface, it will able to largely improve structural images in seismic attenuation. However, MeSO-net is installed at a depth of 20 m and there is a problem to integrate records obtained at the surface. In this study, we investigated relative amplification factors among MeSO-net sites and compared the factors to those estimated at the surface sites, K-NET and KiK-net.

2. Method and Data

Observation records which are obtained at two closely located sites by the same earthquake have almost the same propagation paths, so the difference of the two site records can represent a difference of site amplifications because effects of source radiation and attenuation along paths are canceled out. Based on this idea, some studies have been investigated relative amplification factors between the sites. Recently, Ikeura and Kato (2011) proposed a new method that regards site pairs as a network and estimates relative ground amplification factors by using least squares method within the network.

In this study, the relative amplification factors in MeSO-net was examined by using the Ikeura and Kato's method. In order to compare with the amplification factors on the surface, the ground record of K-NET and KiK-net was also included in the analysis. The ARTB method (Herman, 1980) was used for least squares estimation. A distance between sites to pair is 10 km or short. The Fourier spectrum of every 1 Hz from 1 Hz to 10 Hz were used for the data. The strong motion records of MeSO-net from 2011 to 2015 and K-NET/KiK-net from 1996 to July 2016 were selected. Earthquakes with Mj 4 or more and depths less than 200 km were used. We only adopted records which the maximum acceleration amplitude is 100 Gal or less to exclude the nonlinearity effects resulted in strong ground motion. Finally, we used site pairs of 962,422 with 394 observation sites of 394, which include MeSO-net site of 297.

3. Results

In this study, first, we performed numerical experiments to vilify the validity of results given by the ARTB. The geometries of site and earthquake used in the experiments are the same to the actual investigation. After 50 times iteration, it is confirmed that synthesized dataset well reproduce the relative site amplifications assumed in artificially.

Then, we conducted 100 times iteration for the actual observation records to obtain the relative ground amplification. Fig.1 shows an example of the result at 5 Hz. Here we compare the relationship with the average S wave velocity to 30m depth (AVS 30) provided from the JSHIS. The amplification factors at the

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ground surface (K-NET and KiK-net) is about 3 times larger than that at the underground (MeSO-net) on average. The amplification rate tends to decrease with increasing velocities of the AVS 30. This trend is consistent with the relationship for the PGV data expected based on Fujimoto and Midorikawa (2006) (black solid line in Fig. 1).

We confirmed that the residuals in the attenuation tomographic inversion can be greatly reduced by giving the relative amplification factors obtained in this study as a priori information.

4. Conclusions

Relative amplifications of ground motion were investigated for observation sites of the MeSO-net, K-NET and KiK-net by using the site-pair network and the least squares method. As a result, it was found that amplification factor in the MeSO-net of which seismographs are deployed at the underground, 20 m depth, is about 1/3 comparing with those of ground surface recorded in the K-NET and KiK -net on average.

Keywords: MeSO-net, Relative Amplification Factor

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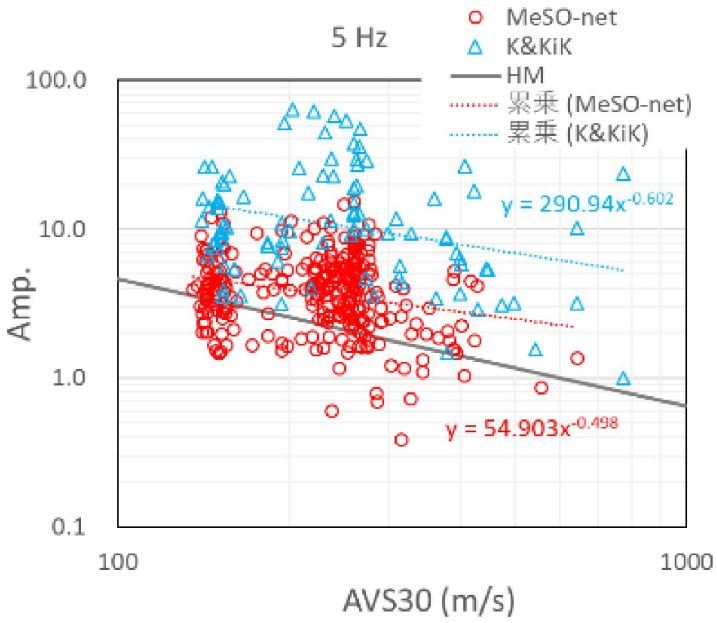


Fig.1 Relation between relative amplification factors at 5 Hz and AVS30 by JSHIS
△ : K-NET・KiK-net (free surface) ○ : MeSO-net(underground G.L.-20 m)
HM : Relation between PGV and AVS30 by Fujimoto and Midorikawa(2006)

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Mon. May 27, 2019 10:45 AM - 12:15 PM JST | Mon. May 27, 2019 1:45 AM - 3:15 AM UTC | Convention Hall A 2F

[S-SS13] Strong Ground Motion and Earthquake Disaster

convener:Masayuki Kuriyama(Central Research Institute of Electric Power Industry), Kazuhiro Somei(Geo-Research Institute), Chairperson:Yasumaro Kakehi(Department of Planetology, Graduate School of Science, Kobe University), Hisashi Nakahara(Solid Earth Physics Laboratory, Department of Geophysics, Graduate School of Science, Tohoku University)

Strong ground motion has social impacts as it induces earthquake disasters. We solicit contribution on any seismological topics related to strong ground motion that includes, but are not limited to, source processes, wave propagation, and site effects. We also welcome contribution on earthquake related disaster mitigation.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SSS13-31] Interpretation of attenuation of high-frequency waves from the intraslab, interplate, and outer-rise earthqukakes of Northeastern Japan

*Yasumaro Kakehi[1], Yu Ogasawara[1] (1.Graduate School of Science, Kobe University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SSS13-32] **Effect analysis of soil interlayer on seismic dynamic response and failure mode of metro station structure**

*Shuai Huang[1], Yuejun Lyu[1], Yanju Peng[1] (1.Institute of Crustal Dynamics,China Earthquake Administration)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SSS13-33] **Investigation on the Applicability of V_{S30} Estimation Models for the Beijing Plain Area**

*Yi Fang, Yanju Peng, Zhijie Jiang

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SSS13-34] Early prediction of PGA and Sa using ANN

*Ting Yu Hsu[1] (1.Taiwan Tech)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SSS13-35] Analysis of strong-motion acceleration records based on the Generalized Pareto distribution

*Hisashi Nakahara[1] (1.Solid Earth Physics Laboratory, Department of Geophysics, Graduate School of Science, Tohoku University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

Discussion

Interpretation of attenuation of high-frequency waves from the intraslab, interplate, and outer-rise earthqukakes of Northeastern Japan

*Yasumaro Kakehi[1], Yu Ogasawara[1]

1. Graduate School of Science, Kobe University

Previous studies (e.g. Tsumura et al., 2000) have shown the backarc side of Northeastern Japan has lower Q-value than the forearc side and remarkably low-Q zones exist just beneath and slightly backarc-side of the volcanic front. On the backarc side, high-frequency seismic waves attenuate due to the low-Q medium, and the contrast is seen between the high-frequency wave amplitudes on the backarc side and those of the forearc side, where such attenuation does not occur. In this study, characteristics of the spatial distribution of peak ground acceleration and the attenuation relation from 3 types of earthquakes: intraslab, interplate, and outer-rise earthquakes, are investigated using high-density strong motion data of NIED K-NET and KiK-net. The number of studied earthquakes is 15 in total. The most clear contrast between the forearc and backarc sides is seen in the intraslab earthquakes with deep focal depths, and the contrast is also clear in the outer-rise earthquakes though the contrast is not so clear as that in the intraslab earthquakes. On the other hand, the contrast is observed also in the interplate earthquakes, but it is less clear than that in the outer-rise earthquakes. The length of seismic wave path propagating in the low-Q region on the backarc side is long in the case of intraslab earthquakes with deep focal depths, and in the case of interplate and outer-rise earthquakes, both of which have shallow focal depths, the lengths of seismic wave path are shorter than the case of intraslab earthqukaes and are approximately the same. Therefore, it is reasonable that the contrast in outer-rise earthquakes is less clear than that in intraslab eartgquake. It is incomprehensible, however, that the contrast in interplate earthquakes is less clear than that in outer-rise earthquakes. To understand this mystery, we newly take the contribution of the attenuation due to the geometrical spreading factor into consideration. In case of interplate earthquakes whose epicenters are close to the land, the curvature of hypocentral distance contors in the land area (where the observation stations are located) is large. Therefore, attenuation due to the geometric spreading factor is large at the northern and southern ends of the Northeastern Japan arc, where hypocentral distances are large than those in the central part of the island arc, the amplitude difference between the forearch and backarc sides is masked. On the other hand, in case of outer-rise earthquake whose epicenter is far away from the land, the curvature of hypocentral distance contors in the land area is very small and the geometrical spreading factor hardly varies throughout the Northeastern Japan arc. Therefore, the mask effect due to the geometric spreading factor at the norther and southern ends of the Northeastern Japan arc does not work effectively. That is, due to the mask effect of the geometric spreading factor, the contrast between the forearc and backarc sides in interplate earthquakes becomes less clear than that in outer-rise earthquakes, where the mask effect does not work. Furthermore, as to the PGA attenuation relation, an apparent effect appears in the case of outer-rise earthquakes that makes the amplitude difference between the forearc and the backarc sides apparently emphasized than it is, as pointed out by Ogasawara and Kakehi (2018, SSJ Fall Meeting). Thus, the difference of the contrast of seismic shaking on the forearc side and that of the backarc side of Northeastern Japan due to the 3 types of earthquakes is interpreted unifiedly by considering the following 3 factors: (1) the length of seismic wave path propagating in the low-Q region, (2) the mask effect due to the geometrical spreading factor, and (3) the apparent effect in the case of outer-rise earthquakes whose hypocentral distances are systematically large.

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Keywords: intraslab earthquake, interplate earthquake, outer-rise earthquake, attenuation of seismic waves

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Effect analysis of soil interlayer on seismic dynamic response and failure mode of metro station structure

*Shuai Huang[1], Yuejun Lyu[1], Yanju Peng[1]

1. Institute of Crustal Dynamics,China Earthquake Administration

When the metro station structure is built in the site with weak interlayer, the metro station structure shows different patterns of destruction. In this article, based on the nonlinear elastic-plastic finite element model for metro station, considering the structure-soil dynamic interaction, the influence laws of the weak interlayer on the dynamic response and failure mode of the metro station structure under near and far-field earthquakes are studied. We found that the weak interlayer in the middle of the metro station has the greatest effect on the displacement, dynamic amplification factor and internal force of the metro station which leads to the poor anti-seismic performance of the metro station structure, and the metro station is more vulnerable to damage under near-field earthquake. When there is a middle interlayer, the maximum horizontal displacement of the metro station increases 63% at most compared to no interlayer under near-field earthquake. The interlayer below the metro station has a minimal impact on the dynamic amplification factor which shows that the existence of the interlayer below the metro station could reduce the vibration of the metro station to a certain extent. At last, indoor shaking table test for metro station was done, through which we determined the position of initial failure and the failure mode of the metro station structure under earthquake, and shaking table test results demonstrate the validation of the numerical simulation results.

Keywords: weak interlayer, metro station, near and far-field earthquakes, shaking table test, failure mode

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Investigation on the Applicability of V_{S30} Estimation Models for the Beijing Plain Area

*Yi Fang, Yanju Peng, Zhijie Jiang

Using three models which respectively are bottom-layer constant velocity model, velocity gradient model and the extrapolation model with the travel-time averaged shear-wave velocities at two different depths, we investigate the data from 460 boreholes in Beijing plain area that the shear-wave velocity profile reaches at least 30 m. Through a detailed research, we found that the last method can estimate V_{S30} with high accuracy. It does not need any regression analysis to derive empirical relations from a large number of data. Meanwhile, this method is not regionally dependent, and has a remarkable improvement in the accuracy, therefore, it is potentially useful for many parts of the world including Beijing. It provides a basis for site classification, and then extends its application to evaluation of site effect in a rapid assessment of earthquake damage, thus being worth to be extensively applied.

Keywords: Vs30 , Estimation Models, Beijing Plain Area

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Early prediction of PGA and Sa using ANN

*Ting Yu Hsu[1]

1. Taiwan Tech

In order to perform on-site earthquake early warning, in this study, we develop a novel approach to predict the peak ground acceleration (PGA) and pseudo-spectral acceleration (Sa) using the first few seconds of P-wave features. The Fourier spectrum amplitude (FSA) and phase (FSP) are handled separately and then combined together to predict the acceleration time history, then the PGA and Sa can be estimated accordingly. The FSA is predicted using the artificial neural network (ANN) with the predominant period, peak acceleration amplitude, peak velocity amplitude, peak displacement amplitude, cumulative absolute velocity, integral of the squared velocity, and FSA of the first three seconds of P-wave as input. The mean and standard deviation of the group delay time of phase spectrum of each separated frequency range decomposed by wavelet transform is employed as the prediction target, then the FSP can be generated using these mean and standard deviation of the group delay time. The FSP is predicted using another ANN model using similar P-wave features as the FSA ANN model. The earthquake records of the Taiwan Strong Motion Instrumentation Program from 1992 to 2006 were used to train and validate the proposed approach, and the promising accuracy of PGA and Sa prediction is obtained.

Keywords: Peak Ground Acceleration, Pseudo-spectral Acceleration, Artificial Neural Network

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Analysis of strong-motion acceleration records based on the Generalized Pareto distribution

*Hisashi Nakahara[1]

1. Solid Earth Physics Laboratory, Department of Geophysics, Graduate School of Science, Tohoku University

Owing to K-NET and KiK-net managed by NIED, high-quality strong ground motion data have been accumulating in Japan in these two decades. Analyzing these data set, I investigate the upper limit of ground accelerations of near-field strong motion records in Japan. I apply the Generalized Pareto distribution (GPD) to amplitude distributions of ground accelerations exceeding given threshold levels, and estimate the parameters of GPD. Especially, the shape parameter of GPD is very important for this purpose. If the shape parameter is negative, an upper limit exists in the distribution. If the shape parameter is greater or equal to 0, there is no upper limit.

Among the strong motion database from K-NET and KiK-net, I select 98 strong motion records whose peak ground accelerations exceed 1g. I finally use 77 strong motion records after eliminating records contaminated by other events like aftershocks and those whose duration times are too short to have enough data. Positive values and negative values of ground accelerations are independently analyzed. I use the absolute value for the negative amplitude. Changing the threshold value of ground acceleration from 10 to 300 gal, I fit GPD to the data exceeding the threshold, and estimate the minimum threshold over which the estimated parameters of GPD (the shape parameter, the scale parameter, and the mean excess) will not change much. I also confirm the goodness of fit of GPD by checking P-P plots and Q-Q plots visually.

GPD explains amplitude distributions of 77 acceleration records. For the positive amplitudes of accelerations, 48 records show the upper limits. For the negative amplitudes of accelerations, 53 records show the limits. In total, about 70 % records show the limit in ground accelerations. The range of the limit is mostly smaller than about 6000gal. However, a few results with very small negative shape parameters suggest much larger limits. These results should be regarded practically as no limits. For the rest of about 30 % records, the existence of the limit is not statistically supported. However, there should be the upper limit in ground accelerations from the viewpoint of physics. So it is necessary to clarify reasons why about 30 % records do not suggest the upper limit in ground acceleration.

Acknowledgment:

I used strong motion records obtained by K-NET and KiK-net, NIED.

Keywords: Strong motion, peak ground acceleration, generalized Pareto distribution

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[J] Oral | S (Solid Earth Sciences)：S-EM Earth's Electromagnetism

Mon. May 27, 2019 9:00 AM - 10:30 AM JST | Mon. May 27, 2019 12:00 AM - 1:30 AM UTC | 304 3F

[S-EM19] Electromagnetic Induction in the Earth and Planetary Interiors, and Tectono-Electromagnetism

convener:Koki Aizawa(Institute of Seismology and Volcanology, Faculty of Sciences, Kyushu University), Tetsuo Matsuno(Kobe Ocean Bottom Exploration Center, Kobe University), Chairperson:Tetsuo Matsuno, Koki Aizawa

This session welcomes papers on electromagnetism in the Earth and planetary interiors. The topics include but not limited to electromagnetic phenomena associated with earthquakes and volcanism, electrical conductivity structure, laboratory experiments, results of simulations, new equipment for observation, and methods of data analysis.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SEM19-01] Repeated measurements of the Self-Potential at Akita-Yakeyama, Iwate and Kurikoma volcanoes

*Shin'ya Sakanaka[1], Yasiaki Sawada[3], Kenta Kato[2], Inoue Yusuke[1], Kobayashi Takuya[1], Ryuichi Takei[1], YUYA TADA[2], Muhammad Faizul Nizam Bin Zainudin[2], Tomoya Moriwaki[2] (1.Graduate school of International Resource Sciences, Akita University, 2.Faculty of International Resource Sciences, Akita University, 3.Faculty of International Resource Sciences, Akita University (gradusted in 2018))

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SEM19-02] Evaluation of surface conductivity of unsaturated Berea sandstone and porous glasses

*Ryosuke Umezawa[1], Makoto Katsura[1], Satoru Nakashima[1] (1.Department of Earth and Space Science, Graduate School of Science, Osaka University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SEM19-03] Observational and theoretical waveforms of electromagnetic signals generated by the motional induction effect before the arrival of seismic waves

*Ken'ichi Yamazaki[1] (1.Disaster Prevention Research Institute, Kyoto University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SEM19-04] Effect of reference data on geomagnetic transfer functions

*Shinya Sato[1], Tada-nori Goto[1] (1.Kyoto Univesity, Graduate School of Engineering)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SEM19-05] Reliability estimation of magnetotelluric inversion result based on the Principle Component Analysis and Markov Chain Monte-Carlo method

Hisatoshi Koji[1], *Tada-nori Goto[1] (1.Graduate School of Engineering, Kyoto University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SEM19-06] Probing one-dimensional electrical anisotropy in the oceanic upper mantle from seafloor magnetotelluric array data

*Tetsuo Matsuno[1], Kiyoshi Baba[2], Hisashi Utada[2] (1.Kobe Ocean Bottom Exploration Center, Kobe University, 2.Earthquake Research Institute, The University of Tokyo)

Repeated measurements of the Self-Potential at Akita-Yakeyama, Iwate and Kurikoma volcanoes

*Shin'ya Sakanaka[1], Yasiaki Sawada[3], Kenta Kato[2], Inoue Yusuke[1], Kobayashi Takuya[1], Ryuichi Takei[1], YUYA TADA[2], Muhammad Faizul Nizam Bin Zainudin[2], Tomoya Moriwaki[2]

1. Graduate school of International Resource Sciences, Akita University, 2. Faculty of International Resource Sciences, Akita University, 3. Faculty of International Resource Sciences, Akita University (gradusted in 2018)

We will report the SP (Self-Potential) anomalies at Akita-Yakeyama, Iwate, and Kurikomayama volcanoes. They are active volcanoes along the boundary of Akita and Iwate prefectures and their volcanic activities are relatively high recently.

SP measurements and SP anomalies at those volcanoes were reported by some researchers. We are still carrying out the SP measurements there repeatedly so as to monitor the activities of the volcanoes.

We conducted the SP measurements along the mountain trail from Tamagawa hot spring to Goshougake hot spring at Akita-Yakeyama in 2007 and 2017. At Mt. Iwate the SP measurements were conducted along the Yakebashiri trail up to the summit in 1999, 2004 and 2017. At northern part of Mt. Kurikoma we walked from the Nagorigahara moor, went through the summit and returned back anti-clockwised along the trail with SP electrodes in 2018. The result of the previous SP measurement in Kurikoma volcano can be found in the part of the Aizawa (2010) and we can investigate the time-lapse SP anomalies on these volcanoes.

We adopted the leap-frog measurement method with a 50 m cable, copper-copper sulfate electrodes, and a digital multi-meter (voltmeter). The latitude and longitude data were recorded by the handy GPS receiver (like as Garmin product). Although in the measurements of the leap-frog method might be easily piled up each error of the measured value at a site, a short cable can be easier handled than a longer cable over the length of a couple of kilometers using by the total-potential measurement method. The long and thin cable is sometimes cut apart by animals or human beings and unfortunately we have to return back to the cut point all the way to fix it.

On the compiling the SP data in different years we draw the SP curves along the cumulated distance. Since the cumulated distances of the SP measurements are sometimes up to several kilometers, the lengths of the cumulated distance are sometimes different by more than 100 m in the data of the respective years. We measure the SP on the same mountain trail but the end of the cable at each measurement is not always at the same point and the SP paths are slightly different in year to year on the measurements. This is the reason why the difference of the cumulated distance in different years. The problem might be happened also with the measurements of the total-potential method. To solve it, we set a model path with the function of the cumulated distance on the trail map in advance and the measured site were relocated (projected) onto the model path referred by GPS locations. After that we successfully and comfortably compare the SP data on the same trails.

At Akita-Yakeyama and Iwate volcanoes, we cannot find out the outstanding time variations of SP anomalies but the acquired SP data can be use the monitor the active volcanoes.

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Keywords: self potential, active volcano, leap frog method, copper-copper sulfate electrode, Akita-Yakeyama volcano, Iwate volcano

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Evaluation of surface conductivity of unsaturated Berea sandstone and porous glasses

*Ryosuke Umezawa[1], Makoto Katsura[1], Satoru Nakashima[1]

1. Department of Earth and Space Science, Graduate School of Science, Osaka University

Electrical conduction of rocks composed of insulating minerals are known to depend on degree of water saturation, distribution of pore water, pore size and pore structure. Electrical conduction in rocks is considered to be composed of conductions in bulk water and on mineral surfaces. The electrical double layer (EDL), a layer with adsorbed ions on mineral surfaces (Stern layer) and gradients of ion concentrations (diffuse layer), has thickness characteristic length of the diffuse layer (Debye length). Surface conduction becomes important, when bulk water in rock pore decreases, such as in unsaturated rocks and less porous rocks with thin grain boundary water. Since quantification of dissolved ions in rocks with thin grain boundaries is difficult, quantitative description of surface conduction remains poor.
In this study, in order to examine surface conduction with known dissolved ion concentrations, electrical conductivity of a sandstone and porous glasses were measured for varying water saturation and ion concentrations. Berea sandstone (predominant pore diameter: about 40 μm) and Shirasu porous glass (SPG) membranes (SPG technology; uniform pore sizes: 1.0, 0.5, and 0.2 μm) were saturated with aqueous solutions having varying NaCl concentrations (0, 0.001, 0.01, 0.1 mol L^{-1}). Electrical conductivity values were measured for frequencies from 0.1 Hz to 1 MHz while drying.
Effects of surface conduction of Berea sandstone and SPG membranes were compared by their specific surface conductivity values, which were evaluated by conduction models using surface complexation model, and were discussed in relation to water film thickness and Debye length.

Keywords: Water saturation, electrical conductivity, ion concentration, Debye length, surface conductivity

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Observational and theoretical waveforms of electromagnetic signals generated by the motional induction effect before the arrival of seismic waves

*Ken'ichi Yamazaki[1]

1. Disaster Prevention Research Institute, Kyoto University

Earthquake ruptures and consequent ground motions generates variations in the electromagnetic (EM) field by means of variety of conversion processes in the Earth’s crust. The generated EM signals are referred to as seismo-EM signals. Some of the earlier works have reported seismo-EM signals that are observed prior to the arrival of seismic waves [e.g. Iyemori et al. 1996 (JGG); Honkura et al. 2002 (EPS); Okubo et al. 2011 (EPSL)], which are sometimes referred to as “early seismo-EM signals”. Theoretical calculations have been conducted to identify the generation mechanisms of the observed seismo-EM signals assuming some of candidate conversion mechanisms including the electrokinetic effect [Haartsen and Pride 1997 (JGR)], the motional induction effect [Gao et al. 2014 (JGR)], the piezomagnetic effect [Yamazaki 2016 (GJI)] and the piezoelectric effect [Ogawa and Utada 2000a (PEPI), 2000b (EPS)]. However, definitive answers have not been obtained, particularly for the case of early seismo-EM signals.

The objective of this work is to compare theoretical time-series of seismo-EM signals arising from the motional induction effect with observational one by means of simple numerical models. In an earlier work, Gao et al. [2014] consider the same problem by assuming uniform full-space model with analytical solutions. Their results imply that theoretical early seismo-EM signals in this situation are far smaller than observed ones. In the present work, I consider a model composed from conductive half-space that represents the Earth’s crust and another half-space that represents the air as an insulator. In frequency domain, governing equations in this situation are reduced to ordinary differential equations by applying the Hankel transform, which can be solved analytically. Seismo-EM Solutions of the original equations are then obtained after the inverse Hankel transform. Time-series of seismo-EM signals are then obtained after the inverse Fourier transform.

The comparisons between observed and theoretical seismo-EM variations are performed for two cases: one is the phenomena observed at the time of 1999 Izmit earthquake, Turkey [Honkura et al. 2002], and the other is that observed at the time of 2008 Iwate-Miyagi earthquake, Japan [Okubo et al. 2011]. Early seismo-EM signals observed for these two earthquakes have different characters. For the case of Izmit earthquake, signals appeared only after seismic waves reach close to the observational site. In contrast, for the case of Iwate-Miyagi earthquake, EM signals emerges just after the onset of seismic ruptures. Numerical calculations assuming the motional induction effect reasonably account the feature of signals for the Izmit earthquake, but do not account that for the Iwate-Miyagi earthquake.

Keywords: electromagnetic field, motional induction effect, seismic ground motion

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Effect of reference data on geomagnetic transfer functions

*Shinya Sato[1], Tada-nori Goto[1]

1. Kyoto Univesity, Graduate School of Engineering

It is well-known that inter-station transfer functions (TFs), which are derived generally using two sites (as following Schmucker 1984; Neska 2006), are effected by source field. Also, we sometimes use three sites for deriving TFs in order to reduce the noises mixed in geomagnetic data. These 2 or 3 sites-based TFs have been used for evaluating the spatial characteristics of source field. However, the 3 sites-based TFs (i.e., using site 1, site 2 and reference site) do not always reflect the source field’s condition between site 1 and site 2, and can possibly be effected by the source field’ characteristics at reference site. Also, the evaluation of source field’s condition at time-frequency domain (i.e., at the stage of spectra or spectrograms) will be more accurate. Therefore, for the evaluation we used Multi-Channel Nonnegative Matrix Factorization (MC-NMF, suggested by Sato and Goto 2018), which can extract components included in several geomagnetic spectrograms. Moreover, we derived the condition of geomagnetic events’ spatial-characteristics, which triggers the effect of reference data on 3 sites-based TFs. In order to verify that the TFs are effected by the reference site, we derived the temporal changes in 3 sites-based TFs replacing the reference sites. As a result, we founded that the TFs changed not only temporally but dependent on the reference site and the interpretation of source field’s spatial characteristics was different dependent on the reference site. For exposing the cause, we evaluated the spatial-characteristics of geomagnetic events using MC-NMF. The evaluated spatial-characteristics of geomagnetic events were corresponding with the condition triggering the effect of reference data on TFs as mentioned above. We succeeded to expose the cause of TFs’ variation triggered by reference data evaluating the spatial-characteristics of geomagnetic events at time-frequency domain. Using TFs together with MC-NMF, the interpretation of source-field’s spatial characteristics will be with high accuracy.

Keywords: Spatial characteristics of source field, Inter-station Transfer Function, Remote reference

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Reliability estimation of magnetotelluric inversion result based on the Principle Component Analysis and Markov Chain Monte-Carlo method

Hisatoshi Koji[1], *Tada-nori Goto[1]

1. Graduate School of Engineering, Kyoto University

Magnetotelluric (MT) method is used for detection of electrical conductive materials such as fluid, clay, partial melt and so on. Subsurface resistivity structure is generally estimated by an inverse algorism, based on the least-square scheme using observed apparent resistivity and phase. The reliability of the optimal model in the inversion procedure should be discussed together with seeking the “better” model having the lower data misfit than the optimal model. However, the sophisticated method is not well developed for the magnetotelluric survey, except for the simple test based on a number of forward modeling, constrained inversions and so on, or simple visualization of sensitivity of model parameters. In this study, for a quantitative visualization of reliability of optimal model parameters, we propose a new way of the numerical test of the model based on the Markov Chain Monte-Carlo (MCMC) methods. Since the MCMC cannot solve a number of unknowns in model parameters, we adopted the principle component analysis (PCA) to reduce unknowns in the model obtained by MT inversion code. First, for testing the PCA ability in subsurface image analysis, various two-dimensional (2-D) resistivity models are decomposed by PCA. As a result, we succeeded to extract the “major features” of 2-D resistivity model, especially by using first to third principle components. Then, we tested the MCMC algorithm with changing parameters of “major features” of 2-D model, such as its resistivity, width, thickness, horizontal and vertical locations. In a case of a simple two-prism model, we confirmed that the reliability of low and high resistive anomalies are shown in the probability density functions obtained by MCMC. We also found that some parameters (e.g., thickness and resistivity of an anomalous body) indicate a tread-off relationship as mentioned in the previous studies, and also found the reliable range of parameters even under the trade-off. We then applied this technique to the magnetotelluric data obtained at a field experiment. In consequence, anomalies in the optimal model are detected properly by PCA, and the reliable range of model parameters based on the MCMC method are similar to those inferred by the conventional forward calculations. We conclude that our proposed method can be widely applied to magnetotelluric exploration, even to the three-dimensional inversion.

Keywords: Principle Component Analysis, Markov Chain Monte-Carlo method, Magnetotelluric Inversion

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Probing one-dimensional electrical anisotropy in the oceanic upper mantle from seafloor magnetotelluric array data

*Tetsuo Matsuno[1], Kiyoshi Baba[2], Hisashi Utada[2]

1. Kobe Ocean Bottom Exploration Center, Kobe University, 2. Earthquake Research Institute, The University of Tokyo

Electrical anisotropy in the oceanic upper mantle provides important clues on mantle structure and dynamics if it is confirmed from seafloor magnetotelluric (MT) data. Here we try to probe electrical (azimuthal) anisotropy in the oceanic upper mantle by analyzing recent seafloor MT array data from the northwestern Pacific at 130-145 Ma seafloor. We propose a method, in which an isotropic 1-D model is first obtained from seafloor MT data through iterative correction for topographic distortion, then anisotropic properties are inferred as deviations from the isotropic 1-D model. We investigate the performance of this method through synthetic forward modeling and inversion, using plausible anisotropic 1-D models and actual 3-D bathymetry and topography for the target area. Synthetic tests reveal that the method can detect the electrical anisotropy in the conductive upper mantle or the electrical asthenosphere. We also compare the performance by using two rotational invariant impedances and two topographic correction equations. An application of the method to two seafloor MT array data in the northwestern Pacific reveal anisotropic inversion models, showing the possible presence of electrical anisotropy in two layers in a conductive mantle of <100 Ω-m at 50-250 km depth. Anisotropic signals are larger in shallower layers for both array areas, while anisotropic azimuths (or most conductive directions) and depths to the two layers are different for two array areas even at similar seafloor ages with the horizontal distance of ~1,000 km. Most conductive directions mostly align rather to directions of past seafloor spreading or their perpendicular directions, than a direction of current plate motion and are inconsistent with fastest directions of seismic azimuthal anisotropy. The electrical anisotropic signals may dominantly result from mantle dynamics in array-scale (~500 km or over), like small-scale convection and the formation of seafloor in the past, over in Pacific basin scale.

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[J] Oral | S (Solid Earth Sciences)：S-EM Earth's Electromagnetism

Mon. May 27, 2019 10:45 AM - 12:15 PM JST | Mon. May 27, 2019 1:45 AM - 3:15 AM UTC | 304 3F

[S-EM19] Electromagnetic Induction in the Earth and Planetary Interiors, and Tectono-Electromagnetism

convener:Koki Aizawa(Institute of Seismology and Volcanology, Faculty of Sciences, Kyushu University), Tetsuo Matsuno(Kobe Ocean Bottom Exploration Center, Kobe University), Chairperson:Koki Aizawa, Tetsuo Matsuno

This session welcomes papers on electromagnetism in the Earth and planetary interiors. The topics include but not limited to electromagnetic phenomena associated with earthquakes and volcanism, electrical conductivity structure, laboratory experiments, results of simulations, new equipment for observation, and methods of data analysis.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SEM19-07] The Analysis of magnetotelluric sounding data on Kikai submarine caldera.

*Toki Hirose[1], Tetsuo Matsuno[2,1], Nobukazu Seama[1,2], Yuki Okizono[4], Hiroshi Ichihara[3], Hiroko Sugioka[1,2], Yoshiyuki Tatsumi[2,1] (1.Department of Planetology, Graduate School of Science, Kobe University, 2.Kobe ocean Bottom Exploration Center, Kobe University, 3.Graduate school of environmental studies, Nagoya University, 4.Department of Planetology, Faculty of Science, Kobe University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SEM19-08] Role of Fluids in the earthquake generation: The Nagamachi-Rifu reverse fault, NE Honshu, Japan

*Sabri Bulent Tank[1], Yasuo Ogawa[2] (1.Bogazici University, 2.Tokyo Institute of Technology)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SEM19-09] Audio-frequency Magnetotelluric Survey of the Tsuyama-hoppou Fault, Yamasaki Fault Zone, southwest Japan.

*Satoru Yamaguchi[1], Daisuke Takakuwa[2], Akira Mimura[1], Kazuki Fkue[1], Shigehiro Katoh[3], Hideki Murakami[4], Shinichi Takakura[5] (1.Department of Geosciences, Graduate School of Science, Osaka City University, 2.Faculty of Science, Osaka City University, 3.The Museum of Nature and Human Activities, 4.Science and Technology Unit, Research and Education Faculty, Kochi University, 5.Geological Survey of Japan, Institute of Advanced Industrial Science and Technology)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SEM19-10] Three dimensional resistivity structure around the focal region of the 2016 Kumamoto earthquakes

*Koki Aizawa[1], Hisashi Asaue[2], Katsuaki Koike[3], Shinichi Takakura[4], Toru Yoshinaga[10], Makoto Uyeshima[5], Takao Koyama[5], Ryokei Yoshimura[7], Ken'ichi Yamazaki[7], Shintaro Komatsu[7], Yusuke Yamashita[7], Hiroshi Ichihara[9], Mitsuru Utsugi[8], Kaori Tsukamoto[12], Dan Muramatsu[12], Yoshiko Teguri[1,11], Kazunari Uchida[1], Hideaki Hase[6], Azusa Shito[1], Satoshi Matsumoto[1], Takeshi Matsushima[1], Hiroshi Shimizu[1] (1.Institute of Seismology and Volcanology, Faculty of Sciences, Kyushu University, 2.Laboratory on Innovative Techniques for Infrastructures, Kyoto University, 3.Environmental Geosphere Engineering, Department of Urban Management, Graduate School of Engineering, Kyoto University, 4.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 5.Earthquake Research Institute, University of Tokyo, 6.GERD, 7.Disaster Prevention Research Institute, Kyoto University, 8.Aso Volcanological Laboratory, Institute for Geothermal Sciences, Graduate School of Science, Kyoto University, 9.Earthquake and Volcano Research Center, Graduate School of Environmental Studies, Nagoya University, 10.Kumamoto University, 11.Japan Meteorological Agency, 12.Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SEM19-11] **A research report on the fundamental investigations of an electrical resistivity structure beneath Chugoku and Shikoku regions, southwestern Japan(2018)**

*Ichiro Shiozaki[1], Tomofumi Uto[1], Makoto Uyeshima[2], Hiroshi Hataoka[3], Yasuo Ikezoe[3], Shinji Yamamoto[3], Tatsuya Noguchi[1], Daiki Furuichi[4], Yuki Murayama[4], Kohei Matsushita[4], Hideki Murakami[5], Naoto Oshiman[6], Yoshihisa Iio[6], Kazuya Ando[7] (1.Graduate School of Engineering, Tottori University, 2.Earthquake Research Institute, The University of Tokyo, 3.Technical Department, Tottori University, 4.Faculty of Engineering, Tottori University, 5.Research and Education Faculty , Kochi University, 6.Disaster Prevention Research Institute, Kyoto University, 7.San'in Kaigan Geopark Museum of the Earth and Sea)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SEM19-12] Fluid distribution beneath central and southern Kyushu imaged by 3-D electrical resistivity model

*Maki Hata[1], Hiroshi Munekane[2], Hisashi Utada[1], Tsuneomi Kagiyama[3] (1.Earthquake Research Institute, the University of Tokyo , 2.Geospatial Information Aurhotiry of Japan, 3.Aso Geopark Promotion Council)

The Analysis of magnetotelluric sounding data on Kikai submarine caldera.

*Toki Hirose[1], Tetsuo Matsuno[2,1], Nobukazu Seama[1,2], Yuki Okizono[4], Hiroshi Ichihara[3], Hiroko Sugioka[1,2], Yoshiyuki Tatsumi[2,1]

1. Department of Planetology, Graduate School of Science, Kobe University, 2. Kobe ocean Bottom Exploration Center, Kobe University, 3. Graduate school of environmental studies, Nagoya University, 4. Department of Planetology, Faculty of Science, Kobe University

Kikai submarine caldera locates on the south waters of Kagoshima. The caldera was formed after super eruption on 7.3ka, and have formed huge lava dome since the eruption(Tatsumi et al., 2018). A main aim of this study is to determine the electrical resistivity structure beneath the Kikai caldera, and estimate the distriution of melt, magma chamber and thermal anomaly. As one step to the main aim, this study presents the results of calculations of apparent resistivity and phase, and estimating 1D inversion resistivity structure models after their correction for topographic distortion.
Measurements of the time variations of electric and magnetic fields at the seafloor were conducted at 10 sites with a sample rate of 8 Hz for about 20 days. At the four of those after the surveys, measurements were switched to the sample period of 60 s for about half year. Observed data with sample rate of 8 Hz were processed as followings: (1) downsampled to 1 Hz, (2) corrected by comparing the instrument clocks with GPS time, (3) detrended for longer-periods than 1 day, and (4) corrected instrument inclines. The instrument coordinates were transformed to geographic coordinate system. After these processing, we extracted the data without noises which attribute to the shaking of instrument and calculated magnetotelluric(MT) inpedances, apparent resistivity, and phase using the BIRRP method(Chave and Thomson, 2004). Kanoya magnetic observatory was used as the magnetic remote reference.
Estimated apparent resistivities were characterized with respect to periods and elements, whose characteristics are commonly found at all the sites. With respect to periods, off-diagonal apparent resistivity ranges 1Ωm to 10Ωm at the periods of 21s, and increases to 10Ωm to 100Ωm at a longer periods of 1024s. As for elements, diagonal elements are smaller than non-diagonal elements by a degree of magnitude. Estimated phases were characterized by xy and yx elements that are within the range of the first quadrant and the third quadrant respectively.
Effect of topography on MT impedances are modeled with with FS3D(Baba and Seama, 2002). Using The results of FS3D and the method of removing of topographic distortion(Nolasco et al., 1998), MT impedance are corrected for bathymetry. Using the corrected MT impedance, the 1D electrical resistivity structure models at the observation sites are estimated by OCCAM1D inversion program(Constable et al., 1987). The 1-D structure models are compared to 3-D electrical resistivity structure model(Matsuno et al., presented at this meeting) .

Keywords: magnetotelluric, Kikai caldera, 1D inversion

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Role of Fluids in the earthquake generation: The Nagamachi-Rifu reverse fault, NE Honshu, Japan

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The Japanese island arc was drastically influenced by the occurence of the 2011 Tohoku-Oki earthquake (M9) which also effected the volcanic activity and modified the local seismicity both of which are proven to be related to crustal fluid distribution. Therefore, for understanding the dynamic behavior of the region and for making further comparisons, developing an electrical conductivity model that enables to image the fluid’ s presence and capacity by means of analyses based on high-quality magnetotellurics data collected prior to the Tohoku-Oki earthquake at 61 sounding locations near the Nagamachi-Rifu Fault, Northeast Honshu, Japan, became an important task. Magnetotelluric data collected along three profiles that orthogonally cross the almost NE-SW geo-electric strike were used to image the epicentral region of this active reverse fault and its vicinity. State-of-the-art three-dimensional data-space inversion schemes were applied on the wide-band magnetotellurics data to map the fluid-rich and/or -depleted zones. Inversions included 0.3 Ohmm cells with realistic bathymetry on both sides of the initial model representing the Japan Sea in the west and Pacific Ocean in the east to realize the ocean effect. Resulting models were compared with prior and post seismicity of the main event.

Keywords: Magnetotellurics, Nagamachi-Rifu fault, Fluids

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Audio-frequency Magnetotelluric Survey of the Tsuyama-hoppou Fault, Yamasaki Fault Zone, southwest Japan.

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The Yamasaki fault zone (YFZ) is a ~80 km long, typical left-lateral strike-slip fault zone extending WNW from eastern part Okayama prefecture to southeastern part of Hyogo prefecture. The YFZ consists of the Nagisen fault zone, the main part of the YFZ, and the Kusadani Fault. The Nagisen fault zone show different features in fault activity (e.g. general strike, mean slip rate, the latest event) and seismic activity. Fewer earthquakes are occurred around the Nagisen fault zone compared with around the main part of the YFZ, and the Kusadani Fault.
Earthquake Research Committee (2013) reported that the Nagisen fault zone consists of the Nagisen Fault and Tsuyama-hoppou Fault (abbreviated as TYN Fault here after) and Okada *et al*. (2016) further divided the Nagisen Fault into the Koegatawa Fault, Nagiike Fault, and Nagisen Fault (we referred to them as Nagisen Fault Group here after) and reported fault displacement is recognized along the Nagisen Fault Group. While the TYN Fault is classified into the fault of Certainty II and Degree of activity C, and is annotated as “no fault activity after Middle Pleistocene is recognized” (The Research Group for Active Faults of Japan, 1991). That is, the TYN Fault is still an unknown fault and further survey is required.
Fukue *et al*. (2018) made a magnetotelluric (MT) survey using an audio-frequency MT (AMT) method, which is suitable for revealing shallow part (0 - 2 km in depth) with high spatial resolution, along the line across the Nagiike and Nagisen Faults, then established the two-dimensional resistivity model (NGS model). They pointed out that the Nagiike Fault is recognized as an clear resistivity boundary but that the Nagisen Fault is not recognized in the model.
Aiming to reveal subsurface structure of the unknow TYN Fault, we made an AMT survey along the line of ~4 km long across the TYN Fault and determined the two-dimensional resistivity model along the line. In this paper, we present outline of observation, procedures of data & model analysis, and the resistivity model, then discuss the subsurface structure of the TYN Fault comparing the NGS model.

Keywords: Yamasaki Fault Zone, Tsuyama-hoppou Fault, active fault, resistivity, Magnetotellurics

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Three dimensional resistivity structure around the focal region of the 2016 Kumamoto earthquakes

*Koki Aizawa[1], Hisashi Asaue[2], Katsuaki Koike[3], Shinichi Takakura[4], Toru Yoshinaga[10], Makoto Uyeshima[5], Takao Koyama[5], Ryokei Yoshimura[7], Ken'ichi Yamazaki[7], Shintaro Komatsu[7], Yusuke Yamashita[7], Hiroshi Ichihara[9], Mitsuru Utsugi[8], Kaori Tsukamoto[12], Dan Muramatsu[12], Yoshiko Teguri[1,11], Kazunari Uchida[1], Hideaki Hase[6], Azusa Shito[1], Satoshi Matsumoto[1], Takeshi Matsushima[1], Hiroshi Shimizu[1]

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In December 2018, we have conducted broad-band magnetotelluric (MT) observation around Hinagu fault and Uto Peninsula, which are close to the focal regions of the 2016 M_{JMA} 7.3 Kumamoto earthquakes. Since the resistivity structure of these regions are not well imaged by the previous 3-D inversion by using the 80 MT sites (Aizawa et al., 2017, Sgepss fall meeting), we acquired the new data by using the Metronix ADU-07 system and the telluric loggers (NT System Design ELOG1K). We will present new 3-D resistivity structure and argue its relationship to the hypocenters that are relocated by using the double difference method and 3-D seismic velocity structure (Shito et al., 2017, GRL).

Acknowledgment

We are greatly indebted to the land owners for their permission for field campaigns. The geomagnetic data used for the remote-reference processing were provided by the Kakioka Geomagnetic Observatory of JMA. This work is partly supported by MEXT KAKENHI Grant Number JP16H06298, the Ministry of Education, Culture, Sports, Science and Technology of Japan under its Earthquake and Volcano Hazards Observation and Research Program, and Earthquake Research Institute, The University of Tokyo under Joint Usage Program.

Keywords: resistivity structure, magnetotellurics, Kumamoto earthquake

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A research report on the fundamental investigations of an electrical resistivity structure beneath Chugoku and Shikoku regions, southwestern Japan(2018)

*Ichiro Shiozaki[1], Tomofumi Uto[1], Makoto Uyeshima[2], Hiroshi Hataoka[3], Yasuo Ikezoe[3], Shinji Yamamoto[3], Tatsuya Noguchi[1], Daiki Furuichi[4], Yuki Murayama[4], Kohei Matsushita[4], Hideki Murakami[5], Naoto Oshiman[6], Yoshihisa Iio[6], Kazuya Ando[7]

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In order to contribute to a reduction in damage caused by earthquakes and volcanic eruptions, heterogeneities of crustal and upper mantle structure should be clarified based on fundamental investigations of electrical resistivity structure in Chugoku and Shikoku regions, southwestern Japan arc.
Our research group has shown that there is a clear relationship between resistivity and seismicity in the San'in and Shikoku regions. In the eastern part of San'in region, it was found that a conductive area exists in the deep crust part under the seismic region, which is a resistive area, along with the seismic activity area stretching nearly in the east and west direction. Assuming that inland earthquakes occur because of local stress concentration caused by heterogeneity beneath a seismic activity band(Iio, 2009), it is necessary to improve spatial data and to clarify the heterogeneity in this area hereafter.
On the other hand, in the Shikoku district, it was suggested that the distinctive low resistivity region exists in the upper crust mainly from the survey results in the outer belt, and that there is a clear relation between the low resistivity and low seismicity in the central and the western area. In order to understand the earthquake phenomenon, it is important to clarify the generation environment and the principle as well as the activity style of the slow earthquake (Obara(2017)).
In this background, a Magnitude (M6.6) Earthquake in the Central Tottori Prefecture on October 21, 2016 occurred. In order to elucidate the heterogeneous structure of the lower crust beneath the seisimic region, we set up several survey lines across the central focal region of the Chubu region to carry out wideband MT observation at 12 sites in the observations gap area around this region.
By integrating the existing MT data, we tried model analysis using the program code of Ogawa and Uchida (1996) assuming that this region had a two-dimensional structure of EW strike direction harmonious with the seismic active band. According to the 2D model, we confirmed the southern limit of the low resistivity part existing in the deep crust of the focal region.
In the Chugoku and Shikoku district, we aimed to determine the 3D resistivity structure as a whole, and as in the 2017 research, 1D Occam inversion analysis based on determinant impedance was performed and integrated with existing MT data to estimate the preliminary spatial resistivity structure distribution. As a result, in San'in region, it is generally harmonious with the former studies, the low resistivity region in the deep crust continues to exist in the east-west direction with a certain scale.
In the Shikoku district, the resistivity in the mid crust shows the existence of a relative high/low resistivity boundary in the vicinity of the MTL is prominent, consistent with the existing research. Although there is a observation gap on the Seto Inland Sea side, continuity to the south of the low resistivity region of the San'in region is suggested with respect to the northern extension of the high resistivity crust. Moreover, when we look at the correspondence with the epicentral distribution of the crustal earthquake at this depth, there is clear correspondence with the high resistivity region in the north side of inner zone around

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the Median Tectonic Line. This relevance is common knowledge with that in the San'in region.
Acknowledgments : This study was supported by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan, under its Observation and Research Program for Prediction of Earthquakes and Volcanic Eruptions, and also supported by 2018 Tottori Prefecture Environmental academic research promotion promotion project. We would like to express sincere gratitude for the Nittetsu Mining Consultants Co. Ltd. kindly let us use their continuous geomagnetic records as remote references. We used joint research equipment of Kyoto University Disaster Prevention Research Institute for observation of this research.

Keywords: electrical resistivity, Chugoku and Shikoku regions, fundamental investigations

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Fluid distribution beneath central and southern Kyushu imaged by 3-D electrical resistivity model

*Maki Hata[1], Hiroshi Munekane[2], Hisashi Utada[1], Tsuneomi Kagiyama[3]

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The island of Kyushu is characterized by a high concentration of active Quaternary volcanoes along a volcanic front of N30˚E–S30˚W associated with the subduction of the Philippine Sea Plate. Some of the active volcanoes exist in southern Kyushu (the southern volcanic region), whereas no volcano exists in central Kyushu (the non-volcanic region). Most of volcanoes in the southern volcanic region exist in the Kagoshima Graben, whose formation was created with ejecting huge pyroclastic flows by the Quaternary volcanism. The Kirishima volcano group appears in Kakuto-Kobayashi caldera on the northern edge of the graben. Shinmoe-dake of the Kirishima volcano group experienced a magmatic eruption of the VEI 3 in 2011 and ash emissions in March 2018. Moreover, Iwo-yama of the Kirishima volcano group experienced hot material ejections in April 2018. Besides, Sakurajima volcano in the southern part of the graben has experienced 153–1,355 small eruptions per year for the last 10 years (the Japanese Meteorological Agency).
The Philippine Sea Plate, whose subduction involves the formation of the volcanic island of Kyushu, in and around Kyushu is classified into three portions: a younger portion, an older portion, and the other part of the Kyushu–Palau Ridge between the two portions. A non-volcanic region distributes in central Kyushu above a junction where the three portions of the subducting Philippine Sea Plate contact with each other. Owing to the subduction of the Philippine Sea Plate, moment magnitude 7-class thrust earthquakes have repeatedly occurred in the Hyuga-nada, lying offshore of the southeast Kyushu. In addition, recent studies using continuous global-navigation-satellite-system data have revealed that long-term slow slip events and short-term slow slip events occur in the Hyuga-nada. Besides, most of the earthquakes in the land area occur along three tectonic lines: Oita-Kumamoto tectonic line, Usuki-Yatsushiro tectonic line and Butsuzo tectonic line.
Fluid distribution in the mantle wedge is an essential factor for the seismic activity and magmatism leading to volcanic activity. Electromagnetic sounding data have high sensitivity to a few percent of interconnected fluids (aqueous fluid and melt). In this study, we generated a three-dimensional (3-D) electrical resistivity model by inverting magnetotelluric data, which covers the active southern volcanic region and the non-volcanic region, to examine the fluid distribution in the mantle wedge beneath Kyushu. We find three important conductive features in the 3-D model. A magma system and a fluid system imaged as two vertical conductors relating to slab-derived fluid, which exist along the volcanic front beneath the southern volcanic region and the non-volcanic region, respectively. The other conductor, relating to the presence of slab-derived fluid and serpentinite in the mantle wedge, appears at a blank area of the slow slip events.

Keywords: 3-D electrical resistivity model, Fluid distribution, magmatism, seismic activity, mantle wedge

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[J] Oral | S (Solid Earth Sciences)：S-GL Geology

Mon. May 27, 2019 9:00 AM - 10:30 AM JST | Mon. May 27, 2019 12:00 AM - 1:30 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-GL28] Regional geology and tectonics

convener:Makoto Otsubo(Geological Survey of Japan, Research Institute of Earthquake and Volcano Geology), Jun Hosoi(Geological Survey of Japan, Institute of Geology and Geoinformation, AIST), Chairperson:Makoto Otsubo(Research Institute of Earthquake and Volcano Geology, Geological Survey of Japan)

The main aim of this session is to discuss geologic structure and tectonic history of East Asia, especially of Japanese Islands, on the basis of the recent results of geology and other earth sciences.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SGL28-01] Lithology and zircon U-Pb geochronology of Paleoproterozoic and Paleozoic granitic complex in Maizuru Terrane from Tsuwano area, Shimane Prefecture, SW Japan

*Kosuke Kimura[1], Yasutaka Hayasaka[1], Tomoyuki Shibata[1], Kenta Kawaguchi[1], Hiroshi Fujiwara[1] (1.Hiroshima University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SGL28-02] Tectonic significance of new Zircon U-Pb ages of sedimentary complexes in the northern Hidaka Belt, central Hokkaido, northern Japan

*Futoshi Nanayama[1,5], Toru Yamasaki[1], Jun Tajika[2], Hideki Iwano[3], Tohru Danhara[3], Takafumi Hirata[4] (1.Geological Survey of Japan, AIST, 2.Docon Co. Ltd, 3.Kyoto Fission-Track Co.Ltd, 4.Tokyo Univ., 5.CWMD, Kumamoto Univ.)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SGL28-03] New age constraints and tectonic significance of Late Oligocene marine biosiliceous deposits in the Hidaka Belt, northeastern Hokkaido, northern Japan

*Futoshi Nanayama[1,6], Hiroshi Kurita[2], Toru Yamasaki[1], Jun Tajika[3], Hideki Iwano[4], Tohru Danhara[4], Takafumi Hirata[5] (1.Geological Survey of Japan, AIST, 2.Niigata Univ., 3.Docon Co. Ltd, 4.Kyoto Fission-Track Co. Ltd, 5.Tokyo Univ., 6.CWMD, Kumamoto Univ.)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SGL28-04] Late Cretaceous sea-level changes and tectonic history recorded in the forearc sedimentary successions of the Northeast Japan

*Jun Arimoto[1], Reishi Takashima[2], Hiroshi Nishi[2], Yuji Orihashi[3], Toshiro Yamanaka[4] (1.Department of Earth Science, Graduate School of Science, Tohoku University, 2.The Center for Academic Resources and Archives, Tohoku University, 3.Department of Earth and Environmental Sciences, Graduate School of Hirosaki University, 4.Tokyo University of Marine Science and Technology)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SGL28-05] Paleo-stress analysis in coherent zone, an exhumed Cretacesou accretionary complex, Shimanto Belt, in Konan city and Geisei villege, Kochi prefecture, SW Japan

*Makoto Hashiguchi[1], Yoshitaka Hashimoto[1] (1.Kochi University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SGL28-06] Relationship between accretion of limestone blocks and subduction tectonics in Japan

*Koji Wakita[1] (1.Yamaguchi University)

Lithology and zircon U-Pb geochronology of Paleoproterozoic and Paleozoic granitic complex in Maizuru Terrane from Tsuwano area, Shimane Prefecture, SW Japan

*Kosuke Kimura[1], Yasutaka Hayasaka[1], Tomoyuki Shibata[1], Kenta Kawaguchi[1], Hiroshi Fujiwara[1]

1. Hiroshima University

Maizuru Terrane is geographically distributed from Oshima Peninsula of Fukui Prefecture to western Shimane Prefecture, Southwest Japan. Maizuru Terrane is divided into three subzones, the Northern zone, Central zone, and Southern zone. Northern zone is mainly composed of granitic rocks and metamorphic rocks that derived from continental crust, and Siluro-Devonian granitoids have been reported from Maizuru-Oe area which is the type locality of the Maizuru Terrane (Fujii et al., 2008; Tsutsumi et al., 2014). Recently, Kimura et al. (2018) reported granitic complex from Tsuwano area, Shimane Prefecture. This complex contains not only Paleozoic granitoid that show same age of the Maizuru granite but also the late Paleoproterozoic granitoid and orthogneiss those are unreported so far from the basement rock distributed in Honshu island.

The granitic complex occurs in Tsuwano area is distributed discontinuously along with the northern margin of Maizuru Terrane, and about 2 km long. This complex occurs as lenticular blocks in a narrow zone of several hundred meters in width. This complex is mainly composed of granitic rocks and mafic rocks that intruded into granitic rocks, and suffered cataclasis in the major part. From the viewpoint of their age and lithology, this granitic complex could be divided into three groups, which are as follows:

1) early Paleoproterozoic metaquartzite: Quartz completely recrystallized and doesn’t show the dust rim. Grain boundary shows sutured texture. Detrital zircon grains show reddish brown color and rounded shape. Zircon U-Pb concordant ages are only older than 2.4 Ga, and the probability density curve shows two large peaks around 2.5 Ga and 2.7 Ga.

2) late Paleoproterozoic granitoids and orthogneiss: These rocks are most common in the granitic complex. These rocks show various lithology. Orthogneiss show banded structure and granoblastic texture. Zircon grains show reddish brown color and core-rim structure, and zircon U-Pb ages range 1.85-1.83 Ga. Furthermore, 2.8-2.05 Ga inherited ages are also yielded.

3) early Paleozoic rocks: These Paleozoic rocks are less in amount than Paleoproterozoic rocks in Tsuwano area. Paleozoic rocks are subdivided into plutonic rocks and volcaniclastic rocks. Plutonic rocks are leucocratic granodiorite and metagabbro. Their zircon U-Pb ages range from 423-411 Ma. On the other hand, volcaniclastic rock is felsic tuff that shows light brown to light greenish gray color, and this lithology varies from glassy to crystalline. Zircon U-Pb ages range from 424-413 Ma.

Metaquartzite have only older than 2.4 Ga concordant ages in spite of 1.85 Ga rocks are most common in this granitic complex. Therefore, the sedimentation age of metaquartzite is considered to be between 2.4

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to 1.85 Ga. On the other hand, detrital monazite and zircon ages reported from orthoquartzite pebble that occur in the conglomerate layer of Tetori and Muro groups show 1.8 Ga peak (Yokoyama et al., 2002; Hisada et al., 2010). Therefore, metaquartzite occur in Tsuwano area have a different origin that of these orthoquartzite pebbles.

Ages of 2.7, 2.5 and 1.8 Ga that measured from metaquartzite and late Paleoproterozoic rocks are consistent with similar rocks reported from North China Craton.

Zircon U-Pb ages of early Paleozoic rocks range from ca. 424-411 Ma. These ages and occurrence of this granitic complex are consistent with that of Northern zone from Maizuru-Oe area. Therefore, the granitic complex of Tsuwano area can be compared with Northern zone of Maizuru Terrane.

Reference: Fujii et al. (2008) Island Arc, 17, 322-341. Tsutsumi et al. (2014) JMPS, 101, 289-298. Kimura et al. (2018) 125th Annu. Meet. Geol. Soc. Japan, Abstr, R5-O-23. Yokoyama et al. (2002) Research Report of the Mesozoic Tetori Group in the Tedori River Area, Ishikawa Prefecture, 57-70. Hisada et al. (2010) JpGU Meeting 2010 Abstr., SGL046-03.

Keywords: Inner Zone of Southwest Japan, Tsuwano area, Northern zone of Maizuru Terrane, Paleoproterozoic granitoid, Zircon U-Pb age, North China Craton

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Tectonic significance of new Zircon U-Pb ages of sedimentary complexes in the northern Hidaka Belt, central Hokkaido, northern Japan

*Futoshi Nanayama[1,5], Toru Yamasaki[1], Jun Tajika[2], Hideki Iwano[3], Tohru Danhara[3], Takafumi Hirata[4]

1. Geological Survey of Japan, AIST, 2. Docon Co. Ltd, 3. Kyoto Fission-Track Co.Ltd, 4. Tokyo Univ., 5. CWMD, Kumamoto Univ.

The Hidaka belt in the central axis zone of Hokkaido has been one of the areas where geological research is most delayed in Japan, and their depositional ages and tectonic settings were not clear untill now. It has been considered as late Cretaceous accretionary complex like the Shimato belt in southwestern Japan. In this study, zircon particles are extracted from turbidite sandston beds of eastern Rurochi Formation, central Kamiokoppe Formation and western Iwaonai Flysch and zircon U-Pb ages were measured by LA-ICP-MS method. As a result, age values of 52.4 ±0.5 Ma from Rurochi Formation, 54.9 ±0.3 Ma from Kamiokoppe Formation and 47.3 ±0.5 Ma from Iwaonai Flysch were obtained respectively. Looking down the entire Hidaka belt including the age data of the southern part of the Hidaka belt reported by Nanayama et al. (2018), the following four points have been clarified.
(1) Clastic rocks (Hidaka Supergroup) distributed in the Hidaka belt are within the age of Paleocene ~ early Eocene.
(2) The Hidaka belt is distributed widely across the east-west width of more than 100 km. However, its internal structure and age differences are not clear, and it can not be explained by the accretionary growth model which becomes younger in the eastward.
(3) There is no significant age difference in the eruption age of the three bands of in situ basalts (N-MORB) recognized in the Hidaka belt (Miyashita et al., 1997), and if this is explained by the ridge subduction model, It can be explained only one event.
(4) The Hidaka Supergroup was a sedimentary body mainly composed of turbidite facies filled in the sea area between the Paleo-Japan arc and the Paleo-Kuril arc in Paleocene ~ early Eocene age. After 47 Ma, according to the joining of two arc-trench systems, significant deformation was occurred it. So, it is considered to be "collision complex".

This work was supported by JSPS KAKENHI Grant Number 16K05585.

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Keywords: Depositional age, Hidaka Belt, Hidaka Supergroup, LA-ICP-MS, zircon U-Pb age, collision complex

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New age constraints and tectonic significance of Late Oligocene marine biosiliceous deposits in the Hidaka Belt, northeastern Hokkaido, northern Japan

*Futoshi Nanayama[1,6], Hiroshi Kurita[2], Toru Yamasaki[1], Jun Tajika[3], Hideki Iwano[4], Tohru Danhara[4], Takafumi Hirata[5]

1. Geological Survey of Japan, AIST, 2. Niigata Univ., 3. Docon Co. Ltd, 4. Kyoto Fission-Track Co. Ltd, 5. Tokyo Univ., 6. CWMD, Kumamoto Univ.

The Tatsuushi Formation distributed in the Kitami-Monbetsu area consisted of siliceous mudstone, and has been incorporated into the Hidaka Supergroup along associated with the surrounding the Uenkotan and Rurochi Formations (Tajika and Iwata, 1994). In this study, the depositional age of the Tatsuushi Formation was examined by three methods. Detrital zircon grains are separated from turbidite sandstone and a U-Pb age of 27.2 ±0.1 Ma is obtained by the LA-ICP-MS method. Dinoflagellate cysts indicate late Oligocene and early Miocene, respectively. Therefore, the U-Pb age is shown as the depositional age of this formation. The depositional age of the Hidaka Supergroup has been reported Paleocene to Early Eocene so far. Therefore, it is difficult to include this formation in Hidaka Supergroup. The Tatsuushi Formation can be compared to the Erimo Formation in the soutjern Hidaka Belt (Kurita and Kusunoki, 1997) and the lower part of the Tsubetsu and Kawakami Groups based on their depositional ages and affinity of the lithology (Kurita et al., 1998) distributed along the Abashiri tectonic line as the right-lateral strike-slip fault since late Oligocene. These siliceous mudstones may have been formed by the upwelling flow caused by the bottom deepwater brought from the Sea of Okhotsk by the opening of the Kuril basin.

This work was supported by JSPS KAKENHI Grant Number 16K05585.

(References) Kurita and Kusunoki, 1997, Jour. Geol. Soc. Japan, 103, 1179-1182. Kurita et al., 1998, Research reports of JAPEX Research Center, no. 13, 11-31. Tajika and Iwata, 1994, Chikyu monthly, 16, 495-499.

Keywords: LA-ICP-MS U-Pb age, late Oligocene to early Miocene, Tatsuushi Formation, Hidaka Belt, Hidaka Supergroup, Dinoflagellate cysts

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Late Cretaceous sea-level changes and tectonic history recorded in the forearc sedimentary successions of the Northeast Japan

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1. Department of Earth Science, Graduate School of Science, Tohoku University, 2. The Center for Academic Resources and Archives, Tohoku University, 3. Department of Earth and Environmental Sciences, Graduate School of Hirosaki University, 4. Tokyo University of Marine Science and Technology

Elucidating tectonic history of the Cretaceous East Asian continental margin provides us essential information to understand the origin of modern Japanese islands and paleo-biogeography of terrestrial fauna and flora, with implications for connection with the Eurasia continent. One of the keys to reconstruct the geologic history of the NE Japan is the Upper Cretaceous to Paleogene siliciclastic sedimentary successions that filled a N-S trending large fore-arc basin (the Yezo forearc basin) along the Pacific margin. The Futaba, Kuji, and Yezo groups are known as representative strata among these successions, and have been well studied. Especially the Kuji and Futaba groups were accumulated in shallow-marine and non-marine environments, and their facies changes were reflected by relative sea-level changes attributed to global eustacy and regional tectonic uplift/subsidence. The previous studies for these two groups, however, have not fully made it clear that the observed depositional changes were derived from local tectonic effects or global eustatic sea-level changes due to lack of precise age controls. To address this issue, here we provide the latest age model of the Kuji Group and partly revised regional sequence stratigraphic correlation. Comparing our age-calibrated depositional sequences of the Kuji Group with an available global sea-level reconstruction would separates the influence of eustacy from that of regional tectonics which formed the Yezo forearc basin sedimentary successions.

The Kuji Group is distributed along the northeastern coastal area of the Iwate prefecture. The group mainly comprises sandy siltstone, coaly mudstone, sandstone and conglomerate, with intercalated coal and felsic tuff beds. The total thickness is over 700 m. It unconformably overlies the pre-Cretaceous accretionary complex and lower Cretaceous granitoids, and is unconformably overlain by the Paleogene siliciclastic succession. The Kuji Group is divided into three lithostratigraphic units: the Tamagawa (marine and non-marine), Kunitan (marine), and Sawayama (non-marine) formations, in ascending order. The overall succession consists of at least four largely upward-fining sequences. Previous studies on sedimentary facies analysis divided them into five depositional sequences derived from the third-order sea level change (DS1 to DS5) (Ref. 1).

The newly established age model, based on carbon isotope stratigraphy and U–Pb ages, indicates that the depositional sequences in the Kuji Group is correlated with the middle Turonian to middle Campanian stages. The DS2 to DS4 in the Kuji group are likely coeval with the depositional sequences of the adjacent Futaba Group (the Coniacian to Santonian stages) (Ref. 2). Relative sea-level changes recognized in the DS1 to DS4 are mostly consistent with the second- and third-order global eustatcy (Ref. 3). In contrast, the DS5, equivalent to the Sawayama Formation of the Kuji Group, represents lowstand systems tract (non-marine fluvial facies) with maximum thickness of 200 m. Similarly, development of shallower facies is implied in the Hakobuchi Formation (the Campanian stage; Ref. 4) of the Yezo Group, accumulated in the northern sub-basin. These coeval relative sea-level falls are apparently inconsistent with contemporaneous global transgressive trend, and thus are interpreted to reflect basin-wide uplift of the forearc region in the early Campanian. Here we provide a new constraint for the age of the major tectonic event occurred in the Late Cretaceous East Asian continental margin, possibly related to the change in

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subducting oceanic plate motion (e.g. Ref. 5).

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Keywords: Late Cretaceous, Northeast Japan, forearc basin, Kuji Group, Sequence stratigraphy, tectonics

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Paleo-stress analysis in coherent zone, an exhumed Cretacesou accretionary complex, Shimanto Belt, in Konan city and Geisei villege, Kochi prefecture, SW Japan

*Makoto Hashiguchi[1], Yoshitaka Hashimoto[1]

1. Kochi University

Stress state in a subduction zone can be exchanged between reverse-fault and normal-fault regimes with an earthquake cycle. A similar change in paleostresses has been also obtained in some exhumed accretionary complexes (e.g., Hashimoto et al., 2014). However, most of previous studies in exhumed accretionary complexes cover only mélange zones exposed to the coastline. Therefore, in this study, we examine the paleostress change in a coherent zone. In order to investigate a spatial relationship, we analyzed the paleostress in the coherent zone adjacent to a mélange zone.

The study area is in Konan City, Yasu Town and Geisei Village in Kochi Prefecture, Southwest Japan where the Cretaceous northern Shimanto Belt is cropped out. The geology of the study area is composed of the coherent and mélange zones in the northern and the southern sides, respectively. The coherent zone consists mainly of alternating layers of sandstone and mudstone. The strike and dip of bedding are about N 37 ˚E and 75 ˚S, respectively. The age of the coherent zone has been reported as Cenomanian–Campanian (100 Ma–72 Ma) from microfossils (Taira et al., 1988). As a result of the micro-fault analysis, six stress state (stress 1, 2, 3, 4, 5, and 6) were obtained. Four stresses (stress 1, 3, 5, and 6) could be reasonbale because many unique faults, which are micro-faults with misfit angle of less than 30 degree only in individual stress state, are found. Stress 2 and stress 4 are not treated as reasonable stress solutions because the number of the unique fault is small. Stress 1 and stress 3 are the reverse-fault stress regimes. Stress 5 is obscured for fault types. Stress 6 is a normal-fault stress regime.

In order to constrain stress magnitude, stress polygon was employed. Furthermore, a liner function between SHmax and Shmin can be obtained from the estimated paleo-stress, which can be drawn in the stress polygon. Sv is calculated from density and paleo-maximum depth (5.5 km from vitrinite reflectance). Stress magnitude would be constrained from the overlapping area between the stress polygon and the liner function. According to the results, the stress for the reverse fault regimes is larger than that for the normal fault stress regime. In addition, assuming that the reverse fault changed to a normal fault, the validity of the difference of shear stress (stress drop) was examined. The stress drop is estimated from the difference in the radius of Mohr circles ((SHmax - Shmin) / 2) between the normal fault and the reverse fault stress regimes. The stress drops between stress 1 (reverse fault) and stress 6 (normal fault) ranges, and stress 3 (reverse fault) and stress 6 (normal fault) range 1.8-14.0 MPa and 43 - 63 MPa, respectively. Susan L. et al. (2018) showd the distribution of stress drops from geophysical observations in trench type earthquakes rangeing approximately 0.01–100 MPa. The stress drops obtained from our results are consistent with the range of 0.01-100 MPa. Therefore, it is possible for our results to be related to earthquake cycles.

In conclusion, we would like to emphasize that the exchange of stress accompanying earthquake cycles occurs even in the coherent zone as the same as that observed in mélange zones based on the differences in stress magnitude between the reverse and normal fault stress regimes and the reasonable range of stress drop. The interpretation that the exchange of stress observed in the mélange zone and

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also in the coherent zone implies that the exchange in stress state could be recorded after the mélange zone were located adjacent to coherent zonet. In other words, it is suggested that the micro-faults we examined in this study were activated within an accretionary wedge at the critical stress states.

Keywords: Paleo-stress analysis, accretionary complex, Shimanto Belt

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Relationship between accretion of limestone blocks and subduction tectonics in Japan

*Koji Wakita[1]

1. Yamaguchi University

Detailed mechanism for accretion of limestone and basalt is not elucidated yet. Seamount collapse occurs in the tectonic erosion convergent margin such as the Japan trench, but the seamount accretion does not happen in accretionary convergent margin such as the Nankai trough. How are the limestone and basalt blocks preserved in accretionary complexes? The key to understand the reason of accretion of limestone and basalt is the tectono-stratigraphic position of limestone and basalt blocks. In the most of the Japanese accretionary complexes, limestone and basalt blocks occur in the youngest unit of each complex. The cessation of the development of the accretionary complex must be associated with the special tectonic setting, which caused less supply of detrital materials from the provenance area. Flat slab subduction is one of the candidates to cause the less igneous activities in the provenance area. The flat subduction may be caused by the subduction and accretion of buoyant body such as ocean plateau. This subduction and accretion of oceanic plateau caused the cessation of accretionary process, and may have allowed to preserve limestone and basalt block in the accretionary complexes in Japan.

Keywords: limestone, accretionary complex, oceanic plateau

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[J] Oral | S (Solid Earth Sciences)：S-GL Geology

Mon. May 27, 2019 10:45 AM - 12:15 PM JST | Mon. May 27, 2019 1:45 AM - 3:15 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-GL28] Regional geology and tectonics

convener:Makoto Otsubo(Geological Survey of Japan, Research Institute of Earthquake and Volcano Geology), Jun Hosoi(Geological Survey of Japan, Institute of Geology and Geoinformation, AIST), Chairperson:Jun Hosoi(Geological Survey of Japan)

The main aim of this session is to discuss geologic structure and tectonic history of East Asia, especially of Japanese Islands, on the basis of the recent results of geology and other earth sciences.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SGL28-07] Discovery of faulted basin margin from the middle Miocene Tottori Grope, Tottori Prefecture, Southwest Japan and its significance

*Yuta Maruyma[1] (1.Shimane Umiversity)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SGL28-08] Fault activity during Quaternary Period off the Shimane Peninsula based on the profiles acquired by the high-resolution seismic survey

*Masaaki Tanaka[1], Norihiro Matsuda[1], Masaru Nakamura[1], Yuichi Shimizu[1], Masanori Shimazaki[2], Kazuhito Hatakeyama[2] (1.The Chugoku Electric Power Co., Inc., 2.Sogo Geophysical Exploration Co., Ltd.)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SGL28-09] Paleomagnetic directions of early Miocene sediments in central Japan and tectonic implications

*Hiroyuki Hoshi[1], Takuro Matsuo[2] (1.Department of Earth Sciences, Aichi University of Education, 2.Aichi Prefectural Kariya High School)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SGL28-10] Revised Cenozoic chronostratigraphy and tectonics in the Yatsuo Area, Toyama Prefecture, central Japan

*Takeshi Nakajima[1], Hideki Iwano[2], Tohru Danhara[2], Tohru Yamashita[2], Yukio Yanagisawa[1], Yoshihiro Tanimura[3], Mahito Watanabe[1], Takayuki Sawaki[1], Satoshi Nakanishi[4], Hiroyuki Mitsuishi[4], Okiyuki Yamashina[4], Seiichi Imahori[5] (1.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2.Kyoto Fission-Track Co., Ltd., 3.National Museum of Nature and Science, 4.JX Nippon Oil & Gas Exploration Corporation, 5.JX Nippon Oil & Gas Exploration Technical Services Corporation)

11:45 AM - 12:15 PM JST | 2:45 AM - 3:15 AM UTC

Discussion

Discovery of faulted basin margin from the middle Miocene Tottori Grope, Tottori Prefecture, Southwest Japan and its significance

*Yuta Maruyma[1]

1. Shimane Umiversity

Some Miocene sedimentary basins in the San’in region extend N-S or NE-SW and, have been called the indentation of sedimentary basins. Several studies speculated that these basins were aulacogenes formed in association with the Japan Sea opening event, or extensional basins opened parallel to the rifting axis before the rotation of Southwest Japan. The little sedimentary geological and chronological studies for this type of sedimentary basins remain their evolution to have been still unknown. The precise reconstruction of evolution of these sedimentary basins leads to understanding of the deformation of Southwest Japan crust associated with the Japan Sea opening event and thus to know the concrete Japan Sea opening process. The geological information in the marginal part of such type of basin fills is indispensable in order to elucidate their evolution.

A sedimentary basin, extending almost N-S and called the Tottori Indentation, is spread in the eastern part of Tottori Prefecture, Southwest Japan. Because the sediments of this basin have not been suffered from extensive intrusion of the volcanic rocks in its southeastern part, unlike the other basin fills in the Shimane Prefecture, this is an ideal sediment succession as the target of the sedimentary basin analysis in order to know the evolution of this type of sedimentary basins. The present study conducted geological survey of the Tottori Group using a conventional sedimentary geological method (facies analysis) for reconstruction of the sedimentary environment of the southeastern part of the Tottori Group (Iwami Formation).
The Iwami Formation of the Tottori Group is made up from the Entsuji Conglomerate and Sandstone Member (EM) and Fuganji Mudstone Member (FM). The FM contains both freshwater and marine mudstones. New faults with large displacement on and near the boundary with the underlying rocks are discovered. One represents the boundary between the granitic rock and the EM sandstone with thin vertical veneer of the deformed Kawabara Volcanic Rock Member of the underlying Yazu Formation along the fault. The other is running within the EM sandstone. The presence of gravels of debris fall origin in the FM mudstone near the fault and the talus deposits together with the presence of the deformed Yazu Formation along the fault imply that the fault started to be activated after the Kawabara Member phase and may have been active during the Fuganji period to have formed the slope along the fault. As the result, the block to the west of the fault subsided to have formed a lacustrine basin. Another faults are also expected along the boundary between the basement rock or the Yazu Formation and the Iwami Formation based on the presence of small slump structures indicating a slope that dipped away from the boundary in the southeastern part of the group. Additional study is necessary in order to elucidate the basin type (e.g. strike slip basin or half graben) and to determine the specific timing of basin generation. The present study is financially supported by the Grant-in-aid for scientific research from the San’in Kaigan UNESCO Global Geopark Promotion Council.

Keywords: Tottori Group, Middle Miocene, Sedimentary basin, Japan Sea opening event

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Fault activity during Quaternary Period off the Shimane Peninsula based on the profiles acquired by the high-resolution seismic survey

*Masaaki Tanaka[1], Norihiro Matsuda[1], Masaru Nakamura[1], Yuichi Shimizu[1], Masanori Shimazaki[2], Kazuhito Hatakeyama[2]

1. The Chugoku Electric Power Co., Inc., 2. Sogo Geophysical Exploration Co., Ltd.

A number of faults are shown off the Shimane Peninsula by Tamaki *et al.* (1982), Japan Coast Guard (1991, 1992), Tokuyama *et al.* (2001) and others. The Chugoku Electric Power Co., Inc. (Energia) carried out seismic reflection survey by using mainly Sparker in 1981 in the area including some faults described by the above-mentioned authors. The investigated area was about 60 kilometers long along the shoreline and about 30 kilometers long perpendicular to the shoreline. Seismic survey lines were deployed at the interval of about 1 to 4 kilometers in it. Since then, Energia has continually been investigating to grasp more detailed locations and characteristics of the faults in the area by using the latest technology such as multi-channel seismic system and so on. Furthermore, Energia has referred to the concepts of sequence stratigraphy in its interpretation to improve the reliability of the evaluation for fault activity. Government organization MLIT, Cabinet Office and MEXT referred to the Energia's fault evaluation in their document published in 2014.

Structures found off the Shimane Peninsula mostly extend ENE-WSW, forming reverse faults and flexures. Ito and Arato (1999) and others indicate that the stress field off the San-in district was north-south compression during Late Miocene epoch and has been east-west compression since Pliocene epoch, and many folds and reverse faults extending ENE-WSW in this region were developed during Miocene epoch. Therefore, most faults off the Shimane Peninsula are considered to develop around Late Miocene epoch under the north-south compression stress field and end their activity by Latest Miocene epoch. However, Middle to Upper Pliocene (Unit-B) off the Shimane Peninsula is distributed in a narrow area, and it is also extremely thin. These factors have made the evaluation for fault activity during Quaternary period difficult.

On the basis of the above information, we conducted seismic survey in 2014 by using various sound sources off the Shimane Peninsula to grasp the detailed geological structure from shallow to deep. We also conducted bottom sampling for dating on the seismic line at about 7 kilometers off the coast of Kashima town in Matsue city. The samples collected in Unit-A were analyzed by tephrochronology and radiocarbon dating. As a result, we found the Sanbe-Unnan (SUn : about 50ka. Machida and Arai, 2011) tephra and a few samples dated as Late Pleistocene. This shows that most Unit-A is possibly Upper Pleistocene except its surface portion. We confirm that the conventional sparker profiles cannot distinguish Unit-A in more detail, but the high-resolution profiles acquired by multi-channel boomer system can distinguish it into more units : Middle to Upper Pleistocene and Holocene.
From the above, we confirm that faults existing within the area where Middle to Upper Pleistocene, have been inactive at least since Late Pleistocene epoch. Pleistocene possibly exist much more widely compared to the previous interpretation off the Shimane Peninsula. Additional multi-channel high-resolution boomer seismic survey may contribute to reveal the detailed fault activity under the east-west compressive stress field in Quaternary period.

Keywords: offshore area of the Shimane Peninsula, seismic profile, bottom sampling, tectonic evolution, Quaternary period, fault

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Paleomagnetic directions of early Miocene sediments in central Japan and tectonic implications

*Hiroyuki Hoshi[1], Takuro Matsuo[2]

1. Department of Earth Sciences, Aichi University of Education, 2. Aichi Prefectural Kariya High School

We present new paleomagnetic data obtained from early Miocene (~18-17 Ma) sediments in three areas (Iwamura, Tengudana and Niinotoge) in central Japan. Oriented cores consisting mainly of mudstones and intercalated fine felsic tuffs were collected at more than 50 sites. Stepwise thermal demagnetization of both natural and isothermal remanent magnetizations suggests magnetite as a main magnetic carrier, with possible presence of greigite in rock samples from some sites. Site-mean directions of characteristic remanent magnetization components are all reverse polarity, suggesting deposition within the same reverse polarity chron, probably Chron C5Dr. Declinations of the site-mean directions are mostly southwesterly and deflected clockwise from the expected direction, indicating clockwise rotation after deposition. These declinations are similar to those from early Miocene and older rocks of the main part of the SW Japan arc, while they are significantly different from the undeflected paleomagnetic direction from Tomikusa, located 10-20 km northeast of Niinotoge. Thus, the Iwamura, Tengudana and Niinotoge areas are located on the main part of the SW Japan arc. It is suggested that the main part of the SW Japan arc has its eastern "rotational" boundary with a differentially rotated piece of crust between Niinotoge and Tomikusa.

Keywords: central Japan, early Miocene, paleomagnetism, rock magnetism, tectonic rotation

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Revised Cenozoic chronostratigraphy and tectonics in the Yatsuo Area, Toyama Prefecture, central Japan

*Takeshi Nakajima[1], Hideki Iwano[2], Tohru Danhara[2], Tohru Yamashita[2], Yukio Yanagisawa[1], Yoshihiro Tanimura[3], Mahito Watanabe[1], Takayuki Sawaki[1], Satoshi Nakanishi[4], Hiroyuki Mitsuishi[4], Okiyuki Yamashina[4], Seiichi Imahori[5]

1. Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2. Kyoto Fission-Track Co., Ltd., 3. National Museum of Nature and Science, 4. JX Nippon Oil & Gas Exploration Corporation, 5. JX Nippon Oil & Gas Exploration Technical Services Corporation

Cenozoic chronostratigraphy of the Yatsuo Area in Toyama Prefecture is revised based on U-Pb and fission-track (FT) dating on the same zircon grains from tuff beds using LA-ICP-MS, mineralogical analysis of tuff beds and diatom biostratigraphy. The results reveal followings. Syn-rift volcanism (the Iwaine Formation) started at around 17.5 Ma. The Ikahama unconformity between the syn-rift Higashibessho Formation and the post-rift Tenguyama Formation was a relatively short duration (c. 0.5 m.y.) tectonic event around 15 Ma. The Otogawa Formation unconformably overlying the Tenguyama Formation is divided into Middle Miocene (Serravallian) lower portion and Late Miocene upper portion with a possible unconformity between them. The age of the Mita Formation ranges from 4 to 2 Ma and unconformably overlies the Otogawa Formation. Local correlation of a key tuff bed MT2 in the Mita Formation in previous reports was misleading and needs to be reassessed.

Facies and sequence stratigraphic analysis of the lowermost Nirehara Formation clarifies that the Nirehara Formation comprises many depositional cycles formed by sea level or lake level fluctuation in a coastal or lacustrine fan delta environment. The results also suggest that the Nirehara Formation was formed in an early rift basin, which is overlain by the syn-rift Yatsuo Group with an unconformity. Detrital zircon U-Pb and FT dating of sandstone in the Nirehara Formation suggests that possible source of sandstone was the Nohi Rhyolite.

Regional correlation of onshore and offshore Cenozoic chronostratigraphy in the Hokuriku district shows multistage rifting during Oligocene-Middle Miocene opening of the Sea of Japan. The regional correlation also suggests that post-rifting compressive tectonics was also incremental associated with fluctuation of strength and direction of compressive stress fields.

Keywords: Cenozoic, chronostratigraphy, U-Pb dating, Fission-Track dating, diatom, tectonics

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[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

Mon. May 27, 2019 1:45 PM - 3:15 PM JST | Mon. May 27, 2019 4:45 AM - 6:15 AM UTC | 105 1F

[S-VC35] Mitigation of volcanic disasters - basic and applied researches

convener:Shinji Takarada(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Mitsuhiro Yoshimoto(Mount Fuji Research Institute, Yamanashi Prefectural Government), Yasuhiro Ishimine(Research and Education Center for Natural Hazards, Kagoshima University), Tomohiro Kubo(National Research Institute for Earth Science and Disaster Prevention), Chairperson:Tomohiro Kubo(防災科学技術研究所), Shinji Takarada(Geological Survey of Japan/AIST)

Volcanic disasters are caused by wide range of volcanic phenomena including ash fall, pyroclastic flow, debris avalanche, lahar, and lava flow. To mitigate volcanic disasters, wide range of technologies including simulation, data processing on GIS, and communication techniques are required. Researches on volcanic hazards mapping, eruption scenarios, and probabilistic eruption assessments are getting important. This session invites presentations and broad reviews related to these topics. Contributions on database technology, case studies of social and school educations, and specific examples of eruption crisis events are also encouraged.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SVC35-01] A working hypothesis for source craters and sequence of the 1707 Hoei eruption of Fuji Volcano, Japan

*Masato Koyama[1] (1.Shizuoka Univ.)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SVC35-02] Consideration of the formation process of Mt.Hoei, Fuji volcano

*Akira Baba[1], Toshitsugu Fujii[1], Tatsuro Chiba[2], Mitsuhiro Yoshimoto[1], Fumikatsu NISHIZAWA[1], Hidetoshi Shibuya[3] (1.Mount Fuji Research Institute, 2.Asia Air Survey Co., Ltd., 3.Department of Earth and Environmental Sciences, Faculty of Advanced Science and Technology, Kumamoto University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SVC35-03] Airborne LiDAR Bathymetry reveals underwater topography of Lake Motosu - The level of water raised by lava inflow -

*Tatsuro Chiba[1], Sin-ichi kaneta[1], Makoto Ohashi[1] (1.Asia Air Survey Co., Ltd.)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SVC35-04] Volcano monitoring using satellite thermal infrared imagery of CIRC (Compact Infrared Camera)

*Yuki Takakura[1], Koji Nakau[1], Junichiro Ishizawa[1] (1.Japan Aerospace Exploration Agency)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SVC35-05] Impact absorption properties of wooden buildings roof subjected to ballistic block collision

*Kohei Tateyama[1], Hiroyuki Yamada[2], Mitsuhiro Yoshimoto[3], Ryo Honda[3], Toshitsugu Fujii[3] (1.Ritsumeikan University, 2.National defense academy, 3.Mount Fuji Research Institute, Yamanashi Prefectural Government)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SVC35-06] Distribution of ballistic ejecta of the phreatic eruption at Kusatsu-Shirane volcano, on 23 Jan, 2018, part 2

*Mitsuhiro Yoshimoto[1], Ryuta FURUKAWA[2,3], Yoshihiro Ishizuka[2], Yusuke Minami[2], Masashi NAGAI[4], Shuichi Hosokawa[3], Ryo Honda[1], Taisuke Yasuda[1], Akihiko Terada[5], Tatsuji Nishizawa[5], Yasuhiro Ishimine[6], Kenichi Arai[7], Hisashi Sasaki[7], Shino Naruke[7], Yuko Sekiguchi[3], Takahiro Yanada[3], Yasuo Ishizaki[8], Nobuko Kametani[8], Fukashi Maeno[9] (1.Mount Fuji Research Institute, Yamanashi Prefectural Government, 2.Geological Survey of Japan, National Institute of Advanced Industrial Science and

Technology, 3.Japan Meteorological Agency, 4.Volcano Research Department, National Research Institute for Earth Science and Disaster Resilience, 5.Volcanic Fluid Research Center, Tokyo Institute of Technology, 6.Research and Education Center for Natural Hazards, Kagoshima University, 7.Asia Air Survey Co., Ltd., 8. Graduate School of Science and Engineering, University of Toyama, 9.Earthquake Research Institute, University of Tokyo)

A working hypothesis for source craters and sequence of the 1707 Hoei eruption of Fuji Volcano, Japan

*Masato Koyama[1]

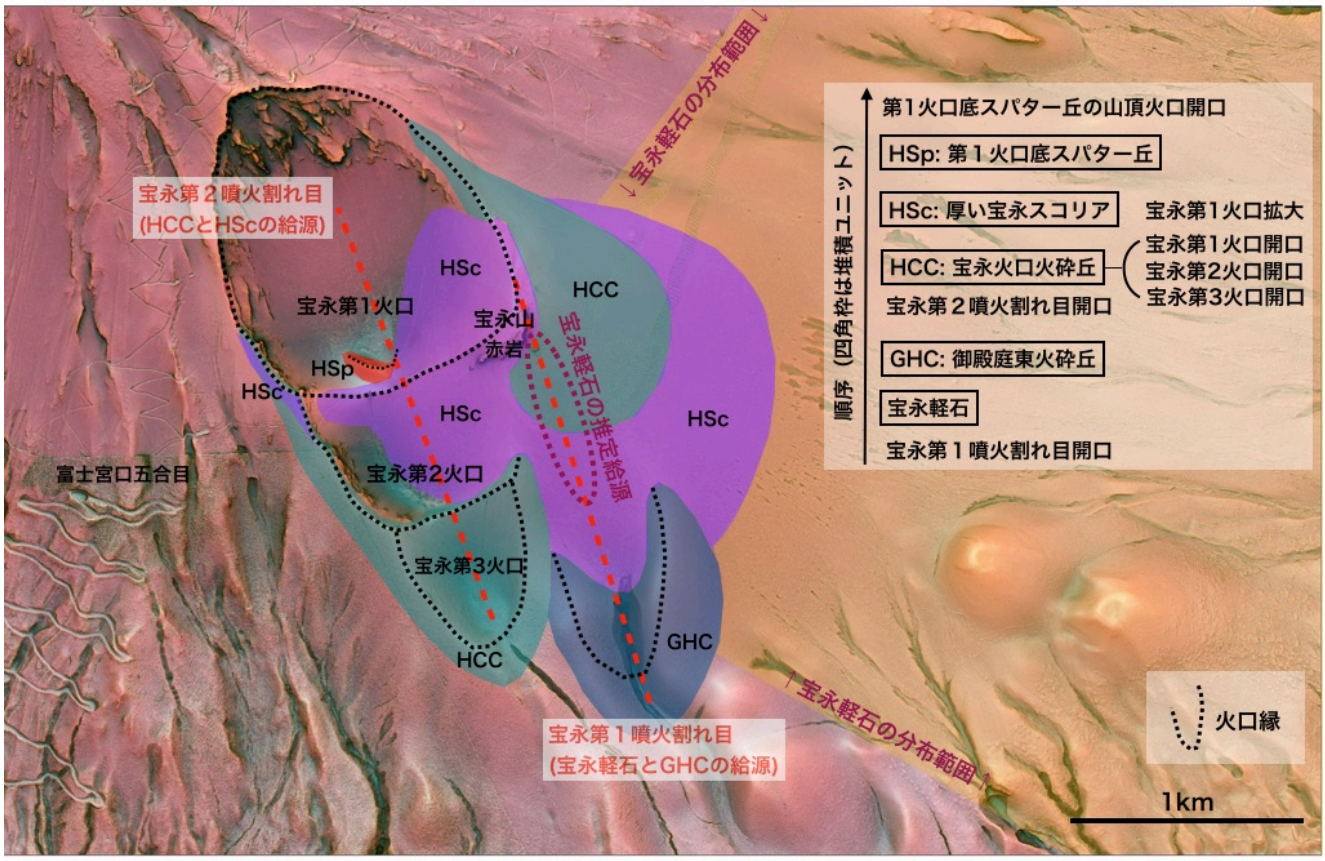
1. Shizuoka Univ.

The 1707 Hoei eruption, one of the most voluminous and violent eruptions of Fuji Volcano, has been considered to have occurred from the NW-SE trending three craters (Hoei craters) on the southeastern flank of the volcano and to have made the bulge (Hoei mound) at the edge of the craters. The Akaiwa rock, located near the summit of the Hoei mound, has been thought to be an outcrop of older strata, which have unconformable relationship with overlying deposits.
On the basis of careful geomorphological and geological survey including SfM(Structure from Motion) technology with UAV photos, the strata exposed on the Akaiwa rock are revealed to be part of the proximal deposits of the Hoei eruption. Moreover, another NW-SE eruptive fissure is estimated to have opened between the Hoei mound and the Gotenniwa Higashi pyroclastic cone in the initial stage of the Hoei eruption and to have been buried by the subsequent eruptive deposits from the Hoei craters. The hypothesis of this fissure can resolve the problem thatlocation of a source crater of the basal pumice layer of the distal Hoei pyroclastic deposits is still unclear.

Keywords: Fuji Volcano, 1707 Hoei eruption, source craters, Hoei mound, eruption sequence, working hypothesis

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宝永火口周辺の地形・地質の新たな解釈（作業仮説）



背景図：国交省富士砂防事務所・(株)アジア航測

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Consideration of the formation process of Mt.Hoei, Fuji volcano

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1. Mount Fuji Research Institute, 2. Asia Air Survey Co., Ltd., 3. Department of Earth and Environmental Sciences, Faculty of Advanced Science and Technology, Kumamoto University

It is important to review the sequence of each eruption in the past in order to mitigate volcanic hazard in the future. Especially the Hoei eruption is regarded to be important because it represents large scale explosive eruption that is rare in the eruptive history of Fuji volcano, but may cause extensive disaster in the metropolitan area. Mt.Hoei has been considered to be protuberance formed during the Hoei eruption and to be composed of Old Fuji formation (Tsuya, 1955). The protuberance has been considered as a kind of bulge accompanied by lateral intrusion of degassed magma (Miyaji et al., 2011). Koyama (2018) suggested the bulge by intrusion of magma could cause sector collapse and the evacuation plan for such sector collapse should be made. In this presentation, we will discuss the genesis and the formation process of Mt.Hoei based on new data obtained from geological survey, geochemical analysis and palaeomagnetic measurements of the constituents of Mt. Hoei and the ultraproximal deposits of Hoei eruption.

Mt.Hoei located at the northeast of Hoei craters, consists of pyroclastic rocks including mainly dense blackish-grey scoriaceous lapilli, spatters, volcanic bombs capturing gabbro and gabbroic fragments. From these observations, microscopy, whole rock chemical composition analysis, palaeomagnetic measurements and XRD analysis results, Mt.Hoei (Akaiwa) is presumed that ultraproximal fall and surge deposits by phreatomagmatic eruptions, compared with Ho-Ⅲ(Stage 2) of Miyaji et al.,(2011) from petrography and chemical composition. In addition, 2nd and 3rd crater ridge, the wall of the erosion valley of Gotenniwa consists of fallout deposits of Hoei eruption, corresponding to Ho-Ⅰ to Ⅲ(Stage 1) of Miyaji et al.,(2011). Although the white and banded pumice layer cannot be confirmed at the base of the erosion valley of Gotenniwa at the present moment, the deposits show a gradual compositional change from andesite to the basalt (SiO_2 = 62.8 to 52.2 wt%) upward. The paleomagnetic directions obtained from the spatter cone in the 1st crater of Hoei, the deposit around the summit of Mt.Hoei and the fallout deposit at erosion valley of Gotenniwa coincides with 1707 A.D.of the paleomagnetic secular variation curve (JRFM 2K.1).

We estimated the formation process of Mt.Hoei based on these new findings, isopach maps of Hoei eruption(Miyaji et al., 2011), the model of magmatic development of Hoei eruption (Fujii, 2007 ; Yasuda et al.,2015), and historical records and drawings (Koyama, 2009). Mt.Hoei is not a bulge caused by the magmatic intrusion, but a pyroclastic cone of Hoei eruption formed in only 9 days.

1. The basaltic magmas contacted and mixed with the dacitic magma, white-banded pumice squirted from the vicinity of the 1st crater and was swept in the east direction by the westerlies (December 16th around 10 to 17 o'clock, Unit A, B of Miyaji et al.,(2011)).
2. As the crater expanded, the side of the mountain of the first crater was also scraped off, and abundant accessory materials were ejected in the east-south direction together with the essentials, and deposited near crater to form Mt.Hoei (December 17th before daylight, Unit C ~ F of Miyaji et al, (2011)).
3. The vent transitioned to the 2nd crater due to the landslide at the 1st crater edge or expansion of the vent. (December 17 to 19 th, Unit G ~ I of Miyaji et al, (2011))
4. The vent transitioned to the 1st crater due to the accessory materials of landslide were gradually ejected, Mt.Hoei (Akaiwa) was formed by intermittent phreatomagmatic eruptions (December 19-25 th, Unit J ~ M of Miyaji et al, (2011)).

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5. As crater is restricted to the 1st crater, inflow of accessory materials stopped and Plinian eruption of basaltic magma continued for 6 days and ended (December 25 - 30 th, Unit N ~ Q of Miyaji et al, (2011)).

Keywords: Fuji volcano, Mt.Hoei, formation process, hazard map

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Airborne LiDAR Bathymetry reveals underwater topography of Lake Motosu
- The level of water raised by lava inflow -

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1. Asia Air Survey Co., Ltd.

1. Introduction

Lake Motosu is a dammed lake located northwest of Mt. Fuji, the elevation of the lake is about 900m. Aokigahara lava flow, which is occurred by the eruption of 864 AD, flood into the lake, and the northeast lake shoreline is seen like cut off by the truncated arc. Though regarding the characteristics of this lava flow, there is a study by Obata and Unno (1999), no survey of the shallow part of the lake had been conducted. Generally, the level of lake water is the possibility of rising up by the entry of a large amount of debris or lava flows. Of course, it is not a kind of transient phenomenon like Tsunami, but the possibility to rise permanently because of the bottom of the lake getting shallow. Airborne LiDAR Bathymetry measurement was carried out in order to investigate whether the level of water of Motosu Lake changes during Aokigahara lave flow entry, and the results are as bellows.

2. Airborne LiDAR Bathymetry

Airborne LiDAR Bathymetry, as follows ALB, is a measurement method aiming to measure depth and topography of shallow water along river and coast. The equipment used in this research consists of two pair of laser ranging systems for ground measurement using NIR laser and underwater measurement using visible range (532nm). The measurable depth depends upon the transparency of the object greatly. It was expected to be measurable up to 15m depth since Lake Motosu has high transparency throughout the year and is visible around 14-16m depth. The measurement carried out on 9th September 2017. Since the area terrain is heavily rough, Helicopter, which is easy to control flight height, is used and flew 11 courses.

3. Bathymetry

For ALB measurement, the position of the aircraft is determined by kinematic GNSS survey based upon GNSS-based Control Station, objective terrain of the ground and the seafloor are measured by both the data of the initial navigation device and the two channels of laser ranging device. The density of point-clouds was 10 to 100 points/m^2 on land and 1 to 5 points/m^2 on water. The maximum water depth was measured to be 11-15m. Based on pon point-clouds data, the topography of the lake bottom is totally different between the northern and southern measurement range. On the northern side, unique irregularities of Aokigahara lava can be seen from land to underwater. There is no change between the border of the surface of the lake and reach to around 15m continuously. On the other side, the topography of the southern side of the lacustrine terrace, there can be seen slightly higher hill than the seafloor closer to the lakeshore. Not less than two stages of rectangular flat surface can be seen on the northern slope of the hill.

4. Conclusion

On the northern side of the measurement range, there found lava topography divergent like branch coral and split on the center part, and there found red oxidized portion, so it is clear that the lava landscape was deposited on land (Obata and Unno, 1999). Continuously tracking terrain similar to this topography

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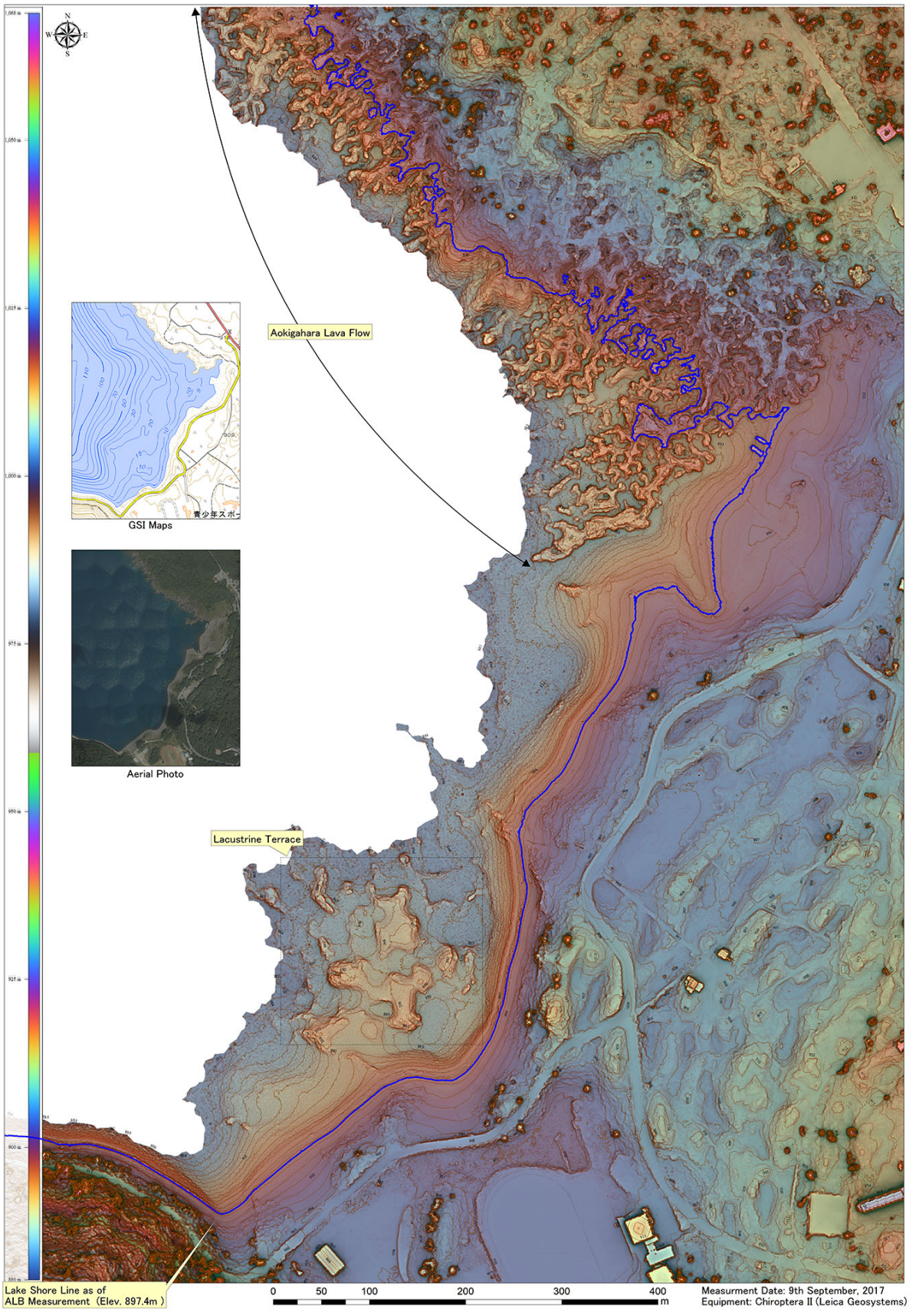
to 15m water depth suggests that the level of water at the time of lava flow was at least 15m lower than the current one. Underwater archeology surveys are also conducted around the southern lacustrine terrace (Kamikuissiki Village Board of Education, 1999). Relics including turtle type earthenware have been ensured so far, most of relics were identified as the age of the beginning of the early stage of Kofun Period. Many of them are completed and it seems to have been submerged since there is no inconsistency that the time is the invasion time of Aokigahara lava flow in the Heian era. It is to be wished that the detailed investigation confirms the red oxidized portion of the underwater lava topography and the research of the possibility of flat surface to be the construction of the submerged village in the future.

Reference

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Keywords: LiDAR, lava flow, bathymnetry, water level change

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Volcano monitoring using satellite thermal infrared imagery of CIRC (Compact Infrared Camera)

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1. Japan Aerospace Exploration Agency

Although volcanic activities are monitored by various approaches, it is difficult to observe some volcanoes in Japan using ground equipment (e.g. remote islands or submarine volcanos). In such case, satellite imagery is one of the powerful tools to monitor them. Satellite can observe extensive area simultaneously, including many volcanos. Thus, we can capture geothermal activities; lava flow, pyroclastic flow or heat of crater even at night.

To prevent or to mitigate volcanic disaster, the disaster management agencies needs ready-to-use dataset; information extracted from satellite imagery. Therefore, we developed “Volcano Monitoring System” (released in Sep 2018; https://kazan.jaxa.jp/); which system provides such information and visualized satellite infrared imagery of CIRC and other satellites. CIRC is uncooled microbolometer thermal infrared sensor for the earth observation and it is on board ALOS-2 satellite (Advanced Land Observing Satellite 2). On the Volcano Monitoring System, we can browse satellite RGB or infrared imagery as a map and get the variation of volcanic activity’s indices automatically extracted from satellite imagery. To produce concrete indices for volcano monitoring, we are studying several approaches of satellite infrared data processing in cooperation with the disaster management agencies. In such study, we are focusing on 12 volcanoes which are defined among us. In this presentation, we introduce “Volcano Monitoring System” and some volcanic events captured by CIRC.

Keywords: Satellite, Infrared, Volcanic disasters

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Impact absorption properties of wooden buildings roof subjected to ballistic block collision

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Volcanic disasters include various factors such as eruption, lava flow, pyroclastic flow, debris avalanche, debris flow and so on. Especially, at the phreatic eruption of Mt. Ontake in September 27, 2014, most of the damages were caused by clashes of ballistic block. In order to prevent these damages, it is suggested that evacuation to a mountain hut is effective. Thus, evaluation of impact absorption properties for wooden buildings (e.g. mountain hut) against ballistic block collision is necessary. Previously, we reported the protective abilities of as-built wooden buildings, which were reinforced with high performance fabric using aramid fiber. In addition, the penetration boundary energy for a 15 mm thick wooden building roof was reported. However, the impact absorption properties of various type wooden buildings has not been clarified enough. Therefore, in this study, impact absorption properties of wooden buildings roof subjected to ballistic block collision was experimentally investigated.

A collision test was carried out at the velocity of 10 to 90 m/s using a large scale launching system. In this system, a projectile was accelerated by compressed air and then collided with the target. The projectile velocity was measured using two lasers and light receiving parts. In many cases, size of the ballistic block is almost the fist size (ϕ100 mm) under phreatic eruption. Therefore, Vitrified whetstone similar to the common ballistic block (density: 2400 kg/m^3) was used as the projectile, and the diameter was determined ϕ90 mm (mass: 2.66 kg). For the target, typical wooden roof structure (e.g. cedar boards, waterproof sheet, galvalume steel plate and cedar rafter) was used. Two types of thickness of cedar board (15 mm and 18 mm) were prepared. The thickness of the waterproof sheet and galvalume steel plate were 1.0 mm and 0.4 mm, respectively. The dimensions of the specimen were 600 mm ×600 mm. The components were fixed with nails and its spacing was approximately 150 mm. In addition, specimens in which two cedar plates were superimposed was also prepared. There are two kinds of superimposing methods: a ” staggered structure “ that is alternately superimposed on one another, and a "cross structure" in which plates are orthogonalized.

Collision test results revealed penetration boundary energies of 15 mm and 18 mm specimens, respectively. In previous study, it was shown the maximum collision energy of volcanic ballistic block (ϕ 2-64 mm) was 1700 J (in the case of ϕ64mm, 100 m/s), and average collision energy was less than approximately 1200J in many cases. From the result, it was revealed that the roof of cedar board having a thickness of 15 mm and 18 mm could prevent penetration of volcanic ballistic block. In addition, it was found that by superimposing the cedar boards, impact absorption properties can be improved simply. At the time of superimposition, the impact absorption properties was hardly improved in the ” staggered structure”. However, in the "cross structure", it was confirmed that the impact absorption properties were greatly improved. From this it was found that the "cross structure" is better when reinforcing by simple superimposition.

Keywords: ballistic block collision, Impact absorption, wooden buildings roof

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Distribution of ballistic ejecta of the phreatic eruption at Kusatsu-Shirane volcano, on 23 Jan, 2018, part 2

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1. Mount Fuji Research Institute, Yamanashi Prefectural Government, 2. Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 3. Japan Meteorological Agency, 4. Volcano Research Department, National Research Institute for Earth Science and Disaster Resilience, 5. Volcanic Fluid Research Center, Tokyo Institute of Technology, 6. Research and Education Center for Natural Hazards, Kagoshima University, 7. Asia Air Survey Co., Ltd., 8. Graduate School of Science and Engineering, University of Toyama, 9. Earthquake Research Institute, University of Tokyo

Moto-Shirane volcano, which is part of Kusatsu-Shirane volcano, erupted on 23 January 2018 after 1500 years dormancy. One parson died and 11 other people were injured by the ballistic ejecta of this phreatic eruption. We report the results of a survey on the distribution of ballistic rocks around the crater and climbing trails and ski courses on May 10 - 12, 2018 and October 23 - 25, 2018.The maximum size of the ballistic rocks was measured at a total of 191 sites and the number density of the rocks (>64mm) was measured at a total of 64 sites. Ballistic rocks of the eruption are distributed within 500 meters around the main crater and is mainly distributed from north to northeast. The maximum size of ballistic rock was 4.8 m which fell to the western crater rim, and near the main crater was 3.4 m. The flight-distance of ballistic rocks with a major axis of about 20 cm, 50 cm, 100 cm, 200 cm are 400 to 650 m, 400 m, 350 m, 150 m, respectively. It suggests that the initial velocity of ballistic rocks of each size is different.

Keywords: ballistic ejecta, Kusatsu-Shirane volcano, phreatic eruption

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[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

Mon. May 27, 2019 3:30 PM - 5:00 PM JST | Mon. May 27, 2019 6:30 AM - 8:00 AM UTC | 105 1F

[S-VC35] Mitigation of volcanic disasters - basic and applied researches

convener:Shinji Takarada(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Mitsuhiro Yoshimoto(Mount Fuji Research Institute, Yamanashi Prefectural Government), Yasuhiro Ishimine(Research and Education Center for Natural Hazards, Kagoshima University), Tomohiro Kubo(National Research Institute for Earth Science and Disaster Prevention), Chairperson:Mitsuhiro Yoshimoto(山梨県富士山科学研究所), Yasuhiro Ishimine(鹿児島大学地域防災教育研究センター)

Volcanic disasters are caused by wide range of volcanic phenomena including ash fall, pyroclastic flow, debris avalanche, lahar, and lava flow. To mitigate volcanic disasters, wide range of technologies including simulation, data processing on GIS, and communication techniques are required. Researches on volcanic hazards mapping, eruption scenarios, and probabilistic eruption assessments are getting important. This session invites presentations and broad reviews related to these topics. Contributions on database technology, case studies of social and school educations, and specific examples of eruption crisis events are also encouraged.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SVC35-07] Developing Ash-fall impact forecasting content.

*Tomohiro Kubo[1], Yosuke Miyagi[1], Setsuya Nakada[1], Eisuke Fujita[1], Masamitsu Miyamura[1] (1.National Research Institute for Earth Science and Disaster Prevention)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SVC35-08] New Websites and a Pamphlet of IVHHN

*Yasuhiro Ishimine[1] (1.Research and Education Center for Natural Hazards, Kagoshima University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SVC35-09] State of river water pollution derived from the recent volcanic activity of Mt Iwo-Yama, Kirishima volcanoes

*Yoshikazu Kikawada[1], Haruka Yamamoto[2], Wei Deng, Megumi Fukai (1.Faculty of Science and Technology, Sophia University, 2.Graduate School of Science and Technology, Sophia University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SVC35-10] Development of information tools for evacuation and rescue in the event of volcanic disaster

*Yosuke Miyagi[1], Setsuya Nakada[1], Tomohiro Kubo[1], Mitsuhiro Yoshimoto[2], Ryo Honda[2] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Mount Fuji Research Institute, Yamanashi Prefectural Government)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SVC35-11] **Ignimbrite, tephra-fall, caldera and fatalities of major volcanoes in the East and Southeast Asia**

*Shinji Takarada[1], Joel Calupas Bandibas[1] (1.Geological Survey of Japan, AIST)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SVC35-12] On the climber’s attitudes to the Volcanic mitigation for active volcanoes.

*Hideyuki Itoh[1], Chizuru Totani[2], Mizuho Arai[2] (1.Faculty of policy studies, Iwate prefectural University, 2.Asia air Survey, Co.Ltd.)

Developing Ash-fall impact forecasting content.

*Tomohiro Kubo[1], Yosuke Miyagi[1], Setsuya Nakada[1], Eisuke Fujita[1], Masamitsu Miyamura[1]

1. National Research Institute for Earth Science and Disaster Prevention

The falling ash is expected to cause extensive damage over a wide area, because the ash widely spread out. For example, the highway road was closed to traffic due to falling ash, because the falling ash causes a car slip accident. In Mt.Aso 2016 Eruption, the Aso-shi lost power, because the ash fall an electric power substation. On the other hand, the wooden houses may be collapsed by over volcanic ash load. In addition, the buildings that are constructed by Reinforced Concrete or Steel such as a hospital, an office or a city hall are not collapsed, but the building equipment on the roof supposes to be damaged by the falling ash. Thus, we research the impact of the building equipment function due to falling ash by experimental study.

We report the experimental result of a cooling tower by falling ash. In addition, we report the prototype ash-fall impact forecasting content for the infrastructure and the building equipment, based on the Central Disaster Management Council report and the experimental result.

Keywords: ash-fall, damage estimation, volcano disaster countermeasure, experiment, building equipment

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New Websites and a Pamphlet of IVHHN

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I will present an outline of new websites and a pamphlet of International Volcanic Health Hazard Network (= IVHHN), both of which have been translated into Japanese by the author. IVHHN is an IAVCEI commission which has been launched in 2003 and focuses on research and dissemination of information on volcanic health hazards. Dr. Claire Horwell and some other leading members of IVHHN have conducted a research project entitled “A New Evidence Base for Respiratory Health Interventions in Volcanic Eruption Crises”, which is called HIVE project for short, with a grant from Enhancing Learning and Research for Humanitarian Assistance (ELRHA), a global charity organization in 2015-2018. IVHHN has revised its websites and published in August 2018 to include new outcomes obtained from HIVE project. It is notable that the new websites include the guideline on recommended facemasks for respiratory protection during ashfall on the basis of the field research in Indonesia, Mexico and Japan carried out as a part of HIVE project. The guideline advises residents to stay indoors to reduce exposure to volcanic ash if possible and wear a well-fitting industry-certified facemask such as a N95 mask, or a DS2 mask, which is Japanese standard equivalent to N95, when they are cleaning up volcanic ash or stay outdoors for a long time. The guideline also mentions that industry-certified facemasks are not usually designed to fit children’s face, and thus, they are not effective for children. The new IVHHN websites add the guideline and some other scientific protocols for assessing volcanic health hazard. They also adopt a responsive layout to works well on smartphones. The websites also contain three new videos which describe the experience of coping with volcanic ash, how to protect yourself from breathing ash and how to properly fit a facemask. Subtitles are available in English by clicking on the CC button or you can switch to Spanish or Bahasa in the Settings button. They are also available on YouTube and Vimeo. As the author has been a member of IVHHN since 2005 and managed Japanese IVHHN website. he translated the revised English websites into Japanese and published in January 2019. The new Japanese pages is published newly obtained internet domain at http://www.ivhhn.jp/, while the Japanese website has been published at http://www.geocities.jp/ychojp/ivhhn/ for twelve years. The author printed 2,000 copies of the Japanese version IVHHN guideline on the protection from breathing volcanic ash as a pamphlet. A half of the copies were distributed at the general disaster drill on large-scale eruptions of Sakurajima held on 12 January 2019.IVHHN now prepare for another guideline on the health effects of volcanic gases, which has already been reviewed by the author and some other members of an IVHHN expert panel. The author also provides IVHHN with some photos of fumaroles taken at volcanic areas in Japan.

Keywords: IVHHN, HIVE, Mask

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State of river water pollution derived from the recent volcanic activity of Mt Iwo-Yama, Kirishima volcanoes

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1. Faculty of Science and Technology, Sophia University, 2. Graduate School of Science and Technology, Sophia University

Mt Iwo-Yama belonging to the Kirishima Volcanoes erupted in 2018 for the first time in 250 years. The recent activity of the volcano has a profound effect on the regional economy, especially in the fields of agriculture and tourism. With the phreatic eruption in April 2018, muddy thermal water spouted out from the newly opened vents resulting pollution in the downstream river. As a result, about 1,400 farmers in the downstream area abandoned rice cultivation in 2018.
The muddy water from the newly opened vents is strongly acidic and high in the concentrations of chloride and sulfate with a remarkable amount of arsenic and some kinds of heavy metals. The mud from the vents is mainly composed of grayish argillaceous particles and elemental sulfur suggesting that it is originated from highly-altered zone related to the geothermal reservoir beneath the volcano.
The vents are still busy gushing the muddy thermal water and vapor/steam as of mid-February 2019, ten months after the eruptive events. Based on our continuous investigation, the overflowing water from the vents is constantly strongly acidic (pH <1) and contains a relatively high concentration of arsenic, although the overflow rate is not constant and changes on occasion. The results of our latest chemical analysis show the water contains around 5 mg/L arsenic. Besides, the spring water in the west flank area of the volcano, which is one of the headwaters of the local river, has become strongly acidic with a rise of volcanic activity. That spring water is also one of the reasons for water pollution in the downstream. As a result, even recently the river water pollution in the foot of the volcano is sometimes reported. The river water pollution thus remains as a problem to be solved both environmentally and economically.

Keywords: Iwo-Yama, Kirishima Volcanoes, Ebino Highland, river water pollution, arsenic

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Development of information tools for evacuation and rescue in the event of volcanic disaster

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1. National Research Institute for Earth Science and Disaster Resilience, 2. Mount Fuji Research Institute, Yamanashi Prefectural Government

Integrated Program for Next Generation Volcano Research (IPNGVR) conducted by Ministry of Education, Culture, Sports, Science and Technology, Japan started in 2016. This project takes notice to not only observation and prediction researches but also research for countermeasure technology of volcano disasters. National Research Institute for Earth Science and Disaster Resilience (NIED) has been in charge of one of the main theme which is named “Development of countermeasure technology for volcano disasters”. In this theme, we develop an information tool for volcano disasters, in which we consider disaster management personnel in local governments as users, and we try to provide appropriate information for them in both the event of disaster and normal times.

In the tragic disaster of Ontake Volcano in 2014, it was difficult for local governments to grasp whereabouts of climbers and to conduct rescue and search for victims. Even recently, climbers can approach to an active vent in many volcanoes in Japan, for example Mt. Fuji, it is quite important to grasp whereabouts of climbers in the event of disaster for proper decision of rescue and search. Experiments to acquire data of climbers in Mt. Fuji have conducted since 2015, named “Mt. Fuji Challenge”. Mt. Fuji is active volcano and gets more than 200,000 of visitors including climbers from all over the world each year. In experiments, we distribute beacons to climbers and receivers which are set in mountain trails detect signals from the beacons, then we can grasp the number and location of climbers who have the beacons. Numbers of beacon which we distributed were 2,300 in 2017 and 14,000 in 2018.

The tool developed in our research use the data from the above experiments as input data, and visualize on GIS software. As a result, it is possible to grasp whereabouts of climbers on map information, including trails, shelters and hazard information from hazard map. Even in normal times, information from the tool can be used for evacuation plans, including establishment of shelters or evacuation routes, instituted by local governments. And, by combining with hazard simulations, we can infer casualties in the event of disaster.
In this presentation, we introduce a summary of the experiments in Mt. Fuji in 2018, and report a progress of the development of the tool.

Keywords: Next Generation Volcano Research, countermeasure technology for volcanic disaster, Mt. Fuji Challenge

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Ignimbrite, tephra-fall, caldera and fatalities of major volcanoes in the East and Southeast Asia

*Shinji Takarada[1], Joel Calupas Bandibas[1]

1. Geological Survey of Japan, AIST

Large-scale caldera-forming eruption can cause major destruction within 10 to several 100-km radius from the erupting volcano. The information about the area affected by ignimbrite and tephra falls and size of caldera are useful for future volcanic hazard assessment. Hence, the compilation of data about the distribution of ignimbrite and tephra fall, shape and size of caldera and fatalities caused by volcanic eruptions in East and Southeast Asia is very important.

The G-EVER Promotion Team of the Geological Survey of Japan, AIST is implementing the Asia-Pacific region earthquake and volcanic hazards mapping project, which compiles earthquake source regions, active faults, tephra falls, caldera, ignimbrite, and fatalities caused by earthquake and volcanic events, in collaborations with geohazard research institutes in the Asia-Pacific region. The G-EVER Promotion Team published the 1:10M Eastern Asia Earthquake and Volcanic Hazards Information Map in 2016 (Takarada et al., 2016). The contents of the map can also be viewed or downloaded using the Asia-Pacific Region Earthquake and Volcanic Hazard Information System at http://ccop-geoinfo.org/G-EVER/. The distribution of ignimbrite and tephra fall, shape of caldera and fatality data are updated and available on the site in 2019.

Ignimbrite: The distribution of large-scale ignimbrites (VEI>6) in East and Southeast Asia are compiled. Ignimbrites data are obtained from 19 volcanic caldera-forming eruptions in the region such as Toba 74 ka, Changbaishan 946AD, Tambora 1815AD, Rinjani-Samalas 1257AD, Aso-4, Aso-3, Aira-Ito, Kikai-Koya, Kikai-Nagase, Ata, Toya, Shikotsu 4.6 ka, Kutcharo I, Kutcharo IV, Krakatau 1883AD, Rabaul 7c, Pinatubo 1991AD, Hakone-Tokyo, and Towada-Hachinohe.

Tephra falls: The distribution of large-scale tephra falls (VEI>6) in East and Southeast Asia are compiled. Tephra falls data are obtained from 24 volcanic caldera-forming eruptions in the region such as Toba 74 ka, B-Tm 946AD, Tambora 1815AD, Rinjani-Samalas, Krakatau 1883AD, Rabaul 7c, Pinatubo 1991AD, Long Island 1660AD, Witori-Kimbe2, Ulleung-Oki and Ulleung-Yamato.

Caldera: The shape of major calderas (VEI>6) in East and Southeast Asia are compiled. There are 23 caldera data obtained from volcanoes such as Toba, Tambora, Aso, Aira, Kikai, Ata, Toya, Shikotu, Akan, Kutcharo, Taal, Krakatau, Rinjani-Samalas, Pinatubo, Rabaul, Long Island, Dakataua, Wiroti, Billy Michel, Towada, Mashu, and Moekeshi.

Fatalities: The number of volcanic eruption fatalities and their causes (i.e. pyroclastic flow, debris avalanche, tephra fall, lahar, tsunami, volcanic gas and other reasons) since 1400AD in East and Southeast Asia are complied. The 13 events at 9 volcanoes in Papua New Guinea, 3 events at 2 volcanoes in Solomon Islands, 6 events at 3 volcanoes in Vanuatu, 74 events at 27 volcanoes in Indonesia, 20 events at 6 volcanoes in the Philippines and 36 events at 21 volcanoes in Japan (152 events at 67 volcanoes in total) were compiled.

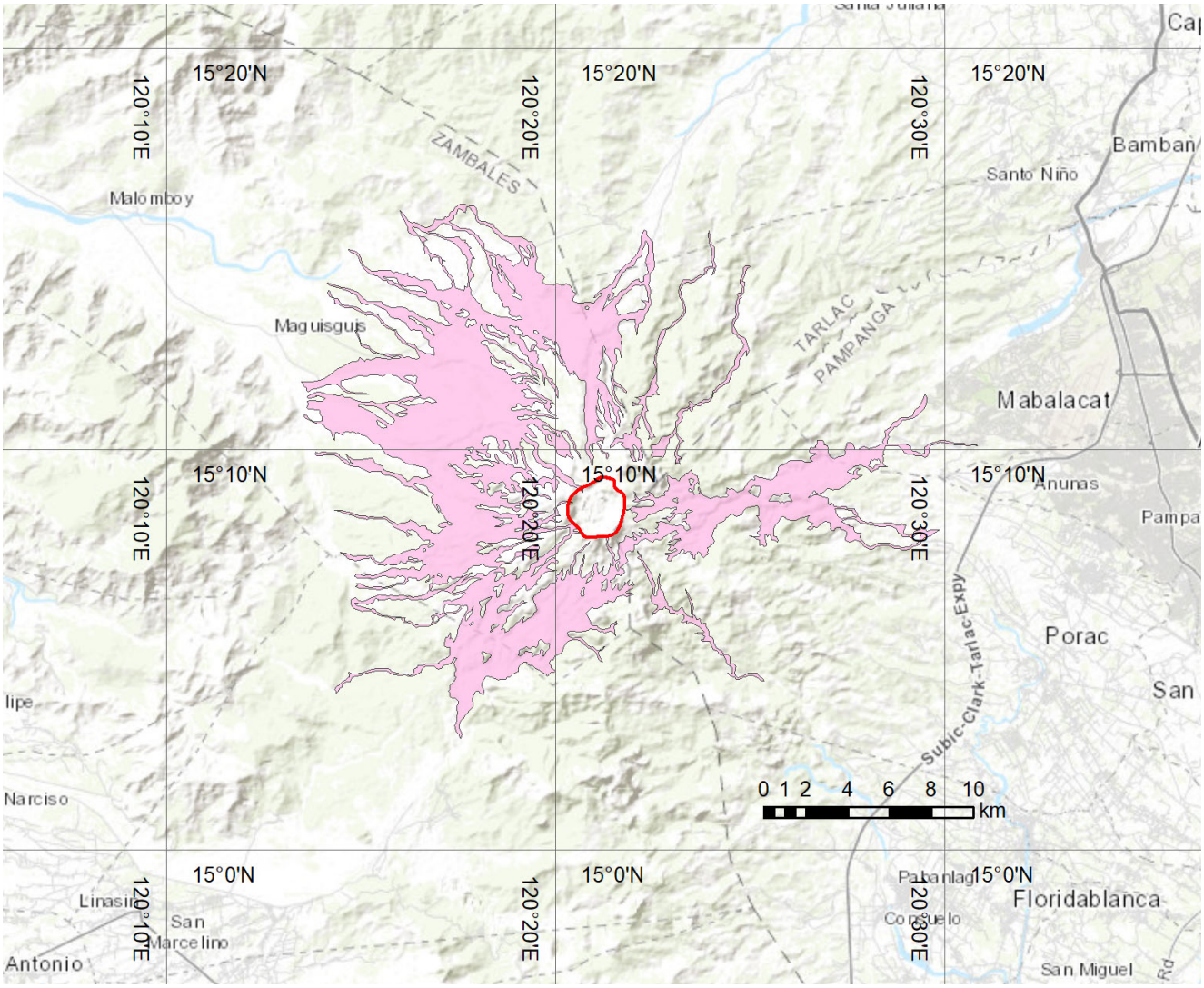
The data in ESRI shapefile and other formats are available for download at the Asia-Pacific Region

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Earthquake and Volcanic Hazard Information System site. The same data with detailed explanation are also available from GSJ open file report. The data are very useful for the various volcanic hazard assessment undertakings.

Figure: Distribution of ignimbrite and shape of Pinatubo caldera after its eruption in 1991AD (Base map provided by the ArcGIS software is used).

Keywords: Ignimbrite, Tephra Fall, Caldera, Fatality, Hazard



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On the climber’ s attitudes to the Volcanic mitigation for active volcanoes.

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Following the Ontake disaster on September 27,2014, the act on active volcano special measures law was revised in 2015, local governments well informed of hazardous area, items for smooth alert evacuation by distributing volcanic hazard map. On the other hand, it is hard to say that the method of transmitting volcanic disaster information to climber is sufficiently under the present circumstances, it is urgent to provide information smoothly in emergency and evacuation method.

We carried out questionnaire survey on the climber in order to know the attitudes to the volcanic mitigation for active volcanoes. 74 respondents were collected at Kurikoma volcano, and 84 respondents were collected at Akita-Komagadake volcano.

At the result, climber in Akita –Komagadake, more than 62 percent of respondents visited from both Iwate and Akita prefecture, whereas in Kurikoma volcano, 56 percent of respondents visited from Kanto area by the large –scale bus with a sightseeing tour.

More than 67 percent of climbers have not issued climbing notifications in both volcanoes.
It is clear that the 40 percent of respondents in Kurikoma volcano, 25 percent of respondents in Akita –Komagadake climber are not recognized where they are climbing as active volcano, and eruption alert level is not also well understood.

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[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

Mon. May 27, 2019 3:30 PM - 5:00 PM JST | Mon. May 27, 2019 6:30 AM - 8:00 AM UTC | IC 2F

[S-VC38] Active Volcanism

convener:Yuta Maeda(Nagoya University), Takahiro Miwa(National research institute for earth science and disaster prevention), Takeshi Nishimura(Department of Geophysics, Graduate School of Science, Tohoku University), Chairperson:Takehiko Suzuki, Maya Yasui

This session discusses various aspects of active volcanisms including, but not limited to, recent and historical eruptions, various phenomena associated with the volcanic activities, underground structures of the volcanoes, and developments of new instruments based on geophysical, geochemical, geological, and multidiscipline approaches. We also welcome studies on understanding and predicting the transitions of the eruptive activities from observational, theoretical, and experimental approaches.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SVC38-01] Tephrochoronology in the southwest part of basaltic Izu-oshima volcanic island during last 20,000 years, off Tokyo, Pacific Ocean

*Takehiko Suzuki[1], Satoshi Terayama[1], Jun Matsukaze[1], Yuichi Kato[1] (1.Faculty of Urban Environmental Sciences, Tokyo Metropolitan University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SVC38-02] **Tephrostratigraphy at Daisan-yama and Jinai-jima, and correlation with eruption deposits from Mamashitaura Volcanoes in Niijima Volcano, Izu-islands**

*Makoto Kobayashi[1], Masanori Murata[1], Kaori Aoki[1], Daisuke Ishimura[1,2], Takehiko Suzuki[1,2] (1.Research Center for Volcanic Hazards and Their Mitigations, Tokyo Metropolitan Univ., 2.Department of Geography, Tokyo Metropolitan Univ.)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SVC38-03] Constration of pre-eruptive process using crystal clot: A case study of Unzen 1991-95 eruption

*Kurumi Iwahashi[1], ATSUSHI YASUDA[1] (1.Earthquake Research Institute,The University of Tokyo)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SVC38-04] Petrological study of Pinatubo 1991 eruption ~ Discussions of magma plumbing model~

*Tomohisa Tamura[1,2], Mitsuhiro Nakagawa[2] (1.West Japan Engineering Consultants, Inc., 2.Earth and Planetary System Science, Hokkaido University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SVC38-05] Rediscovery of the Higuruma Debris Avalanche Deposit in Asama-Kurofu Volcano

*Maya Yasui[1], Masaki Takahashi[1], Tatsuo Kanamaru[1] (1.College of Humanities and Sciences, Nihon University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

Discussion

Tephrochoronology in the southwest part of basaltic Izu-oshima volcanic island during last 20,000 years, off Tokyo, Pacific Ocean

*Takehiko Suzuki[1], Satoshi Terayama[1], Jun Matsukaze[1], Yuichi Kato[1]

1. Faculty of Urban Environmental Sciences, Tokyo Metropolitan University

The Izu-oshima volcano (110 km SSW of Tokyo) in northern Izu-Bonin Arc, is one of the most active Quaternary volcanoes in Japan. This volcano originating from basaltic magma has frequently erupted; that is, 12 times of major eruptions occurred after 2 ka. Studies of its eruption history have been carried out by Nakamura (1964), Kawanabe (2012) and so on. However, precise ages of eruption preceding the caldera formation occurred at 1.8 ka have not been determined. Here, we re-examine the chronological framework of eruption history of the Younger Edifice of pre-caldera.

Fall-out tephras are typically exposed along so-called Great Cut of Beds in SW part of the island. Previous studies by Tazawa (1990) and Uesugi et al. (1994) have described this outcrop, numbering each tephra layer using serial numbers (O1–95 and Osb96–127). All tephras except O55 and O58 are proximal fall-out tephras composed of scoriaceous lapilli and/or scoriaceous ash. Due to the large number of tephras and lithological similarity, it is difficult to confirm each tephra defined by previous studies except several characteristic ones such as O95, O58, and O55. O55 and O58 are rhyolitic tephras from Nijima island and Omuro-dashi submarine depression, respectively (Saito et al., 2007).

Uesugi et al. (1994) estimated the age of the lowest tephra to be 25 ka or older by using 15 radiocarbon ages. However, this estimation is not reliable because it was determined using two oldest conventional radiocarbon ages (non-calibration) of 14–13 ka for the same horizon (just above O64) and under the assumption that the frequency of the tephra occurrence (154 years interval) is constant.
In this study, radiocarbon dating was performed for organic tephric loess collected from 9 horizons above O55 and 16 under O55. The oldest radiocarbon age is 18,598–18,287 cal BP, determined at the horizon 4 m below O95. The age of O95, the most prominent scoria fall deposit, is most likely to be 16–17 ka judging from several radiocarbon ages. It is 2400–3700 years younger than the estimated age (19.4–19.7 ka) by Uesugi et al. (1994). We also recognized widespread K-Ah tephra using volcanic glass geochemistry. Two radiocarbon ages determined at 45 cm above and 55 cm below K-Ah are 6,882–6,747 cal BP and 8167–8021 cal BP, respectively. These ages are concordant with revised age of K-Ah (7,307–7,196 cal yrs BP; McLean et al., 2018), indicating the age of horizon detected K-Ah is older than estimated age of 6,330±85 yBP by Uesugi et al. (1994). These results indicate that the interval between O95 and K-Ah is shorter (67–75%) than previous estimation, suggesting higher frequent occurrence of the eruptions in this period.

Keywords: Izu-oshima, eruption history, carbon dating

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Tephrostratigraphy at Daisan-yama and Jinai-jima, and correlation with eruption deposits from Mamashitaura Volcanoes in Niijima Volcano, Izu-islands

*Makoto Kobayashi[1], Masanori Murata[1], Kaori Aoki[1], Daisuke Ishimura[1,2], Takehiko Suzuki[1,2]

1. Research Center for Volcanic Hazards and Their Mitigations, Tokyo Metropolitan Univ., 2. Department of Geography, Tokyo Metropolitan Univ.

In this study, we established tephrostratigraphy at both sites of Daisen-yama and Jinai-jima, and correlated with eruption deposits from Mamashitaura volcanoes based on the characteristics of the mineral compositions, the refractive indexes and major chemical element compositions of the volcanic glass shards. We are aiming to clear long-term eruption history of Niijima volcano.
We recognized deposits associated with at least 20 eruption deposit events at Daisan-yama and Jinai-jima. Based on the stratification of widespread tephra AT, it is considered that the history of the explosive eruption of Niijima volcano and the surrounding volcanoes during late Quaternary (past about 50,000 years) are preserved at these sites. At the both sites, as the ca. 20ka tephra layers, there are coarse fall-out ash deposits containing accretionary lapilli (N), fine fall-out ash deposits (P; Kozushima-Chichibuyama A (Suga et al., 1992)), AT, fine fall-out ash deposits containing pumices (S; Kozushima-Chichibuyama B (Suga et al., 1992)), pyroclastic surge deposits that squeezes phalanx of pumices with diameter several cm (T), fall-out ash deposits containing volcanic lapilli and pumices (V) and pyroclastic surge deposits (X) in descending orders. At Jinai-jima, as lower tephra layers, there are pyroclastic deposit containing many altered volcanic lapilli and blocks (Y) and pyroclastic surge deposit (Z) covering Jinai-jima lava.
Ito and Isobe (2007) suggested that eruption deposits from Mamashitaura Volcanoes were divided into upper Mamashitaura Volcano (cummingtonite rhyolite; ca. 20 ka) and lower Mamashitaura Volcano (biotite rhyolite; >ca. 35 ka) based on the difference of mineral compositions, paleo-soil layers and ^{14}C ages of charcoals contained therein. We recognized that upper Mamashitaura Volcano deposits composed of pyroclastic surge and pyroclastic cone deposits including rhyolite blocks and lapilli, that the lower layer contained more altered brown volcanic breccia (basalt?). On the other hand, lower Mamashitaura Volcanoes deposits composed of pyroclastic flow and pyroclastic surge deposits with a thickness of 20 m or more, and the debris flow containing many volcanic blocks covering them.
We collected data mineral compositions, refractive indexes and major chemical element compositions of glass shards for Daisan-yama and Jinai-jima tephras (T, V, X etc.) and Mamashitaura Volcano deposits. Tephra-T contains many minerals of hornblende and cummingtonite, and is characterized by refractive indexes (1.497-1.500), K_2O contents (3.0-3.3 wt.%) and CaO contents (0.7-1.0 wt %). These characteristics closely resemble features of some of upper Mamashitaura Volcano deposits. On the other hand, the lower tephras V and X are similar to lower Mamashitaura Volcano deposits in point of contain biotite in addition to hornblende and cummingtonite, but the refractive indexes and CaO contents of the volcanic glass shards are significantly different. This suggests that it is difficult to correlation them.
As a result of currently in progress, it is highly likely that T-tephra is eruption deposits from upper Mamashitaura Volcano, and it is appropriate to think that the age is 30,000 to several thousand years ago. On the other hand, we can’t recognize eruption deposits from the lower Mamashitaura Volcano at Daisan-yama and Jinai-jima.

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Keywords: Daisan-yama, Jinai-jima, Mamashitaura Volcano, Niijima Volcano

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Constration of pre-eruptive process using crystal clot: A case study of Unzen 1991-95 eruption

*Kurumi Iwahashi[1], ATSUSHI YASUDA[1]

1. Earthquake Research Institute,The University of Tokyo

1.Introduction

Magma mixing is thought to be the major eruption triggers of arc volcanoes. This process can control whether magmas will erupt or stall in the crust. However, magma mixing processes have not been revealed well. Therefore, it is important to reveal mixing process at magma reservoir.
For this purpose, we focus on Unzen 1991-95 eruption. This eruption is characterized by continuous growth of dacitic lava domes and pyroclastic flows caused by collapse of the lava domes. During the eruption, two vulcanian eruptions were recognized. Previous studies proposed that magma mixing between nearly aphyric, mafic and crystal-rich, silicic end-members occurred in the magma chamber (e.g., Sato et al., 1999). Because there are lots of geophysical and geological studies, this eruption is suitable for getting more detailed information about pre-eruptive processes.
Recent studies demonstrated that igneous amphiboles are powerful tools to constrain pre-eruptive magmatic conditions (e.g., Ridolfi and Renzulli, 2012; Putirka, 2016). For example, empirical equations relating temperature and SiO_2 content of co-existing melt with amphibole composition were proposed by Putirka (2016). By using these equations, we can constrain physicochemical conditions of melts in which individual phenocryst crystallized.
Our previous results suggest that the 1991-95 magma was formed by three-component mixing, in which contribution of the newly-recognized 3rd endmember magma (MT magma) (Iwahashi et al., JpGU2018). Products of 1991-95 eruption often contain crystal clots. They consist of amphibole, plagioclase and Fe-Ti oxides. Because magma reservoir of Unzen volcano is thought to be mushy (e.g., Nakamnura et al., 1995), crystal clots are possible to be part of mushy magma reservoir. Therefore, in this study, we expect to get more detailed information about pre-eruptive process of 1991-95 eruption using crystal clots in addition to amphibole phenocrysts.

2.Methods

We used 11 dacitic samples erupted at different times during the 1991-95 eruption. All of these samples contain crystal clots. They are composed of amphiboles, plagioclases, Fe-Ti oxides and interstitial glass. The major element compositions of amphibole phenocrysts and constituent minerals and glasses in crystal clots were measured by using EPMA at ERI, University of Tokyo.

3.Results

Amphiboles in crystal clots are classified into four types; Type A, Type B, Type C, Type D. Amphibooles of Type A has zonal structure, Type B has reaction rim, Type C has both zonal structure and reaction rim and Type D is almost homogenous. These amphiboles are classified magnesiohornblende and tchermakite based on their compositions. There is an apparent compositional gap between these two clusters. Crystallization temperatures are estimated to be ~750-800ºC and ~850-950ºC for magnesiohornblendes and tchermakites, respectively. Amphiboles in crystal clots reveal temperatures of ~750-800ºC. Estimated SiO_2 contents of melts coexisted with amphiboles (SiO_2^{melt}) are ~66-73wt.% and ~60-67wt.% for magnesiohornblendes and tchermakites, respectively. On the other hand, SiO_2 contents of interstitial melts are ~68-72wt.%. Almost all plagioclases in crystal clots have oscillatory zoned texture. An content (=100*Ca/Ca+Na) of these rim are 60-75.

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4.Discussion

H_2O saturation depth estimated for the interstitial melt compositions are consistent with that of main magma chamber in which the silicic endmember magma was thought to be stored.
On the other hand, zonal texture of amphibole often cut by other crystals and this implies that MT magma reservoir may present before 1991-95 eruption. In addition, comparison of temperatures estimated by amphiboles with phase diagram by Noguchi et al.(2008) indicate that there may be almost no plagioclases in MT magma reservoir.
In addition to these results below, we plan to present some new picture of pre-eruptive process at 1991-95 eruption and MT magma reservoir.

Keywords: pre-eruptive process, crystal clot, amphibole

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Petrological study of Pinatubo 1991 eruption ~ Discussions of magma plumbing model~

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1. West Japan Engineering Consultants, Inc., 2. Earth and Planetary System Science, Hokkaido University

Introduction

Pinatubo volcano which locates at Northern Luzon island, Philippines caused cataclysmic eruption on June 15, 1991. This eruption includes the four main eruptive products, dome lava andesite on June 7 (J7-LD), basaltic mafic enclave in J7-LD (J7-ME), andesitic scoria from first Plinian eruption on June 12 (J12-P) and dacite pumice from climactic Plinian eruption on June 15 (J15-C). J15-C is separated into two types which constitute gray, precise and phenocryst-poor pumice (J15-CP) and white, bubbly and phenocryst-rich pumice (J15-CR). There are many petrological studies of Pinatubo volcano 1991 eruption, and magma plumbing model of this eruption is established by Pallister*et al.* (1996). Their model indicates magma mixing that andesitic magma is generated by mixing between felsic magma and mafic magma in magma reservoir. However, we carry out whole rock and mineral compositions of 1991 products in detail, and obtain the new findings of magma plumbing model of 1991 eruption.

Analytical methods

We made many thin sections and observed them under polarizing microscope, and counted the modal compositions of phenocrysts.Whole rock and mineral compositions were determined by X-ray fluorescence (XRF) and Scanning electron microscope / Wavelength dispersive X-ray spectroscopy (SEM-WDS) at Hokkaido University, respectively.

Results and Discussions

1991 products mainly include plagioclase and amphibole phenocrysts, and there is a few olivine, clinopyroxene, biotite, quartz and opaque minerals. For Harker diagram of major elements, all products stand in a straight line and it means magma mixing trend. J15-C composition, however, has compositional variation and another trend which crosses the mixing trend. J7-LD and J12-P also have slightly crossed compositional variation. This crossed trend and compositional variation are clearly confirmed in K_2O and Rb contents. The contents of amphibole and biotite which include many potassium do not relate the compositional variation. Therefore, felsic magma of Pinatubo volcano has had the compositional heterogeneous before mafic magma injected into felsic magma reservoir.

Plagioclase and amphibole cores have wide compositional range. According to calculating the equilibrium melt compositions from plagioclase and amphibole cores, we estimate the two felsic endmember that are less-evolved melt, D1 and more-evolved melt, D2. Their melt compositions correspond with glass compositions hosted in melt inclusions of plagioclase and amphibole crystals. Above discussion indicates that felsic magma has the heterogenous, and we estimate that the heterogeneous felsic magma was generated by mixing between D1 and D2.

For minerals of 1991 products, normal and reversal zonings coexist and are repeated from line profile analyses. The melt composition and temperature of magma were heterogeneous and convection occurred in magma reservoir because the composition of plagioclase depends on the melt composition and temperature of magma.

Conclusions

The compositional variation of dacitic magma is consistent with one of minerals, plagioclase and amphibole, for example. The felsic magma has compositional heterogeneous before mafic magma injection, and two different compositional endmember magma coexist (D1 and D2). The continuous compositions of felsic magma were generated between D1 and D2 because of the convection in magma

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reservoir. Before 1991 eruption, mafic magma injected into the heterogeneous felsic magma and mixed together, so that andesitic magma which has slightly compositional variation was generated.

Acknowledgements

We thank John Pallister, Cascade Volcano Observatory, US Geological Survey and Takehiro Koyaguchi, Earthquake Research Institute, The University of Tokyo for providing the samples used in this study.

Keywords: Pinatubo volcano, Heterogeneous of silicic magma, Magma mixing

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Rediscovery of the Higuruma Debris Avalanche Deposit in Asama-Kurofu Volcano

*Maya Yasui[1], Masaki Takahashi[1], Tatsuo Kanamaru[1]

1. College of Humanities and Sciences, Nihon University

Asama-Kurofu volcano experienced a large-scale sector collapse in its later stage indicated by a horse-shoe shaped caldera and debris avalanche deposit in the distal flank. The area immediately east of the collapsed caldera is occupied by younger volcanic edifices of Hotokeiwa and Maekake. The medial area that is a flank slope of the former Kurofu is thickly covered with the younger deposits from Hotokeiwa and Maekake. Therefore, few information was available for the distribution and thickness of the debris avalanche deposit. Hummocky topography develops on the eastern area of Maekake and Hotokeiwa volcanoes. Geological survey especially in the valley bottom in the hummocky area in the Gunma Prefecture Asama Dairy Farm, the Nagakurayama National Forest, and its vicinity was carried out in this study. Outcrops of the deposits those occurrences were typical of debris avalanche were occasionally found in the valley bottom. In addition, 50-meter deep borehole core sample was taken on the ENE flank slope of Maekake volcano. This is a part of the “integrated program for next generation volcano research and human resource development” supported by ministry of education, culture, sports, science and technology, Japan. Thick debris avalanche deposit of 27 meters was recognized in the lower half of the borehole core sample. That is, weakly stratified and partly solidified tuff breccia that is characterized by heterogeneous matrix and occasional mega-blocks is observed. Whole-rock chemical analyses of the blocks from these deposits show that they are the same as those of the Asama-Kurofu and Asama-Sennin volcanoes. The distribution of “Higuruma debris avalanche” was shown on Yagi (1936) ‘s geologic map but few descriptions were made about it. The deposit confirmed in this study corresponds to the Higuruma debris avalanche and the description including thickness will be a clue for understanding the scale of the sector collapse.

Keywords: Asama volcano, debris avalanche deposit, sector collapse

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[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

Mon. May 27, 2019 9:00 AM - 10:30 AM JST | Mon. May 27, 2019 12:00 AM - 1:30 AM UTC | IC 2F

[S-VC39] Hydrothermal systems of volcanoes

convener:Yasuhiro Fujimitsu(Department of Earth Resources Engineering, Faculty of Engineering, Kyushu University), Wataru Kanda(Volcanic Fluid Research Center, School of Science, Tokyo Institute of Technology), Takeshi Ohba(Department of chemistry, School of Science, Tokia University), Chairperson:Yasuhiro Fujimitsu(Faculty of Engineering, Kyushu University), Takeshi Ohba, Wataru Kanda

There is a diversity of hydrothermal systems between magmas and the ground surface in various geoscientific environments. Understanding of the hydrothermal systems contributes to understanding of the earth systems, and is essential for utilization of geothermal energy and prediction of volcanic eruption. In this session, we will discuss the topics on subsurface structures and heat and fluid flows of "hydrothermal systems of volcanoes" from the perspectives of geophysics, geochemistry, geology and geothermal reservoir engineering. Any research approaches, theoretical, observational and experimental, are welcome.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SVC39-01] Hydrothermal system of Tokachidake volcano, Japan: Examination from multi-disciplinary surveys

*Ryo Takahashi[1], Noritoshi Okazaki[1], Makoto Tamura[1] (1.Geological Survey of Hokkaido, Hokkaido Research Organization)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SVC39-02] Fumarole and hot spring activities after the 2015 eruption of Hakone Volcano and their relationships with the seismicity and crustal deformation

*Kazutaka Mannen[1], Masatake Harada[1], Yohei Yukutake[1], George Kikugawa[1] (1.Hot Springs Research Institute of Kanagawa Prefecture)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SVC39-03] A possible geothermal source at around 4 km depth estimated by the seismic observation in Ibusuki geothermal area

*Junzo Kasahara[1,3], Yoko Hasada[2,1], Hiroyasu Kuzume[1] (1.ENAA, 2.Daiwa Exploration and Consulting Co., 3.Shizuoka Univ.)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SVC39-04] Time variation in the chemical and isotopic composition of fumarolic gases at Kusatsu-Shirane volcano Japan

*Takeshi Ohba[1], Muga Yaguchi[2], Nozomi Numanami[1], Kotaro Toyama[3], Hirochika Sumino[3], Urumu Tsunogai[4], Masanori Ito[4], Ryo Shingubara[4] (1.Department of chemistry, School of Science, Tokia University, 2.Meteorological Research Institute, JMA, 3.The University of Tokyo Graduate School of Arts and Sciences Department of Basic Science, 4.Nagoya University Graduate School of Environmental Studies)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SVC39-05] Behavior of Arsenic and Mercury related to hydrothermal activities in Kirishima, Satsuma Iwojima, and Yamagawa, Kyushu Japan

*Motoya Habuchi[1], Harue Masuda[1], Tsuyoshi Shintani[1], Shuzo Furuya[1], Keigo Mori[1], Jun-ichiro Ishibashi[2], Takeshi Matsushima[2], Akinori Takeuchi[3], Syogo Oshima[4], Reo Ikawa[5] (1.Osaka City University, 2.Kyushu University, 3.National Institute for Environmental Studies, 4.West Japan Engineering Consultants, Inc., 5.National Institute of Advanced Industrial Science and Technology)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SVC39-06] The chemical composition of thermal waters from spring and hot pool at Mt. Iwoyama of Kirishima volcano

*Muga Yaguchi[1], Takeshi Ohba[2], Kotaro Toyama[3], Fukuoka Regional Headquarters JMA[4], Kagoshima Meteorological Office JMA[4] (1.Meteorological Research Institute, 2.Tokai University, 3.Graduate School of the University of Tokyo, 4.Japan Meteorological Agency)

Hydrothermal system of Tokachidake volcano, Japan: Examination from multi-disciplinary surveys

*Ryo Takahashi[1], Noritoshi Okazaki[1], Makoto Tamura[1]

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Tokachidake volcano, located in central Hokkaido, Japan, has had intermittent magmatic eruptions during the 20th century. Recently, increases in seismic activity, ground inflation around the active craters and chemical changes of thermal waters are observed, and hence, a magmatic eruption in the near future is of concern. The 1926 eruption induced a large-scale lahar (Taisho lahar). Uesawa (2014) proposed that large amounts of thermal water were released as a hydrothermal surge from the interior of the volcanic edifice, expanding the scale of the Taisho lahar. In addition, chemical and thermal changes related to volcanic activity were observed in thermal waters around the volcano (Takahashi et al., 2015). These phenomena are deeply related to hydrothermal systems. Therefore, to detect precursor activities precisely at Tokachidake volcano, we should understand the subvolcanic hydrothermal systems. In this study, we performed multi-disciplinary surveys, such as magnetotelluric (MT) survey, geological investigations and thermal water and fumarolic gas observations, to examine the subvolcanic hydrothermal systems.

We performed MT survey at 13 stations along an NW-SE survey line across the volcano, and detected several conductive zones in the edifice. A conductive zone was detected at more than 3–4 km depth beneath the summit crater area (deep conductive zone). Volcanic earthquakes did not occur in this conductive zone, but their hypocenters were distributed surrounding the zone. This would indicate that the outer margin of the conductive zone is coincident with the brittle-ductile transition zone. Another conductive zone is distributed at 300–1,500 m depth beneath the summit crater area (shallow conductive zone).

In order to discuss the shallow hydrothermal system, we investigated phreatic ejecta, the 1926 debris avalanche deposits and accessory ejecta, all of which record subsurface hydrothermal environments. As a result, we revealed that an alteration zone with a pyrophyllite+quartz assemblage occurs at depths of >500 m beneath the crater area (Takahashi & Yahata, 2018). This zone reflects a high-temperature environment (200–300 ˚C). Also, fumarolic gas observations suggest that high-temperature (200–300 ˚C) hydrothermal systems exist the shallow subsurface. We can consider that the shallow hydrothermal system inferred from these investigations is coincident with the shallow conductive zone detected by MT survey.

We have observed the thermal waters around Tokachidake volcano over a period of more than three decades. At Fukiage spa area, thermal waters caused chemical and thermal changes by the supply of the magmatic NaCl-type thermal water associated with the increase in volcanic activity (Takahashi et al., 2015). A distribution area of the NaCl-type thermal water around magma would be detected as a conductive zone because thermal waters with high temperature and high NaCl concentration show high conductivity. Thus, we can consider that the deep conductive zone is interpreted as a distribution area of the NaCl-type thermal water.
In consequence of multi-disciplinary surveys at Tokachidake volcano, we revealed the subvolcanic hydrothermal systems. We should continue careful observations and revise the model to understand more precisely the volcanic activity of the volcano.

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Keywords: Tokachidake volcano, hydrothermal system, magnetotelluric survey

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Fumarole and hot spring activities after the 2015 eruption of Hakone Volcano and their relationships with the seismicity and crustal deformation

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1. Hot Springs Research Institute of Kanagawa Prefecture

A very small phreatic eruption occurred at Hakone volcano in 2015. Before the eruption, in Owakudani, where the eruption center formed, there has been no significant fumarole activity; however, more than 20 craters and fumaroles formed associated with the eruption and they still remain active. We have routinely measured the steam temperatures emitted from the fumaroles and analyzed chemical composition of hot spring and surface waters every two weeks since we were permitted to enter the eruption center. In this presentation, we show the temporal changes and its relationship with the seismic activity and crustal deformation.

1. Steam temperature of fumaroles
Among the more than 20 fumaroles, we have measured 10 fumaroles that are significant and accessible (Mannen et al., 2019). We have only two stable fumaroles named 15-12 (since May 1, 2017) and 16-1 (since January 11, 2018) for routine measurement.

The temperature of 15-12 was higher than 150 ºC before August 2017. However, the temperature lowered gradually up to 120 ºC until the late 2018. The temperature of 16-1 was approximately 140 ºC when we started measurement. However, the steam temperature also lowered gradually and marked 130 ºC in the late 2018.

On the other hand, fumaroles named 15-1 and 15-14B continuously emit high temperature steams and higher than 150 ºC even in the late 2018 without significant decline although steam vents of these fumaroles are unstable and migrate frequently. We suppose that the steam temperature and emission are on decline since detection of high temperature steam is getting difficult and extinction of fumarolic activity is common recently. The highest temperature ever recorded was 162.0 ºC from 15-1 observed on August 23, 2017.

2. Chemical composition of hot springs and surface waters
In Owakudani area, we routinely correct and analyze waters from 13 sources including natural springs, stream water and artificial hot springs, which is made by mixing of steam emitted from steam well and water (Kikugawa et al., 2019). The stream water, watershed of which includes the eruption center, shows high Cl content associated with the 2015 volcanic unrest ($Cl/SO_4 > 1.0$; Mannen et al. 2018). The Cl concentration lowered to the background level ($Cl/SO_4 \sim 0.2$) until early 2017; however, increased slightly from November 2017 to January 2018 ($Cl/SO_4 \sim 0.3$). The artificial hot springs from No. 52 steam well also showed significant rise of electric conductivity and Cl content and decline of pH.

Our measurement of volcanic gas from underfloor of a building in Owakudani shows continuous decline of CO_2/H_2S ratio after the eruption. The decline rate seemed to lower in 2017; however, it was not clear. On the other hand, Daita et al. (2018) reported that CO_2/H_2S ratio of volcanic gas from Kamiyu, north of Owakudani showed rise from around June 2017.

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3. Seismicity and crustal deformation in 2017
In Hakone volcano, earthquake swarm, deep low frequency earthquakes and increase of baseline length across the volcano have observed before increase of geothermal activity (Harada et al. 2018; Mannen et al. 2018). After the 2015 eruption, there has been no earthquake swarm; however, there were slight increase of seismicity from the late April to the early May in 2017 beneath Mt. Kintoki (Yukutake et al. 2018). Before the earthquake swarm, in the mid-April, deep low frequency earthquakes (DLF) was found active by matched filter method (Yukutake, 2017). The baseline length across Hakone volcano started to increase from the early May in 2017 and ended in the late November of the year with total stretch of 12 mm (the total stretch during the 2015 eruption and unrest was 21 mm). In the period, there is no significant change in steam temperature. Increase of hydrothermal activity was implied by the changes in chemical compositions of artificial hot spring water and surface water in the late April and in November respectively.

The observed trend of the weak change in 2017 are similar to that of the volcanic unrests in 2013 and 2015. We thus suppose that there was a small increase of volcanic activity in 2017. Comparing to the changes in 2013 and 2015, seismicity and stretch rate of the baseline in 2017 are notably lower. Daita et al (2018) also pointed out that the increase in CO2/H2S ratio in 2017 was significantly lower than that observed in 2013 and 2015. Such differences observed in 2017 may imply that the magma-hydrothermal system of Hakone volcano has altered by the 2015 eruption (Daita et al, 2018).

Keywords: Hakone, Deep low frequency earthquake, inflation of edifice, fumarole, hot springs, volcanic activity

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A possible geothermal source at around 4 km depth estimated by the seismic observation in Ibusuki geothermal area

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Introduction: The Medipolis is located in Ibusuki geothermal area, Japan. There are three geothermal boreholes in the field. The geothermal characteristics of the boreholes were studied by NEDO (2008-2010). The IK-1 borehole is commercially used for the electric power generation. The IK-4 is used for observation. The depths of three boreholes are around 1,500 m. The temperature of the boreholes was approximately 250˚C around the 900 m-depth and the production depth for the steam is around 1,200 m. The temperature model by NEDO (2008-2010) proposes a hot reservoir around the NE direction of IK-1 and IK-4 boreholes although it is not confirmed by real drillings.

To know the precise geothermal characteristics of this field, we conducted a seismic observation by a fiber-optic distributed acoustic sensor (DAS) and ground surface seismometers in November 2018.

Field observation: We installed 20 sets of 3C seismometers along the 2 km-long EW line and deployed a fiber-optic cable for the DAS and distributed temperature (DTS) measurements down to 977 m depth. We measured the temperature and seismic signals using the same fiber-optic cable for DAS and DTS. The total DAS observation period is 4.5 days. The interval of ground surface seismometers is approximately 100 m. We observed seven natural earthquakes by DAS and surface seismometers. The largest observed earthquake is M5.2 which occurred west of Tanegashima with 123 km focal depth. The temperature of the IK-4 was measured as 264˚C by DTS at the 914 m depth.

Observed waveforms: The first arrivals of the M5.2 earthquake measured by DAS are traveling from the 977 m depth to the wellhead with the velocity of 4 km/s~3 km/s. There are no evident reflections from the deeper zone than 1,000 m. In addition, any evident attenuation of seismic waves is not identified in the high temperature zone around the 914 m-depth.

Surface seismometers show unusual waveform characteristics. Although the amplitudes of the P-wave first arrivals of M5.2 earthquake on vertical seismometers are small, the EW and the NS seismometers show small P first arrivals and succeeding large amplitude phase with a second delay. Because this phase is recognized only on EW and NS components, this phase is possibly P-to-S converted phase. The aftershocks of the M5.2 Tanegashima also showed similar waveforms as those of the M5.2 event. Other earthquakes also showed similar characteristics on the horizontal components.

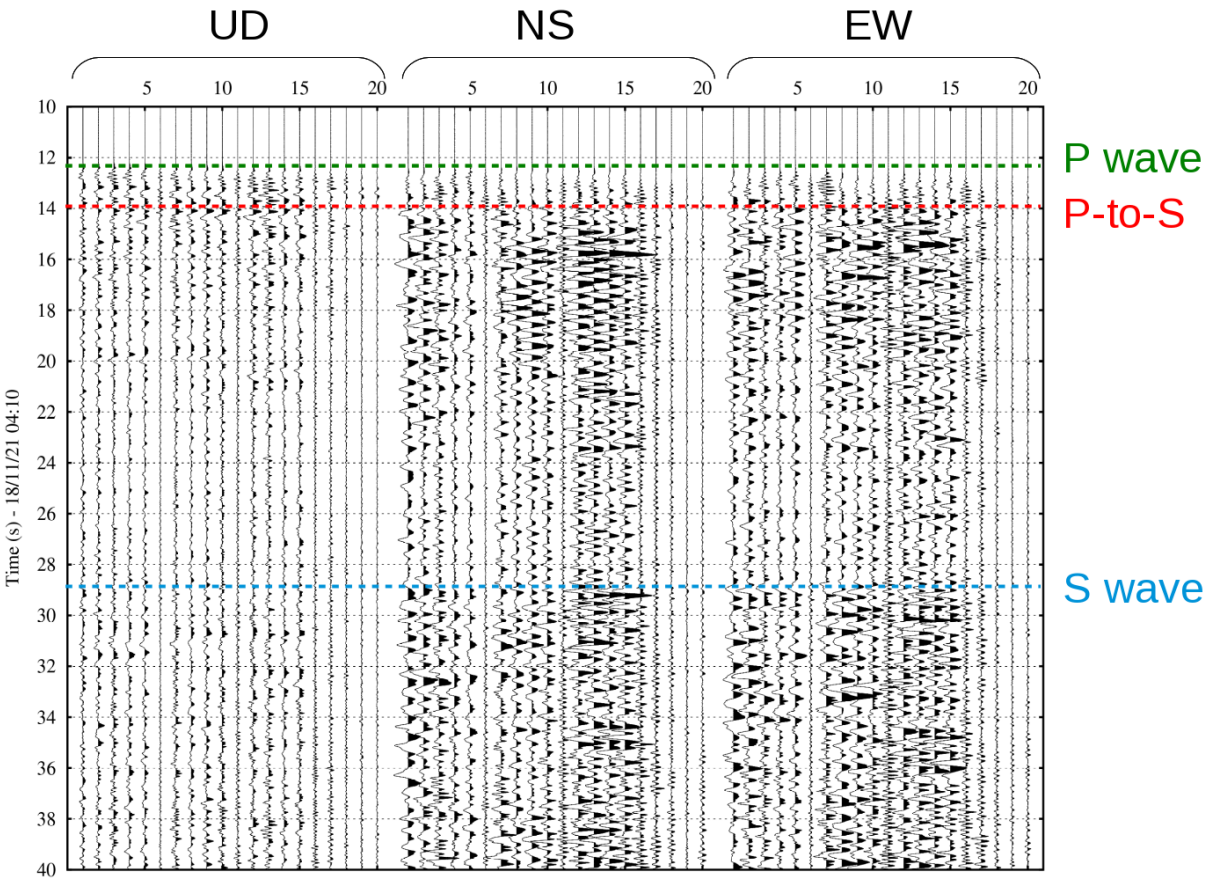
Interpretation of P-to-S converted phase: We examined the cause of estimated P-to-S conversion. The delay time from the P first arrival to the P-to-S converted phase is estimated as ~0.8 s. We assumed a low Vp/Vs zone at the 4 km-depth with 500 m thick and calculated synthetic waveforms generated by deep seismic sources corresponding to natural earthquakes. The seismic velocity profile estimated by the DAS observation is used in the calculation. The models can explain the observed characteristics such as small P amplitude and large P-to-S converted phase on horizontal components, when incident seismic wave is slightly oblique to the low Vp/Vs zone. We also estimated borehole waveforms and ground surface waveforms.

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Discussion and conclusions: According to the simulation, there is a chance to prove the presence of the low Vs zone at the 4 km-depth. Because the temperature around ~900 m is 264˚C, the low Vs zone might be useful for a future geothermal energy source. For either case, more detailed study of the proposed low Vs zone is required.

Acknowledgements: This study is supported by the New Energy and Industrial Technology Development Organization (NEDO). Medipolis Energy Co. kindly allowed the use of their IK-4 geothermal well for this study. Mr. Kimura provided us with the Schlumberger hDVS measurements. WELMA Co. provided us with the borehole fiber-optic system and measurement of temperatures in the borehole. The staff of West Japan Engineering Consultants, Inc., helped us during the field study.

Keywords: Geothermal field, Seismic wave, Vp/Vs, P-to-S conversion, Geothermal reservoir, Passive seismic source



The seismic records of M5.2 Tanegashima earthquake obtained by the surface seismometers. The labels on the horizonal axis are the station numbers and the station interval is approximately 100 m. The vertical axis is time in seconds. The horizontal dotted lines denote arrival times for P, P-to-S, S waves, respectively.

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Time variation in the chemical and isotopic composition of fumarolic gases at Kusatsu-Shirane volcano Japan

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At Kusatsu-Shirane volcano Japan, the intense seismic activity took place in 2014 and 2018. To investigate the relationship between the activity and the chemistry of fumarolic gas, the gas samples have been repeatedly analyzed. A monotonic decrease in CO2/H2O, He/H2O and N2/H2O ratios since July 2014 to November 2017 suggests the decline of magmatic component. On contrary CH4/H2O ratio significantly increased during the seismically quiet period, suggesting the reduced condition in hydrothermal system favoring to the formation of CH4. The high N2/He ratio in the quiet period suggests the addition of component originating in crustal rock hosting hydrothermal system. The N2/He ratio in 2018 was definitely lower than the ratio in 2014, indicating the evolution of magma brought by the degassing. The δD(H2O), δ18O(H2O) and CO2/H2O ratio of fumarolic gas were modeled with the following processes; the generation of vapor phase after the mixing between magmatic gas and a cold groundwater with meteoric origin, the addition of vapor phase with meteoric origin, and the partial condensation of water vapor near surface. Only a single magmatic gas is necessary for the above modeling.

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Behavior of Arsenic and Mercury related to hydrothermal activities in Kirishima, Satsuma Iwojima, and Yamagawa, Kyushu Japan

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Arsenic and mercury behave in similar manners during migration from the deep to the surface of the Earth with magmatic and associating hydrothermal activities. In this study, we sampled total 57 hydrothermal and local meteoric waters from Kirishima, Satsuma-Iwojima and Yamagawa in November 2017 to December 2018 to trace the migration processes of arsenic and mercury related to the volcanic and its associating hydrothermal activities. We analyzed concentrations of major components, arsenic and mercury and hydrogen and oxygen isotope ratios.
The highest temperature of hydrothermal water, which was taken from the craters phreatically exploded in the April 2018, was 94.5 ˚C and the pH was 0.8-1.7. The maximum concentrations of chloride ion and sulfate ion were 300 mM and 190 mM, and the positively linear relationship between these two components indicated the simple mixing of acidic hydrothermal fluid and local meteoric water. In many high temperature hydrothermal waters, $\delta^{2}H$ and $\delta^{18}O$ were in the range of magmatic water, -25 to -5‰ and +4 to +9 ‰. Total arsenic concentration in the hydrothermal waters was 1210-4640 μg/l, which had a positively linear relationship with sulfate ion concentration. Dissolved and suspended total mercury concentrations in hydrothermal waters were 0.5-85 ng/l and 0.5-826 ng/l, respectively. Since highly mercury concentrated hydrothermal water also contained high arsenic, these were derived from the same magmatic fluid. Chloride and sulfate ion concentrations of hot spring waters derived from fumarole in Kirishima and Kurinodake were < 0.2 mM and 26 mM at the maximum. Total arsenic concentration was 0.58-24 μg/l, and total suspended mercury concentration was 1980 ng/l at the maximum. Hot spring waters in Satsuma Iwojima and Yamakawa,contained high total arsenic concentration when the seawater directly infiltrated and the highest concentration was 2500 μg/l for the one of hot spring water in Satsuma Iwojima. In these areas, the highest total dissolved mercury concentration was 177 ng/l for a hot spring water with pH of 1.4 in Satuma Iwojima. Both arsenic and mercury are rising up from the deep with magmatic fluid. However, the two elements may behave differently along the migration path; mercury moves preferentially with vapor and removed from the water during flowing path on the surface, while arsenic preferentially behaves with hydrothermal water and remains as a dissolved phase in the surface water.

Keywords: magmatic fluids, Iwo-yama, phreatic eruption, hydrogen and oxygen isotope ratios of water

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The chemical composition of thermal waters from spring and hot pool at Mt. Iwoyama of Kirishima volcano

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Mt. Iwoyama of Kirishima volcanic complex is an active volcano where fumarolic activity restarted in December 2015 at summit crater. After the restart of the fumaroles, volcanic activities at the surface, such as the expansion of fumarolic area, the appearance of thermal springs and water quality changes in springs around Mt Iwoyama have been observed. In April 2018, small phreatic eruptions occurred at the south of the summit and west flank of Mt. Iwoyama, and boiling hot pools have appeared in some of the newly created craters after the eruptions. In this study, the chemical composition of water samples collected from a natural spring site on the west flank of Mt. Iwoyama and hot pools in the newly created craters have been analyzed to obtain information for evaluation of volcanic activity at this mountain.

Between August 2016 to March 2018 (about a month before the eruption), the Cl/SO_4 of the spring water increased from 0.07 to 0.9. About a month after the eruption, the ratio increased to 1.6 as of May 2018, and remain between 1.2 and 1.6 since then to January 2019.

Cl/SO_4 molar ratio of hot water pool in one of the southern craters was 1.3 in May 2018 and 1.8-2.3 in January 2019. The ratio of hot water pool in the western crater was 1.3 in July 2018, 1.9 in October 2018 and 2.2 in January 2019. The increase of Cl/SO_4 molar ratio may be caused by several reasons, for example, the ascent of volatile-rich magma or chemical composition change of volatiles along with the progress of degassing.

Keywords: Mt. Iwoyama of Kirishimayama volcano, Thermal water, Chemical composition

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[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

Mon. May 27, 2019 10:45 AM - 12:15 PM JST | Mon. May 27, 2019 1:45 AM - 3:15 AM UTC | IC 2F

[S-VC39] Hydrothermal systems of volcanoes

convener:Yasuhiro Fujimitsu(Department of Earth Resources Engineering, Faculty of Engineering, Kyushu University), Wataru Kanda(Volcanic Fluid Research Center, School of Science, Tokyo Institute of Technology), Takeshi Ohba(Department of chemistry, School of Science, Tokia University), Chairperson:Yasuhiro Fujimitsu(Faculty of Engineering, Kyushu University), Takeshi Ohba, Wataru Kanda

There is a diversity of hydrothermal systems between magmas and the ground surface in various geoscientific environments. Understanding of the hydrothermal systems contributes to understanding of the earth systems, and is essential for utilization of geothermal energy and prediction of volcanic eruption. In this session, we will discuss the topics on subsurface structures and heat and fluid flows of "hydrothermal systems of volcanoes" from the perspectives of geophysics, geochemistry, geology and geothermal reservoir engineering. Any research approaches, theoretical, observational and experimental, are welcome.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SVC39-07] Re-examination of origin of the variety in magmatic-hydrothermal fluids

*Hiroshi Shinohara[1] (1.Geological Survey of Japan, AIST)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SVC39-08] **Constraining electrical resistivity structure of volcanoes using multiphase flow modelling: an example of Miyake-jima**

*Marceau Gresse[1], Makoto Uyeshima[1], Takao Koyama[1], Maki Hata[1], Hideaki Hase[2], Koki Aizawa[3], Yusuke Yamaya[4], Yoichi Sasai[5], Jacques Zlotnicki[6], Tawat Rung-Arunwan[1], Hideki Ueda[7] (1.Earthquake Research Institute, The University of Tokyo, Tokyo, Japan, 2.Geothermal Energy Research & Development Co., Ltd., Tokyo, Japan, 3.Institute of Seismology and Volcanology, Faculty of Science, Kyushu University, Fukuoka, Japan., 4.Planning Division, National Institute of Advanced Industrial Science and Technology, Tokyo, Japan, 5.Earthquake Prediction Research Centre, Tokai University, Shizuoka, Japan, 6.CNRS, OPGC-UMR6524, Aubière, France, 7.National Research Institute for Earth Science and Disaster Resilience, Tsukuba, Japan)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SVC39-09] MT survey and 3-D resistivity structure in the Niseko area, southwestern Hokkaido

*Makoto Tamura[1], Toru Mogi[2], Junna Kanahiro[2], Daisuke Oka[1], Junya Maruyama[1], Takahiro Suzuki[1], Noritoshi Okazaki[1] (1.Geological Survey of Hokkaido, Hokkaido Research Organization, 2.Division of Sustainable Resource Engineering, Fucluty of Engineering, Hokkaido University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SVC39-10] **Hydrothermal fluid activity of the Tatun Volcano Group, Taiwan, revealed by self-potentials and seismicity**

*Hong-Jia Chen[1], Zhi-Xian Yang[1], Chien-Chih Chen[1,2], Cheng-Horng Lin[3,4] (1.Department of Earth Sciences, National Central University, Taiwan., 2.Earthquake-Disaster & Risk Evaluation and Management, National Central University, Taoyuan, Taiwan., 3.Institute of Earth Sciences, Academia Sinica, Taipei, Taiwan., 4.Taiwan Volcano Observatory at Tatun, Taipei, Taiwan.)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SVC39-11] Utilizing the electrical conductivity distribution to unravel the hydrothermal system beneath Mt.Hasan composite volcano and its vicinity, southwest Cappodocia, Turkey

*Sabri Bulent Tank[1], Mustafa Karas[1] (1.Bogazici University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SVC39-12] Three-dimensional Magnetotelluric Inversion to map geothermal structures in Eburru Geothermal field, Kenya.

*JUSTUS MAITHYA[1], Yasuhiro FUJIMITSU[2] (1.Graduate School of Engineering, Department of Earth Resources Engineering, Kyushu University, 2.Faculty of Engineering, Department of Earth Resources Engineering, Kyushu University)

Re-examination of origin of the variety in magmatic-hydrothermal fluids

*Hiroshi Shinohara[1]

1. Geological Survey of Japan, AIST

A variety of magmatic-hydrothermal fluids, including volcanic gases, hot spring waters and geothermal waters, is created from a magma and we will re-evaluate those origins with particular interest on variation of Cl/S ratios. Giggenbach (1996) classified fluids in a magmatic-hydrothermal system as 1) Acid Cl-SO_4 water, 2) Neutral NaCl water, 3) Bicarbonate water and 4) Steam heated acid SO_4 waters. The acid Cl-SO_4 waters are formed by condensation of magmatic gases discharged from a magma. The neutral NaCl waters are formed from the acid water through neutralization and S-mineral deposition due to water-rock interaction at lowering temperature. The bicarbonate waters and acid SO_4 waters are formed by mixing of CO_2 or H_2S derived from vapor separation of a deep hydrothermal system with meteoric water or the neutral NaCl waters. The principal differentiation process is the neutralization and S-mineral deposition of the acid Cl-SO_4 water under a temperature gradient to create the neutral NaCl water. However, we also need to consider other factors than the temperature dependence.

Water-rock reactions also have pressure dependent. HCl content in hydrothermal fluids has a negative pressure dependence; a hydrothermal solution has a larger HCl content at a lower pressure than at a higher pressure (Shinohara and Fujimoto, 1996; Botcharnikov et al., 2015). The pressure dependence implies that hydrothermal fluids discharged from a magma at a high pressure tend to have less acid than volcanic gases discharge at the surface. The average Cl/S ratio of the Japanese volcanic gases is about 0.2 (Shinohara 2013), whereas the ratio is about 0.5 in melt inclusion of basaltic magmas and is about 10 in those of silicic magmas. Therefore, a hydrothermal fluid formed by a complete solidification of the magma will have Cl/S ratio much larger than those of volcanic gases or the acid Cl-SO_4 waters. These evidences suggest that the acid Cl-SO_4 waters and the neutral NaCl waters have distinct origins with different condition of a magma degassing. Compilation of chemical compositions of hot spring waters and hydrothermal waters in Japan show a clear two frequency peaks of acid and near neutral pH with a gap at pH 4-5 (Muraoka et al., 2007). This pH distribution also suggests that the distinct origin of the two types of the hydrothermal fluids.

Keywords: volcanic gas, hot spring, geothermal fluids

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Constraining electrical resistivity structure of volcanoes using multiphase flow modelling: an example of Miyake-jima

*Marceau Gresse[1], Makoto Uyeshima[1], Takao Koyama[1], Maki Hata[1], Hideaki Hase[2], Koki Aizawa[3], Yusuke Yamaya[4], Yoichi Sasai[5], Jacques Zlotnicki[6], Tawat Rung-Arunwan[1], Hideki Ueda[7]

1. Earthquake Research Institute, The University of Tokyo, Tokyo, Japan, 2. Geothermal Energy Research & Development Co., Ltd., Tokyo, Japan, 3. Institute of Seismology and Volcanology, Faculty of Science, Kyushu University, Fukuoka, Japan., 4. Planning Division, National Institute of Advanced Industrial Science and Technology, Tokyo, Japan, 5. Earthquake Prediction Research Centre, Tokai University, Shizuoka, Japan, 6. CNRS, OPGC-UMR6524, Aubière, France, 7. National Research Institute for Earth Science and Disaster Resilience, Tsukuba, Japan

Measuring the electrical resistivity of rocks is a powerful and reliable method used to investigate volcanic edifices at depth. The electrical resistivity has two main contributions: (i) the conduction in the bulk pore fluid, associated to saturation, the ionic strength, and temperature of pore water, and (ii) the surface conductivity, related to the formation of secondary minerals. In volcanic environments, these two contributions are controlled by numerous interactions between hydrology, geology, tectonic settings and magmatic forcing. As a consequence, the evaluation of electrical resistivity images is strongly non-unique, and its interpretation remains complex.

Here, we propose a new approach to address this issue. First, we performed a 3-D electrical resistivity imagery of the Miyake-jima volcano using Magnetotellurics. Next, we combined the resistivity model obtained with hypocenters distribution. We revealed the sharp boundary between the saturated and unsaturated region, and a large conductive hydrothermal system connected to the main fumarolic area through a fractured region. Finally, we created a multiphase flow model of the volcano that constrains the resistivity model in term of temperature, fluid content and alteration.

Keywords: Hydrothermal system, Magnetotellurics, Miyake-jima, multiphase flow, electrical resistivity, alteration

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MT survey and 3-D resistivity structure in the Niseko area, southwestern Hokkaido

*Makoto Tamura[1], Toru Mogi[2], Junna Kanahiro[2], Daisuke Oka[1], Junya Maruyama[1], Takahiro Suzuki[1], Noritoshi Okazaki[1]

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In the Niseko area, southwestern Hokkaido, there are many volcanoes distributed along East-West direction that is so called “Niseko volcanic group”. And many hot springs are distributed around Iwaonupuri and Niseko-Annupuri volcano. Recently, geothermal explorations for energy development have been performed in this area.
During such situation, we are carrying out the priority research “Modelling of geothermal structure and assessment of geothermal resource potentials in the Niseko area” for sustainable application of geothermal resources. In this presentation, we show the MT survey and the 3-D resistivity structure analysis result as a part of this research.
We performed wideband MT survey at 18 stations in 2017 and 24 stations in 2018 around the Niseko area. Five components of electromagnetic fields were measured by ADU-07e and ADU-08e (manufactured by Metronix Geophisics). We obtained 32Hz data that was recorded for more than 5 days, 1024Hz data that was recorded more than 5 nights (1:00-5:00 : LT) and 32kHz data that was recorded one hour. Horizontal components of magnetic field data recorded at Ookura Vil., Yamagata Pref. were used for the remote reference processing of 32Hz and 1024Hz data. For 32kHz sampled data, we measured data at the same time in multiple stations for the remote reference processing. Also, we performed noise elimination processing for 50Hz electrical power lines.
MT responses at the frequency band of 12288-0.000488Hz were estimated using the robust time series processing code BIRRP (Chave and Thomson, 2004). Furthermore, we tried to obtain a 3-D resistivity structure with the aid of the ModEM inversion scheme (Egbert and Kelbert, 2012). Topographic effects might strongly affect the MT impedances because the survey area is located from the top to the foot of the volcano. In order to consider the topography into the 3D inversion, we used inland DEM data of 10m spacing provided by Geospatial Information Authority of Japan, and the seabed data of 500m spacing provided by Japan Coast Guard. Three-dimensional inversion was performed using four components of the tensor impedance from the field records.
In the results, we detected several conductive zones. A conductive zone was detected from the surface to several kilometers depth beneath the Iwaonupuri volcano. This would indicate volcanic hydrothermal system or hydrothermal rock alteration area. Also, we detected conductive zones around Ooyunuma Pond that is a hot spring bog, and southern foot of the Niseko-Annupuri volcano area where many hot springs are distributed. These conductive zones would indicate thermal water aquifers or related altered area.

Acknowledgement
The MT equipments (ADU-07) were used by Joint Usage Program in Earthquake Research Institute, University of Tokyo. Also, we used Magnetic field data of Geothermal Energy Research & Development CO., Ltd., for remote reference processing. We would like to thank these institutions.

Keywords: Niseko volcanic group, Magnetotelluric survey, resistivity structure, 3-D modeling

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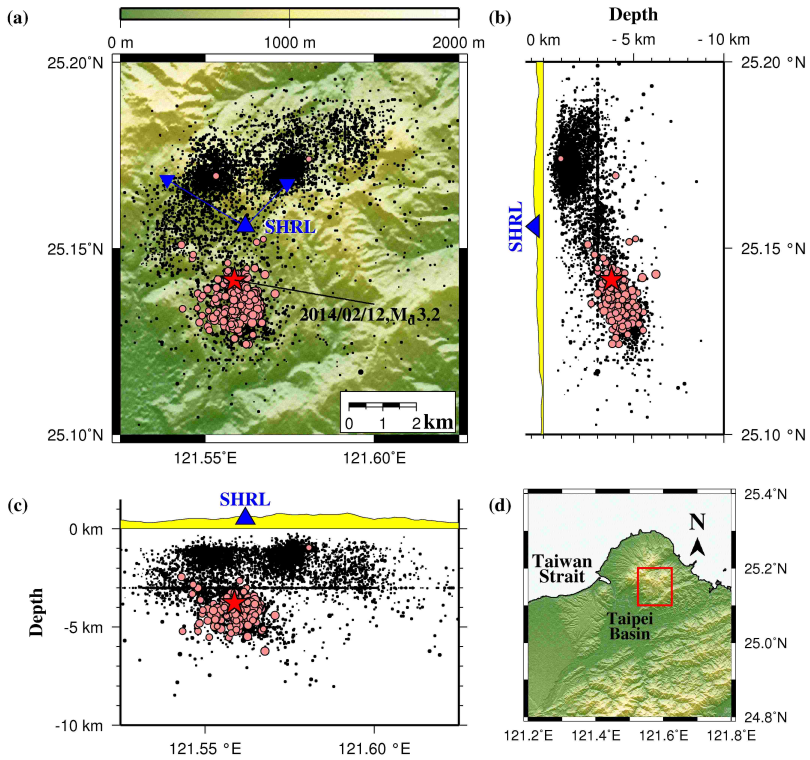
Hydrothermal fluid activity of the Tatun Volcano Group, Taiwan, revealed by self-potentials and seismicity

*Hong-Jia Chen[1], Zhi-Xian Yang[1], Chien-Chih Chen[1,2], Cheng-Horng Lin[3,4]

1. Department of Earth Sciences, National Central University, Taiwan., 2. Earthquake-Disaster & Risk Evaluation and Management, National Central University, Taoyuan, Taiwan., 3. Institute of Earth Sciences, Academia Sinica, Taipei, Taiwan., 4. Taiwan Volcano Observatory at Tatun, Taipei, Taiwan.

The objective of our research was to unravel the evolutions of the hydrothermal activities in the Tatun Volcano Group, Taiwan. We observed the significant variations of monthly earthquake counts, daily cumulative earthquake counts, and self-potential power spectral densities (PSDs) after April 21, 2016, providing strong evidence to identify hydrothermal fluid activities. This was further confirmed by the simulated electrical impedances using the resistivity forward modeling. Thus, an upward hydrothermal fluid movement is required to generate weaker PSDs of self-potentials at different frequencies. Herein, we concluded that geoelectric monitoring, along with seismic monitoring, help to understand the evolution of a hydrothermal system beneath a volcanic region.

Keywords: Hydrothermal fluid, Tatun Volcano, self-potential



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Utilizing the electrical conductivity distribution to unravel the hydrothermal system beneath Mt.Hasan composite volcano and its vicinity, southwest Cappodocia, Turkey

*Sabri Bulent Tank[1], Mustafa Karas[1]

1. Bogazici University

The electrical conductivity structure in the vicinity of Mt.Hasan composite volcano at Central Anatolia, Turkey was imaged by means of wide-band magnetotellurics data collected at 38 sounding locations and three-dimensional numerical modeling. The primary aim in this study was to decipher the major elements that drive a hydrothermal system beneath study area in detail. Therefore, following the dimensionality analyses performed by plotting induction arrows and phase tensor ellipses, the electromagnetic impedance data were numerically modeled in the data-space for imaging (i) the shallow and (ii) the deep electric structure with different frequency tables. While the former approach, provided information on the the thickness of a surficial (surface-to-2 km) and widespread welded ignimbrite layer, the latter approach, revealed the geometry of the deeper two layers beneath the ignimbrites that make up the clay cap. These layers that are found on the top of one another are interpreted as smectite (<10 Ohmm) and smectite-illite mixed (<10-15 Ohmm) layers. And finally beneath the smectite and smectite-illite layers, there is a cone-shaped anomaly (10 –60 Ohmm) that may have been serving as a reservoir for different vents in the area.

Keywords: Magnetotellurics, Volcanology, Hydrothermal systems, Mt.Hasan

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Three-dimensional Magnetotelluric Inversion to map geothermal structures in Eburru Geothermal field, Kenya.

*JUSTUS MAITHYA[1], Yasuhiro FUJIMITSU[2]

1. Graduate School of Engineering, Department of Earth Resources Engineering, Kyushu University, 2. Faculty of Engineering, Department of Earth Resources Engineering, Kyushu University

To explore the geothermal system in Eburru geothermal field in an attempt to delineate possible heat sources and fluid flow pathways governing the system, 107 Magnetotelluric (MT) soundings were deployed in the field. The MT data was analyzed using phase tensor to determine the dimensionality of the subsurface resistivity structure. These data were inverted to a fully three-dimensional resistivity model. Overall, the inverted resistivity model fits the MT data very well as evidenced by the data misfit curves. Consequently, 2-D inversion were carried out and a joint interpretation was made on the basis of the two models. The preferred 3-D model images a resistive top layer overlying a very conductive layer (~ 10 ohm.m) interpreted as the hydrothermally altered clay cap of the system and a moderate resistivity layer (about 30 ohm.m). These layers are underlain by a higher resistivity zone (~ 100 ohm.m). To characterize the resistivity structure in the field, resistivity profiles were extracted from the 3-D model in order to cut across the known geological structures. The profiles analysed show a deep reaching conductive channel connecting two conductors located at ~ 1 km from the surface and at a depth of ~ 4 km. This channel can be interpreted as potential path way used by geothermal fluid to migrate to the surface and manifests as fumaroles and hot spring. The occurrence of fumaroles along faults suggests leakage of steam where the cap is likely to have been cut by the faults. The resultant 3-D resistivity models are generally similar to the two-dimensional (2-D) inversion models, however, the deeper portion of the 3-D model seems to be more realistic than that of the 2-D model.

Keywords: Eburru geothermal field , Magnetotelluric, 3-D Inversion, Resistivity, 2-D inversion

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[J] Oral | S (Solid Earth Sciences)：S-TT Technology & Techniques

Mon. May 27, 2019 10:45 AM - 12:15 PM JST | Mon. May 27, 2019 1:45 AM - 3:15 AM UTC | 303 3F

[S-TT45] Synthetic Aperture Radar

convener:Youhei Kinoshita(University of Tsukuba), Yu Morishita(Geospatial Information Authority of Japan), Shoko Kobayashi(Tamagawa University), Takahiro Abe(Earth Observation Research Center, Japan Aerospace Exploration Agency), Chairperson:Shoko Kobayashi(Tamagawa University), Kazuya Ishitsuka(Kyoto University)

ALOS-2 and Sentinel-1A and 1B, which have highly enhanced capacity compared to previous SAR satellites, were launched in 2014, and their utilization has been widely expanding as the data has accumulated for approximately four years. Other long-operating SAR satellites like TerraSAR-X and Cosmo-SkyMed also contribute to expanding the SAR utilization. Now we are facing a new and abundant era of the satellite SAR, along with a worldwide trend to an open and free data policy of satellite data, with next-generation advanced SAR satellite plans by several countries, and with several plans to construct SAR constellations by private sectors. In addition, SAR technologies with other platforms, such as ground-based SAR with high temporal resolution and UAV (Unmanned Aerial Vehicle) SAR with flexible operability, have also been developed and used for various targets. These facts indicate that the SAR utilization has become widespread in both basic researches (e.g., earth science) and diverse applications (e.g., disaster prevention and forest monitoring). In this session, we would like to widely invite research and application results with regard to SAR, sharing our knowledge and having a discussion for the advancement of the SAR utilization.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[STT45-01] Extraction of ground changes near the crater by the eruption of Kilauea volcano.

*Fujiyama Kaho[1], Masanobu Shimada[1], Yuki Kimoto[1], Kenta Yoshioka[1] (1.TokyoDenki University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[STT45-02] ALOS-2 observation of the 2017 Sefidsang earthquake, northeastern Iran: a blind shallow-dipping thrust event near the Eastern Kopeh Dagh

*Nematollah Ghayournajarkar[1], Yo Fukushima[2] (1.Graduate School of Science, Tohoku University, 2.International Research Institute of Disaster Science, Tohoku University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[STT45-03] **InSAR ground displacements and slip distribution associated with secondary fault slips of the 2016 Kumamoto earthquake**

*Yo Fukushima[1], Daisuke Ishimura[2] (1.International Research Institute of Disaster Science, Tohoku University, 2.Department of Geology, Tokyo Metropolitan University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[STT45-04] Surface displacements at the Kumamoto plain using persistent scatterer interferometry and comparison with groundwater levels

*Kazuya Ishitsuka[1], Takeshi Tsuji[2] (1.Kyoto Univ., 2.Kyushu Univ.)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[STT45-05] Forest fire detection in the low biomass dry forest with JICA-JAXA Forest Early Warning System in the Tropics (JJ-FAST).

*Manabu Watanabe[1], Christian Naohide koyama[1], Masato Hayashi[2], Izumi Nagatani[2], Takeo Tadono[2], Masanobu Shimada[1,2] (1.School of Science and Engineering, Tokyo denki university, 2.JAXA/EORC)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[STT45-06] Nominal operation results of Japanese ALOS-2

★Invited Papers

*Shinichi Sobue[1] (1.Japan Aerospace Exploration Agency)

Extraction of ground changes near the crater by the eruption of Kilauea volcano.

*Fujiyama Kaho[1], Masanobu Shimada[1], Yuki Kimoto[1], Kenta Yoshioka[1]

1. TokyoDenki University

Synthetic Aperture Radar, SAR, is a sensor that irradiates radio waves (microwaves) and receives radio waves reflected and returned from the ground surface.

It is characterized that SAR can observe the target regardless of weather and day and night. Even when the plume is blowing hard, SAR signal can penetrate through the clouds and smokes and can observe the crater.

The Kilauea volcano to be investigated is one of the five shield volcanoes that made up the Island of Hawaii on Hawaii Island. It is an active volcano that is presumed to have formed about 600,000 years ago, and is presumed that it appeared on the sea surface about 100 thousand years ago and the eruption is still continuing, but the eruption of 2018 stopped the flow of the lava did. The Kilauea is known for its calm eruption, but since 1983 it continues to erupt almost continuously, depending on the direction of the lava flow, lava may swallow the settlement and destroy the settlement.

This research will detect the deformation of the volcanic mountain by using the interferometric SAR technique. INSAR uses two types of data with different times and finds variates from the differential distance between from the satellite to the target (phase difference).

Using this method, we measure the crustal deformation with accuracy of several mm to several cm by capturing the variation near the crater of Kilauea volcano which can not be investigated locally. We will quantitatively evaluate the crustal deformation around the crater using image data of two periods including the eruption occurrence period from October 9, 2014 to July 31, 2018.

As a result, the crater was subsided by 6.5 cm from November 25, 2014 to March 27, 2018 in the ascending orbit, and it was subsided by 9 cm during the period from October 9, 2014 to December 14, 2017 in descending orbit.

As a future task, since we observed fluctuations in the north direction other than vertical component fluctuations in the crater, we plan to conduct research including the relation with the ground characteristics of Hawaii Island.

Keywords: INSAR

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ALOS-2 observation of the 2017 Sefidsang earthquake, northeastern Iran: a blind shallow-dipping thrust event near the Eastern Kopeh Dagh

*Nematollah Ghayournajarkar[1], Yo Fukushima[2]

1. Graduate School of Science, Tohoku University, 2. International Research Institute of Disaster Science, Tohoku University

The Iranian plateau is deformed between the converging Arabian and Eurasian plates. Their convergence is principally taken up by the active Makran subduction zone to the South, in addition to shortening and strike-slip faulting accommodated by crustal structures, which are non-uniformly distributed in several continental deformation domains such as the Zagros, Alborz and Kopeh Dagh mountain ranges. During the last decade, several studies carried out in the Zagros, Alborz and central Iran have produced a better understanding of active deformation in these zones. Conversely, such detailed studies are less common in northeast Iran.
Indeed, despite all the efforts made by previous workers to shed light on active tectonics in northeast Iran, this region still suffers from a lack of detailed structural and kinematics data and should be considered as a concealed segment in the geodynamic puzzle of the Arabia-Eurasia collision. This matter is made worse by the facts that northeast Iran is the second populated region and one of the most seismically active deformation domains in the country that has experienced at least nine large earthquakes (M >= 7) during the last six centuries (Tchalenko, 1975; Ambraseys and Melville, 1982; Berberian and Yeats, 1999, 2001).
On 5 April 2017, an Mw 6.1 earthquake occurred in the northeastern region of Iran, about 90 km southeast of the city of Mashhad, the second most populous city in Iran with a population of over 3 million people. The epicenter (35.776 N, 60.436 E, USGS) was at a remote mountainous area, about 30 km northeast of the Sefidsang district where approximately 5000 people live, and the depth was about 13 km. This earthquake raised an opportunity to study the deformation pattern in the SE of the Kopeh Dagh Mountains.
Space geodetic observations of ground deformation provide important data to investigate the seismogenic fault and the subsurface deformation mechanics. Here we used ALOS-2 synthetic aperture radar data to produce SAR interferograms using the GMTSAR software (Sandwell et al., 2010) to investigate coseismic and postseismic deformation associated with the 2017 Sefidsang earthquake. The ascending and descending interferograms were produced and both indicate thrust-dominated slip that is consistent with seismic data sets, with the maximum line-of-sight coseismic displacement of 9.9 and 13 cm, respectively. The obtained coseismic deformation maps have good consistency with Sentinel-1 interferograms that showed maximum line-of-sight displacement of 10.5 and 13.7 cm for ascending and descending interferograms, respectively (Xu et al., 2018).
We also used ascending SAR data acquired on 2017/06/24 to 2018/12/22 for evaluating the postseismic deformation caused by this earthquake. The produced interferogram does not show any displacement more than the noise level (~1 cm).

Keywords: InSAR, Northeastern Iran, Kopeh Dagh, Sefidsang earthquake

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InSAR ground displacements and slip distribution associated with secondary fault slips of the 2016 Kumamoto earthquake

*Yo Fukushima[1], Daisuke Ishimura[2]

1. International Research Institute of Disaster Science, Tohoku University, 2. Department of Geology, Tokyo Metropolitan University

By using interferometric synthetic aperture radar (InSAR) and field reconnaissance surveys, activation of numerous secondary faults associated with the occurrence of the 2016 Kumamoto earthquake has been identified (e.g., Fujiwara et al., 2016, EPS). In this study, we investigated the characteristics of the displacements of secondary faults around the Miyaji district, Aso, within the Aso caldera, and further inverted for the slip distribution of the secondary faults.

In this study, we used RINC software (Ozawa et al., 2016, EPS) to produce three interferograms with different line-of-sight directions, and unwrapped with SNAPHU (Chen and Zebker, 2000). The unwrapped interferograms are “un-referenced”, and each of them contains an unknown offset. The offset values were estimated using the daily coordinates data (F3 solution) of the GEONET network provided by the Geospatial Information Authority of Japan, and are subtracted from the interferograms. Finally, displacements along three line-of-sight directions are decomposed into EW, NS, and UD components, and EW and NS components were further used to derive the horizontal displacements in N50E direction, parallel to the secondary faults in Miyaji. The main characteristics of the ground displacements are as follows. (1) Two strands of parallel displacement discontinuity traces, corresponding to the surface fault, are observed, with a separation of around 0.8 km. (2) The length of the northern and southern strands of traces are around 1.3 km and 2.3 km. (3) Each of the two strands of traces are composed of multiple en-echelon traces. (4) The fault displacements of the northern strand were up to 5 cm for both vertical (northern side downward) and right-lateral directions. (5) The fault displacements of the southern strand were up to 8cm for vertical (northern side downward) and 10cm for right-lateral directions.

Next, we simultaneously estimated the slip distribution and geometry of the two faults (Fukushima et al., 2013, 2018), after removing long wavelength displacements by polynomial fitting. As for the fault geometry, we assumed that the top of the faults reach the averaged location of the fault strands and we set the dip angles as model parameters. We conducted non-negative least squares inversion for the fault slip, prohibiting reverse and left-lateral faulting based on the observed ground displacements. Two types of inversions were made on the assumption of the rake angle; one is assuming a uniform rake angle for all the fault elements, and the other is solving for the vertical and left-lateral slips. The two types of inversions both succeeded in explaining the ground displacement data, so we adopted the result of the simpler model with uniform rake angle as our preferred model.

In our preferred model, two faults dip northward with the southern one having a lower angle (48 degrees) than the northern one (67 degrees), making two faults merge at a depth of approximately 1.3 km. The lower limit of the slip area on the southern fault coincided the merging depth of 1.3 km, and the maximum slip of 25 cm was obtained at a depth of approximately 0.7 km. The slip on the northern fault was limited to shallower than 0.4 km with smaller slips of up to 12 cm.

Acknowledgements
This study used the PALSAR-2 data shared among PIXEL (PALSAR Interferometry Consortium to Study out

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Evolving Land surface), originally provided from Japan Aerospace Exploration Agency (JAXA) through a joint research contract with the Earthquake Research Institute (ERI) of the University of Tokyo. A part of this study was conducted under a special joint research project of ERI. We are grateful to Dr. Taku Ozawa for the RINC software, and to the Geospatial Information Authority of Japan for letting us use the daily coordinates (F3 solution) derived from the GEONET network.

Keywords: Synthetic Aperture Radar Interferometry, Kumamoto Earthquake, Secondary Fault

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Surface displacements at the Kumamoto plain using persistent scatterer interferometry and comparison with groundwater levels

*Kazuya Ishitsuka[1], Takeshi Tsuji[2]

1. Kyoto Univ., 2. Kyushu Univ.

After the 2016 Kumamoto earthquake, change in groundwater levels has been observed at the Kumamoto plain, which is likely associated with the alteration of the aquifer system by the earthquake. Surface displacement can occur due to groundwater level changes at a confined aquifer because pore pressure changes lead to the deformation of its granular skeleton. Persistent scatterer interferometry (PSI) using a satellite imaging is a powerful method to estimate spatial and temporal pattern of surface displacements. In this study, we estimated surface displacement at the Kumamoto plain from May 2016 to June 2017 using PSI analysis of ALOS-2/PALSAR-2 images. Moreover, we compared the displacement pattern in the period after the earthquake with the displacement from Jan. 2007 to Jan. 2011 using ALOS/PALSAR images.

As a result of analysis, we estimated surface displacement with the magnitude of about 2-3 cm along the Futagawa and Hinagu fault systems. We interpreted that the displacements along the fault traces were due to the afterslip. On the other hand, we also found surface displacements apart from the fault traces. For example, surface uplift up to 4 cm/year was observed during about 1 year after the earthquake around the west flank of Aso volcano. The displacement began several months after the earthquake, and generally correlated with the areas of groundwater level increased. Since the displacement pattern was not observed in ALOS/PALSAR results, we speculated that the displacement was induced by the groundwater level changes by the earthquake. In addition, we estimated the skeletal storage coefficients from surface displacements and groundwater levels, and found that the coefficients differed by the earthquake at several locations, indicating the temporal alteration of permeability or compressibility of the aquifer. Our results demonstrate the effectiveness of the surface displacement monitoring combined with groundwater level data at the aquifer system.

Acknowledgements: The ALOS-2/PALSAR-2 level 1.1 data used in this study were provided by the PIXEL (PALSAR Interferometry Consortium to Study our Evolving Land Surface) group in cooperative research with the Earthquake Research Institute, University of Tokyo. The ALOS-2/PALSAR-2 data belongs to the Japan Aerospace Exploration Agency. The groundwater level data used in this study were measured by several public institutes, and the data were corrected by the working group in Japan Association of Groundwater Hydrology.

Keywords: Surface displacement, the Kumamoto plain, change in groundwater levels

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Forest fire detection in the low biomass dry forest with JICA-JAXA Forest Early Warning System in the Tropics (JJ-FAST).

*Manabu Watanabe[1], Christian Naohide koyama[1], Masato Hayashi[2], Izumi Nagatani[2], Takeo Tadono[2], Masanobu Shimada[1,2]

1. School of Science and Engineering, Tokyo denki university, 2. JAXA/EORC

JICA-JAXA Forest Early Warning System in the Tropics (JJ-FAST, [1]) is first and only one SAR-based deforestation detection system monitoring tropical forest globally. The JJ-FAST started from November 2016, and has a merit to operate not only in dry season, but also in rainy season. The current system uses change of gamma_0 for deforestation detection. Watanabe et al. [2] pointed out the JJ-FAST detected not only the deforestation sites, but also detected severely damaged forest fire sites occurred in a dense forest. In this paper, detectability of forest fire in the low biomass dry forest with JJ-FAST system were examined.

JJ-FAST detected 168 deforestation sites between Nov. 11 and Dec. 23, 2018 in South Africa. MODIS burned area product [3] obtained between Oct. 10 and Dec. 31, 2018 were overlapped and confirmed that the almost all the polygons detected by the JJ-FAST deforestation detection algorithm were overlapped with the burned area detected by MODIS. The forest fire area were also identified by Sentinel-2 data. BBC news [4] reported severe wildfire occurred in George, South Africa on Oct. 30, and the area was also coincident with the one detected by the JJ-FAST algorithm. The JJ-FAST algorithm also detected 82 deforestation sites in Mozambique between Aug. 13 and Nov. 5, 2018. These sites were also overlapped with the MODIS burned area. From these facts, we concluded that the current JJ-FAST deforestation detection algorithm could detected severely damaged forest fire area in the low biomass dry forest. It is known that forest fire in dense forest is detected by increase of radar backscattering in HH polarization [2]. This is explained that forest fire makes forest canopy dry and induces more double bounce scattering, implying the increase of backscattering in HH polarization. In the case of low biomass dry forest, forest fire makes forest canopy dry and induces lower volume scattering in a tree canopy layer, implying the decrease of backscattering in HV. The decrease of volume scattering also occurred in the dense forest. But higher density of burned trees left on the ground still induces brighter radar reflection in HV and make it difficult to detects the forest fire sites in HV polarization.

[1] JJ-FAST, http://www.eorc.jaxa.jp/jjfast/jj_index.html, accessed on February 17, 2019

[2] Manabu Watanabe, et al., A possibility of forest fire site detection by JJ-FAST system

[3] https://modis.gsfc.nasa.gov/data/dataprod/mod45.php, accessed on Feb. 17, 2019

[4] https://www.bbc.com/news/world-africa-46029553, accessed on Feb. 17, 2019

Keywords: Forest monitoring, Deforestation detection, PALSAR-2

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Nominal operation results of Japanese ALOS-2

*Shinichi Sobue[1]

1. Japan Aerospace Exploration Agency

The Advanced Land Observing Satellite-2 (ALOS-2) was successfully launched on 24th May 2014. The mission sensor of ALOS-2 is the Phased Array type L-band Synthetic Aperture Radar-2 called PALSAR-2 which is the state of the art L-band SAR system. Until now after the successful completion of initial checkout after launching, ALOS-2 has been contributed to a lot of emergency observations for natural disasters, not only in Japan but also in the world. Furthermore, based on the Basic Observation Scenario (BOS) of ALOS-2, 10m global map data and other mode data are routinely collected and archived. This paper describes the results of ALOS-2 operation in nominal operation phase.

Keywords: ALOS-2, nominal operation

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[J] Oral | S (Solid Earth Sciences)：S-TT Technology & Techniques

Mon. May 27, 2019 1:45 PM - 3:15 PM JST | Mon. May 27, 2019 4:45 AM - 6:15 AM UTC | 303 3F

[S-TT45] Synthetic Aperture Radar

convener:Youhei Kinoshita(University of Tsukuba), Yu Morishita(Geospatial Information Authority of Japan), Shoko Kobayashi(Tamagawa University), Takahiro Abe(Earth Observation Research Center, Japan Aerospace Exploration Agency), Chairperson:Yohei Kinoshita(RESTEC), Takahiro Abe(JAXA)

ALOS-2 and Sentinel-1A and 1B, which have highly enhanced capacity compared to previous SAR satellites, were launched in 2014, and their utilization has been widely expanding as the data has accumulated for approximately four years. Other long-operating SAR satellites like TerraSAR-X and Cosmo-SkyMed also contribute to expanding the SAR utilization. Now we are facing a new and abundant era of the satellite SAR, along with a worldwide trend to an open and free data policy of satellite data, with next-generation advanced SAR satellite plans by several countries, and with several plans to construct SAR constellations by private sectors. In addition, SAR technologies with other platforms, such as ground-based SAR with high temporal resolution and UAV (Unmanned Aerial Vehicle) SAR with flexible operability, have also been developed and used for various targets. These facts indicate that the SAR utilization has become widespread in both basic researches (e.g., earth science) and diverse applications (e.g., disaster prevention and forest monitoring). In this session, we would like to widely invite research and application results with regard to SAR, sharing our knowledge and having a discussion for the advancement of the SAR utilization.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[STT45-07] Estimation of velocity distribution of Shirase Glacier derived from SAR data obtained by ERS-1/2 tandem mission

*Koichiro Doi[1,2], Yuichi Aoyama[1,2], Kazuki Nakamura[3], Tsutomu Yamanokuchi[4], Kazuo Shibuya[1] (1.National Institute of Polar Research, 2.SOKENDAI, 3.College of Engineering, Nihon University, 4.RESTEC)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[STT45-08] Heavy rainfall-induced displacement of more than 2.5m in the Kushiro Marsh in 2016, detected by ALOS-2 SAR

*Satoshi Fujiwara[1], Yu Morishita[1], Takayuki Nakano[1], Yuji Miura[1], Yasuaki Kakiage[1], MURAMATSU Hiroki[1], Hiroshi Une[1] (1.GSI of Japan)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[STT45-09] Surface deformation of Asama Volcano, Japan, detected by time-series InSAR combining persistent and distributed scatterers, 2014-2018

*Yosuke Aoki[1], Xiaowen Wang[1] (1.Earthquake Research Institute, University of Tokyo)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[STT45-10] Improvement of Airborne L-band-SAR (Pi-SAR-L2) Coherence by Pixel by Pixel Resampling

*Makoto Murakami[1], Masato Furuya[1], Taku Ozawa[4], Youichiro Takada[1], Yosuke Aoki[3], Masanobu Shimada[2], Shohei Narita[1] (1.Hokkaido University, 2.Tokyo Denki University, School of Science and engineerring, 3.Earthquake Research Institute, The University of Tokyo, 4. National Research Institute for Earth Science and Disaster Resilience)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[STT45-11] Ionospheric delay estimation in SAR interferometry: Significance of the method using the split-spectrum double-difference interferogram

*Taku Ozawa[1] (1.National Research Institute for Earth Science and Disaster Resilience)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[STT45-12] Detecting surface displacement accosiated with the 2018 slow slip event around Boso peninsla by use of Sentinel-1 InSAR with atmospheric correction

*Youhei Kinoshita[1], Tadahiro Nimura[1], Ryoichi Furuta[1] (1.RESTEC, Remote Sensing Technology Center of Japan)

Estimation of velocity distribution of Shirase Glacier derived from SAR data obtained by ERS-1/2 tandem mission

*Koichiro Doi[1,2], Yuichi Aoyama[1,2], Kazuki Nakamura[3], Tsutomu Yamanokuchi[4], Kazuo Shibuya[1]

1. National Institute of Polar Research, 2. SOKENDAI, 3. College of Engineering, Nihon University, 4. RESTEC

Shirase Glacier is one of the fastest flowing ice stream in Antarctica flowing into the southernmost of Lutzow-Holm Bay in Dronning Maud Land, East Antarctica. It is important to clarify the spatial flow rate distribution with a high resolution to investigate causes of the fast flow and the temporal flow rate changes. In order to make a high resolution flow velocity map, we apply a usual interferometric Synthetic Aperture Radar (InSAR) technique to the obtained data. However, since flowing velocity of the ice stream is greater than 2 km/year (Nakamura et al., 2007, Aoyama et al., 2016), it is difficult to estimate the flow velocity by applying an InSAR technique to the ordinal repeat cycle SAR mission data.

Tandem mission by European Satellite of Remote sensing (ERS)-1/2 was conducted in 1996 and 1999. In this tandem mission, ERS-2 had flown after ERS-1 in the same orbit with an interval of one day, and many InSAR pairs with one day temporal baseline were obtained through the mission.

We successfully obtained two SAR interferograms over Shirase Glacier using this tandem mission InSAR pairs acquired at 1996/06/02-1996/06/03 and 1999/11/14-1999/11/15. We estimated surface displacements along range direction (direction of radar illumination) by applying differential InSAR (DInSAR) with a TanDEM-X 90m DEM (Rizzoli et al., 2017) to remove topographic phase. We also estimated displacements along azimuth direction (direction perpendicular to range direction) by applying a split beam interferometry (SBI) (Bechor and Zebker, 2006) technique to the two InSAR pairs. By combining the range and azimuth displacements, spatial flow velocity distributions can be derived with a high resolution.

In the presentation, we will show two dimensional flow velocity maps with a resolution of approximately 20 m at the two periods and discuss spatial and temporal velocity changes. We will also compare the obtained flow velocity with those by in-situ GNSS measurements in the glacier.

Keywords: Shirase Glacier, flow velocity map, ERS-1/2 tandem mission, DInSAR, SBI

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Heavy rainfall-induced displacement of more than 2.5m in the Kushiro Marsh in 2016, detected by ALOS-2 SAR

*Satoshi Fujiwara[1], Yu Morishita[1], Takayuki Nakano[1], Yuji Miura[1], Yasuaki Kakiage[1], MURAMATSU Hiroki[1], Hiroshi Une[1]

1. GSI of Japan

The Kushiro Marsh in eastern Hokkaido is the largest wetland in Japan. Monitoring changes in environmental conditions is important to support preservation of the wetland. In the summer of 2016, Hokkaido was affected by several typhoons and suffered record-breaking heavy rainfall. We constructed ~50 ALOS-2 SAR interferograms, covering the Kushiro Marsh for the period 2014 to 2018, including the summer of 2016. A time series of vertical displacement of the wetland detected by the interferograms corresponded with water level changes in the rivers in the wetland. This implied that the SAR data had successfully detected the height change of the water surface in the wetland. Between August 6, 2016 and September 5, 2016, an area of the wetland (~1 km) to the southeast of Akanuma shifted ~2.7 m horizontally in the downstream direction, which coincided with a large and rapid increase in the water level caused by the heavy rains. This large displacement remained after the water level decreased. Prior to this large horizontal shift, an uplift of ~10 cm was identified in almost the same region. This uplift might have been caused by the leaking of groundwater from the basement of the Akanuma pond, and implied that the peat layer, which had a thickness of several meters floated slightly, like a floating islands, possibly causing the large horizontal shift.

Reference

Fujiwara et al. (2019): Heavy rainfall-induced displacement of more than 2.5m in the Kushiro Marsh in 2016, detected by ALOS-2 SAR, *Journal of Geography (Chigaku Zasshi)*.

Keywords: Kushiro Marsh, environment of wetland, underground water, heavy rainfall, surface displacement, ALOS-2

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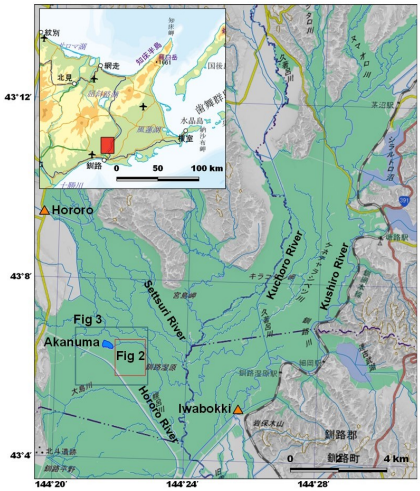


Fig 1 Map of the Kushiro Marsh.
The light green areas denote the wetlands. The red rectangles denotes the area shown in Fig 2, and the dark blue rectangle corresponds to the area shown in Fig 3.

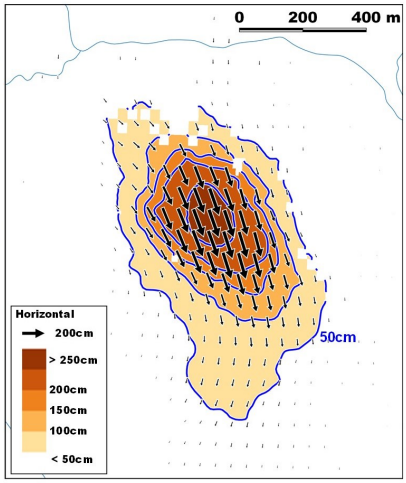


Fig 2 Horizontal displacement to the southeast of Akanuma in the summer of 2016 detected by ALOS-2 SAR.

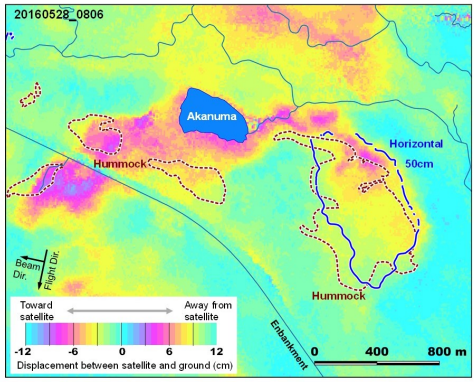


Fig 3 ALOS-2 SAR interferogram of around Akanuma. The blue line denotes the area with large horizontal displacement (>50cm). The brown broken lines denote hummocks.

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Surface deformation of Asama Volcano, Japan, detected by time-series InSAR combining persistent and distributed scatterers, 2014-2018

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1. Earthquake Research Institute, University of Tokyo

Asama volcano, located in Central Japan, is one of the most active volcanoes in Japan. Surface deformation at Asama volcano has rarely been documented because of its high topography and snow cover at the summit. In this study, we present first Interferometric Synthetic Aperture Radar (InSAR) observation of ground deformation of Asama volcano with 120 Sentinel-1 SAR images from both ascending and descending tracks and 20 ALOS-2 images from a descending track acquired between 2014 and 2018. We exploited both persistent and distributed scatterers to overcome SAR signal decorrelation and applied the three-dimensional unwrapping method to retrieval displacement time series efficiently. Our observations reveal asymmetric deformation at Asama volcano with two main deformation regions at the northeast and southeast flanks of the volcano, respectively. The northeast flank (NEF) exhibits line-of-sight (LOS) extensions in all the three SAR datasets with maximum velocities of 14, 10, and 12 mm/year for the descending ALOS-2, ascending and descending Sentinel-1 measurements, respectively. The southeast flank (SEF) shows LOS extension in the ascending observations and LOS shortening in the descending observations with velocities between -12 and 9 mm/year, respectively. Decomposition of the LOS displacements reveals nearly pure vertical subsidence at the NEF, while the SEF also shows an evident eastward component other than vertical subsidence. Comparisons of the vertical subsidence at two continuous GPS stations near the summit crater with our InSAR observations indicate small discrepancies smaller than 3 mm/year. We interpret that the subsidence at the NEF is primarily due to the cooling contraction of pyroclastic deposits emplaced in the 1783 eruption, and the SEF is susceptible to flank instability. The asymmetric deformation of the volcano may also be related to the hydrothermal activity that is controlled by the underground structure of the volcano. This study highlights that much more efforts should be taken to monitor the slope instability of Asama volcano in the future.

Keywords: Synthetic Aperture Radar, Time-series analysis, Thermal contraction

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Improvement of Airborne L-band-SAR (Pi-SAR-L2) Coherence by Pixel by Pixel Resampling

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1. Hokkaido University, 2. Tokyo Denki University, School of Science and engineerring, 3. Earthquake Research Institute, The University of Tokyo, 4. National Research Institute for Earth Science and Disaster Resilience

1. Introduction

Although Airborne SAR is advantageous in terms of flexibility of flight path direction and observation scheduling, the deviation from the flight path linearity due to the perturbation by wind irregularity makes interferometry difficult. We have been working on a development of L band airplane SAR interferometric technique with an aim to use it for volcanic deformation monitoring. The most effective way to improve the coherence between 2 airborne observations is precise coregistration of the slave image against the master image. We here present a new method of precise coregistraion for airborne SAR interferometry using pixel by pixel resampling capability of RINC software package developed by Taku Ozawa at NIED. We demonstrate the usefulness of this technique utilizing airborne repeat path SAR data acquired by JAXA’ s airborne L-band SAR system (pi-sar-l2) over southern Kyushu volcanoes (Sakurajima volcano, Kirishima volcano and Unzen volcano) .

2. The classic coregistration method

Because the flight path of satellite is relatively smooth, the coregistration between master and slave images based on two dimensional quadratic function fitting is sufficient. Our interferometric process for airborne SAR started with the same technique. However, our preliminary tests suggested the insufficiency of this classic method for airborne SAR failing to faithfully follow high frequency component of pixel offset caused by irregularity of the airplane flight path due to the wind fluctuations especially in along-track direction.

3. Precise coregistration method using pixel by pixel matching technique

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To improve the effectiveness of coresistration, we employ an additional step to fit the two dimensional pixel offset field after the primary fitting using a quadratic function. In the process of the additional fitting for the the primary fitting residuals, we use an empirical smooth function fitting capability of Matlab software package. Thus we calculate the offset values between master and slave for every pixel of master image and then we carry out coregistration using pixel by pixel resampling capability of RINC software package. This additional procedure significantly improves the coherence as we see below.

3. Demonstration of Usefulness of New method using data over Kirishima volcano

We tested the usefulness of the new method for the repeat path SAR data acquired on 2014 and 2016 over the Kirishima volcano complex. The figure shows the comparison of the coherence between the results of classic and new methods. The area of good coherence increases significantly in the image derived by the new method in the right hand, where brighter colorization corresponds to better coherence. The improvement of the lower half of the image is obvious. Although there still remain stripes of worse coherence which run in the direction perpendicular to the azimuthal axis, the width of those stripes is reduced. This bad coherency seems to be caused by abrupt change of flight speed of the airplane. In this particular observation, our target is Iwoyama dome which is a nest of recent phreatic activity, and the coherence there is actually greatly improved by the new method resulting in better understanding of the ongoing inflation mechanism which will be reported elsewise. In the presentation, we will show the test results using other data sets and discuss the usefulness of the new methods.

Credits: We used RINC (Ver. 0. 36) developed by Dr. Taku Ozawa and Geospatial Information Authority of Japan height data for SAR interferometric processing. This study was supported by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan, under its Earthquake and Volcano Hazards Observation and Research Program.

Keywords: Airborne SAR, SAR Interferometry, Crustal Deformation

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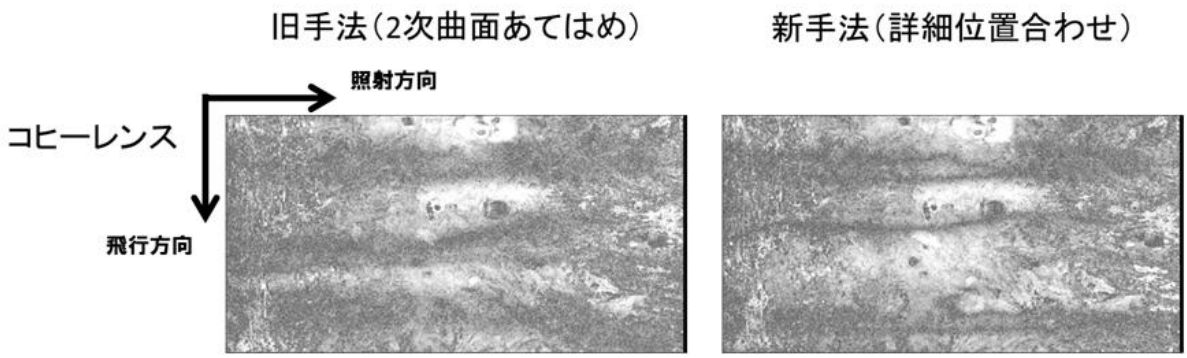


図　EW軌道データ（2014-2016）に対するリサンプル新旧手法の比較.
コヒーレンスは，明るいピクセルほど干渉性が高い．全体的に干渉性が上がっているが，特に，画像の下半分で改善が顕著である.

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Ionospheric delay estimation in SAR interferometry: Significance of the method using the split-spectrum double-difference interferogram

*Taku Ozawa[1]

1. National Research Institute for Earth Science and Disaster Resilience

Split-spectrum method is used as a useful method in reducing the ionospheric delay which is one of the major error factors in SAR interferometry (e.g., Brcic et al., 2010; Rosen et al., 2010; Gomba et al., 2016). This method divides chirp signal of SAR into high and low bands, and generates interferograms for each bands. The ionospheric delay and crustal deformation components are extracted from them. Generally, the ionospheric delay component phai,iono can be estimated from

$\Phi_{iono}=f_L f_H(\Phi_L f_H - \Phi_H f_L)/(f_0(f_H^2-f_L^2))$ -(1)

where f0, fl, fh are center frequencies of full, lower, and higher bands. phai,l phai,h are phase differences of interferograms for lower and higher bands. Empirically, for interferometric pairs with high coherence, the ionospheric delay component can be accurately estimated from this equation. However, that with low coherence, the accuracy degrades mainly due to the difficulty of unwrapping. Then Wegmüller et al. (2018) proposed the method using following equation,

$\Phi_{iono}=A\Phi_0 + B(\Phi_H-\Phi_L)$ -(2)

where phai,0 is phase difference of full-band interferogram, and A, B are coefficient derived from center frequencies. In general, the better coherence is obtained for interferometric pair with wider bandwidth, and therefore the first term is relatively easier to unwrap than that with divided frequencies. Since the second term falls within the value of $-\pi$ to $+\pi$ in most cases, it is possible to easily obtain the phase difference. Furthermore, since A is approximately 0.5, equation (2) can be approximated to

$2\Phi_{iono}=\Phi_0 + 2B(\Phi_H-\Phi_L)$ -(3)

As mentioned before, the second term can easily estimate the phase difference, and then it is possible to obtain an interferogram showing only the ionospheric delay component without unwrapping.

Now, we are developing ionospheric delay estimation tools based on the above three equations. In this presentation, we describe the results of test analysis on several pairs using tools under development. In this analysis, SAR images divided the band in half are used. For high and low frequency pairs, interferograms are generated. After removing orbital and topographic fringes, the spectrum filter (Goldstein and Werner, 1998) is applied to them. From these interferograms, ionospheric delay is estimated using each equation. An outlier removing filter and a Gaussian filter are applied to ionospheric delay image.

First, as a pair with relatively high coherence, the interferometric pair of ALOS-2/PALSAR-2 images which observed Azuma-yama on September 9, 2014 and August 11, 2015 was analyzed. About this pair, almost the same results were obtained from analysis using each equation. However, as a result from interferometric pair which observed on March 7, 2016 and April 18, 2016, included large crustal deformation associated with the 2016 Kumamoto earthquake, differences were obtained in results from analysis using each equation. In particular, in the analysis using Eq. (1), the unwrapping error in the vicinity of the fault seems to have a big influence. In manual analysis, if the error is correctly masked, it is considered that roughly the same result as equation (2) is obtained. In a result from equation (3), the ionospheric delay component was obtained even in the vicinity of the fault. However, in other interfering pairs with particularly poor coherence, the ionospheric delay could not be properly estimated by the analysis using Equation (3) in some cases.

Although there are few analysis cases at the present time and more case analysis is required, it is generally felt that the method based on equation (2) can estimate the ionosphere delay with relatively high

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accuracy. However, in cases where large crustal deformation are included such that unwrapping is difficult, the method based on equation (3) may be better. It may be necessary to select a method which is appropriate for a case.

Keywords: SAR, ionospheric delay, crustal deformation

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Detecting surface displacement accosiated with the 2018 slow slip event around Boso peninsla by use of Sentinel-1 InSAR with atmospheric correction

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1. RESTEC, Remote Sensing Technology Center of Japan

The slow slip, also denoted as the slow eathquake, is known to release accumulated strain energy with no or slight seismic wave radiation. The slow slip is usually detected by highly accurate geophysical measurements such as the Global Navigation Satellite System (GNSS) and seismometers because of very small surface deformation on the order of millimeters to centimeters, and small ground oscillation (named as a tremor). Until now, several papers reported slow slip events, for example, at Tokai area (e.g. Yamamoto et al. 2005, EPS; Ozawa et al. 2016, EPS), Cascadia (e.g. Dragert et al. 2004, EPS; Hawthorne and Bartlow 2018, JGR), and Nankai Trough (e.g. Kobayashi 2017, EPS; Ozawa 2017, EPS). The area around Boso Peninsla is also a location where slow slip events have occuered with intervals of several years (Fukuda 2018, JGR). However, most of the reffered papers here used GNSS observations that have a limitation of low spatial resolution (Usually a few tens of kilometers between ground stations). In this study we conducted the InSAR analysis to detect the surface displacement accosiated with the 2018 slow slip event near the Boso peninsla by use of Sentinel-1 observations and numerically-derived atmospheric models.

In the InSAR andalysis we used Sentinel-1 TOPS IW data with three satellite paths (path 39, 141, and 46). Paths 39 and 141 are ascending direction and path 46 is descending direction. The interferometric analysis was conducted by GAMMA software with the 1-arcsecond SRTM DEM for the topographic fringe simulation. All of the InSAR pairs have absolute perpendicular baselines below 200m, indicating most InSAR pairs showed good coherence. Because the expected surface displacement has an amplitude of 2cm or below (by GNSS observations), we performed the stacking analysis for each paths to enhance the detectability of line-of-sight (LOS) displacements. In addition, we applied the MSM-based atmospheric delay correction to each interferograms to further increase the detectability of the surface displacement signal.

The stacking result showed that the surface displacement signal with an amplitude of approximately 1 cm in the LOS direction was clearly detected in path 141. The displacement signal extended spatially to approximately 20 km in both north-south and east-west direction. The spatial distribution and amplitude of InSAR-detected displacement was consistent with the GNSS observation. On the other hand, There were no clear displacement signal in the stacked interferogram in paths 39 and 46. This would be due to the significant atmospheric delay effect in several interferograms of these paths. Therefore we only used the stacking interferogram in path 141 for the fault modeling.

We also performed the assessment of the atmospheric delay correction effectiveness. Phase standard deviations (SDs) calculated on the area outside of the expected displacement signal clearly showed the effectiveness of the atmospheric delay correction. Before the correction, SDs of the stacked interferograms were 5.9 cm, 7.5 cm, and 4.2 cm for paths 39, 46, and 141, respectively, which decreased to 2.7 cm, 4.6 cm, and 1.6 cm after the correction. Although the spatial and temporal resolutions of MSM were 10 km and 3 hours that were not significant for the InSAR atmospheric delay modeling, it showed good performance for the InSAR stacking.

Based on the derived displacement signal in path 141, we performed a forward modeling to estimate preliminary fault parameters using the simple Okada fault model. The estimated fault model suggested

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that the upper-left corner of the fault was located at 140.8 degrees in longitude and 34.98 degrees in latitude with the depth of 15 km, which was consistent with the boundary of the Phillipine plate. The fault length and width were set to 50 km and 30 km with the dip angle of 18 degrees. The estimated slip amount was 13 cm with the rake of 105 degrees, which was equivalent to the moment magnitude of 6.6.

Keywords: InSAR, Atmospheric delay correction, Slow Slip

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[J] Oral | S (Solid Earth Sciences)：S-TT Technology & Techniques

Mon. May 27, 2019 1:45 PM - 3:15 PM JST | Mon. May 27, 2019 4:45 AM - 6:15 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[S-TT46] Seismic Big Data Analysis Based on the State-of-the-Art of Bayesian Statistics

convener:Hiromichi Nagao(Earthquake Research Institute, The University of Tokyo), Aitaro Kato(Earthquake Research Institute, the University of Tokyo), Takuto Maeda(Graduate School of Science and Technology, Hirosaki University), Keisuke Yano(The university of Tokyo), Chairperson:Nana Yoshimitsu(Earthquake Research Institute, The University of Tokyo), Takeru Matsuda(Graduate School of Information Science and Technology, The University of Tokyo)

Recently, a big seismic database has been being constructed that collects data of vibrators implemented in such as buildings, lifelines and smartphones, in addition to seismic data of the conventional continuous/temporal dense seismic observation arrays. Development of methodologies and algorithms, which are inadequate at this moment, optimized to comprehensively analyze the seismic big data is essential in order to utilize the big database as much as possible for prevention/mitigation of earthquake disasters and clarification of earthquake phenomena. On the other hand, recent progress of Bayesian statistics is significant, which is the mathematical basis of various methodologies, such as machine learning, especially deep learning, to extract valuable information from big data. The state-of-the-art of Bayesian statistics is expected to substantially advance seismic big data analyses.
This session mainly accepts presentations that focus on analyses of seismic big data, especially related to analysis methods based on Bayesian statistics such as machine learning, sparse modeling and data assimilation, and their applications to real seismic data. Presentations related to mathematical or statistical theories beneficial to data analyses, feasibility studies of algorithms eventually applicable to real seismic data, and the current status of seismic observations and analysis results are also highly welcome.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[STT46-01] A bad inversion result suggests bad modeling

★Invited Papers

*Yukitoshi Fukahata[1], Yuji Yagi[2] (1.Disaster Prevention Research Institute, Kyoto University, 2.Graduate School of Life and Environmental Sciences, University of Tsukuba)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[STT46-02] A seismic wavefield estimation in a dense seismograph network: An optimization for the MeSO-net

*Takahiro Shiina[1], Takuto Maeda[2], Masayuki Kano[3], Aitaro Kato[1], Naoshi Hirata[1] (1.Earthquake Research Institute, The University of Tokyo, 2.Graduate School of Science and Technology, Hirosaki University, 3.Graduate school of science, Tohoku University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[STT46-03] Uncertainty quantification based on 4DVar data assimilation for massive simulation models

*Shin-ichi Ito[1], Masayuki Kano[2], Hiromichi Nagao[1] (1.The University of Tokyo, 2.Tohoku University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[STT46-04] Bayesian approach for statistical modeling and forecasting of aftershock activities

★Invited Papers

*Takahiro Omi[1] (1.Institue of Industrial Science, the University of Tokyo)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[STT46-05] Bias Correction for the Distribution of Aftershocks Within Short-Term Period Immediately After Large Main Shock

*Kosuke Morikawa[1], Hiromichi Nagao[2], Shin-ichi Ito[2], Shin'ichi Sakai[2], Naoshi Hirata[2] (1.Osaka University, 2.Earthquake Research Institute, The University of Tokyo)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[STT46-06] Deep-learning-based Earthquake Detection for Continuous Seismic Network Records

*Keisuke Yano[1], Takahiro Shiina[2], Sumito Kurata[1], Aitaro Kato[2], Fumiyasu Komaki[1], Shin'ichi Sakai[2], Naoshi Hirata[2] (1.Graduate School of Information Science and Technology, The University of Tokyo, , 2.Earthquake Research Institute, The University of Tokyo)

A bad inversion result suggests bad modeling

*Yukitoshi Fukahata[1], Yuji Yagi[2]

1. Disaster Prevention Research Institute, Kyoto University, 2. Graduate School of Life and Environmental Sciences, University of Tsukuba

Bayesian inference is a powerful tool in inversion analyses of geophysical problems. In Bayesian inference, we always encounter a problem in determining the relative weight between observed data and prior information. ABIC (Akaike's Bayesian Information Criterion) gives an objective solution to this problem by maximizing the marginal likelihood for the relative weight. In principle, ABIC gives us an inverse solution that mostly follows observed data when we have enough amounts of data with good accuracy, and gives us an inverse solution that mostly follows prior information when observed data are insufficient and/or inaccurate.

In inversion analyses using ABIC, we do not manually adjust the relative weight. Hence, geophysically unrealistic results are quite easily obtained. Because of that, someone may think that inversion analyses using ABIC is difficult in dealing with or even unreliable. However, this is an excellent point of ABIC. If we obtain a geophysically unrealistic result, this implies that some problems are hidden in this analysis.

In this talk, we show some examples of the invention of inversion methods inspired by ABIC, including the discovery of the importance of modeling errors. As shown by these examples, we can get closer to the true solution not by manually adjusting the relative weight to obtain a seemingly good-looking result, but by determining the relative weight statistically. It is a harder way to determine the relative weight statistically, but we should pursue this way to understand geophysical problems more appropriately.

Keywords: Inversion analysis, ABIC, slip distribution of earthquakes

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A seismic wavefield estimation in a dense seismograph network: An optimization for the MeSO-net

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MeSO-net (Metropolitan Seismic Observation network) is a dense seismograph network deployed in and around Tokyo, Japan [Kasahara et al., 2009; Sakai and Hirata, 2009]. Station separation of the MeSO-net is about 5 km on average and ~2 km at the densest area. Recently, some reconstructing method of seismic wavefield in such dense seismograph networks have been developed [e.g., Langston, 2007; Kano et al., 2017]. Kano et al. [2017] proposed a wavefield imaging method based on the data assimilation: they demonstrated the reconstructions of wavefield up to ~1 Hz using the MeSO-net. Their method can simultaneously determine layered structures and location of the hypocenter. Seismic wave gradiometry (SWG) method is also well known as another method for estimating 2D seismic wavefield. The SWG method has low computational cost and can apply to observations without assumptions of hypocenter and structural heterogeneity. Therefore, the SWG method will be useful for monitoring wavefield and investigating ground motions without source data as prior information.
We adopt the SWG method developed by Maeda et al. [2016] to estimate seismic wavefield within the MeSO-net. In this method, amplitude and its spatial gradients of seismic wave at grid points are estimated from observed amplitude at surrounding stations. Interpolation coefficients used for the estimation are determined by the weighted least squares technique and are only depended on a grid-station distance.
In order to optimize the interpolation coefficient, we perform the analysis based on numerical modeling. The finite difference modeling, the OpenSWPC [Maeda et al., 2017], is used to simulate seismic waves at any grid points and sites of which locations correspond to the MeSO-net stations. For the simulated waveforms, we adopt bandpass filter of 0.1-0.2 Hz which is lower than the upper-limit frequency of our numerical modeling, ~0.25 Hz. Then, we synthesize waveform at a grid point from simulated ones at surrounding sites by the SWG method. As the weighting function imposing to the least square, we assume the 2D Gaussian form with respecting to the grid-station distance. The 2D Gaussian weight is characterized by the lengths in two orthogonal axes, long and short arms, and a rotation angle of the short axis in the clockwise direction from the north. The ” optimization” in this study is to find the three parameters which maximize the three-components cross-correlation coefficient between the SWG-synthesize and the simulated waveforms at the grid point. We investigate the parameters by the grid search technique.
We carry out the numerical simulations for hypocenters of 12 directions with 30 degree interval. The hypocenters are located at a depth of 10 km and a distance of 150 km from the center of the MeSO-net. In this case, the determined Gaussian weight realize the highest reproducibility of the seismic wavefield for wave incidence from an arbitrary direction. The obtained Gaussian weights mark small and isotropic shapes near the central area of the MeSO-net, whereas they mark large and elliptical shapes around edges of the network. These shapes of the optimum weight would represent the configuration of the MeSO-net stations and demonstrate that the high-reproducible area of seismic waveform is expanded. Moreover, we confirmed that the accuracy of the seismic wavefield estimation can improve when selecting the interpolation coefficients coinciding with the incoming direction of the seismic waves.

Keywords: Seismic wavefield, Seismic wave gradiometry, MeSO-net

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Uncertainty quantification based on 4DVar data assimilation for massive simulation models

*Shin-ichi Ito[1], Masayuki Kano[2], Hiromichi Nagao[1]

1. The University of Tokyo, 2. Tohoku University

Data assimilation (DA) is a fundamental computational technique that integrates numerical simulation models and observation data on the basis of Bayesian statistics. Originally developed for meteorology, especially weather forecasting, DA is now an accepted technique in various scientific fields. One key issue that remains controversial is the implementation of DA in massive simulation models under the constraints of limited computation time and resources. This work proposes a DA technique based on a four dimensional variational (4DVar) method for massive autonomous models that produces optimum estimates and their uncertainties within reasonable computation time and resource constraints. The uncertainties are given as several elements of an inverse Hessian matrix, which is the covariance matrix of a normal distribution that approximates the target posterior probability density function in the neighborhood of the optimum. The proposed method based on a second-order adjoint method allows us to directly evaluate the elements of the inverse Hessian matrix without computing all of its elements. Some numerical tests assuming a massive simulation model confirm that the proposed method works well and enables us to evaluate the uncertainties of the parameters involved in the assumed model faster than the conventional DA approaches. Such information regarding uncertainty is valuable, as it can be used to optimize the design of experiments.

Keywords: Bayesian statistics, Data assimilation, Uncertainty quantification

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Bayesian approach for statistical modeling and forecasting of aftershock activities

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A large earthquake triggers a considerable number of aftershocks, which potentially cause additional damage in the affected area. It is therefore important to forecast aftershock activities as early as possible after a main shock. A basic method for forecasting aftershocks was proposed in 1989. However, for practical application of aftershock forecasting, we have to additionally consider (i) the missing of early aftershocks (ii) the forecast uncertainty. We consider such features by taking Bayesian statistical approach. In this talk, we briefly explain our forecasting method and demonstrate its utility.

Keywords: aftershock activity, probabilistic forecasting, bayesian statistics

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Bias Correction for the Distribution of Aftershocks Within Short-Term Period Immediately After Large Main Shock

*Kosuke Morikawa[1], Hiromichi Nagao[2], Shin-ichi Ito[2], Shin'ichi Sakai[2], Naoshi Hirata[2]

1. Osaka University, 2. Earthquake Research Institute, The University of Tokyo

The main shock of a large earthquake often makes it difficult to identify a number of subsequent aftershocks. Knowing the distribution of magnitudes and arrival times of the aftershocks is essential to figure out the characteristics of the sequence of earthquakes, which enables us to predict the frequency of earthquakes depending on space and time. Such the distribution of aftershocks should be estimated within a couple of days eventually since most of the large aftershocks occur within one day from the main shock. However, an exact count of all aftershocks right after a main shock is very hard due to large signal-to-noise ratio, so that an estimated distribution of the aftershocks is usually biased.

An adoption of a likelihood that incorporates models of the detection rate of aftershocks can be a solution to correct the bias, but the simultaneous dependency on both magnitudes and arrival times of the aftershocks makes this difficult. Thus using nonparametric models for the detection rate is unrealistic though misspecification of the model may lead to a severe biased estimator.

In this study, we propose two detection rate models that are individually conditional on the magnitudes and the arrival times. The Generalized Moments of Methods (GMM)-type estimator overcomes the difficulty in estimation due to the imcompletely defined joint distribution. With the use of prior information, the distribution of the aftershocks can be effectively estimated within short-time period.

Keywords: Magnitude frequency, Marked point process, Geoscience

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Deep-learning-based Earthquake Detection for Continuous Seismic Network Records

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1. Graduate School of Information Science and Technology, The University of Tokyo, , 2. Earthquake Research Institute, The University of Tokyo

Over the last decade, continuous seismic data have been enormously acquired on seismic networks consisting of multiple sensors at distributed locations. Analyzing these data efficiently and thoroughly offers substantial benefits to seismology. The first important step in the analysis is earthquake detection, that is, detecting earthquakes in continuous massive datasets.

In this talk, we present a deep-learning-based scheme for earthquake detection from continuous records in a seismic network. We work with a convolutional neural network (CNN), which is one of the most powerful supervised learning techniques, to capture features discriminating between earthquakes and noises. Our scheme has an advantage of utilizing multiple stations in a seismic network to discriminate between earthquakes and noises.

We apply our scheme to continuous data on Metropolitan Seismic Observation network (MeSO-net) from September 4, 2011 to September 16, 2011. We show our scheme improves on CNNs based on few stations especially in preventing mis-detection. In addition, the trained network in the last fully connected layer has quasi-sparsity, by which we identify features important for CNN to recognize earthquakes.

Keywords: Seismology, Deep learning

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Mon. May 27, 2019 9:00 AM - 10:30 AM JST | Mon. May 27, 2019 12:00 AM - 1:30 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-CG56] Ocean Floor Geosciences

convener:Kyoko Okino(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Arata Kioka, Atsushi Noda

Most of Earth's volcanism and much of its tectonic activity occur on and beneath the seafloor. Various phenomena on the seafloor are closely linked to plate tectonics, Earth and atmosphere. Seafloor rocks and sediments record Earth's evolution and heat and material fluxes on the Earth. Ocean Floor Geosciences session covers a broad range of research on LIPs, crustal movement and structure etc. Any fields of research and approach are welcomed. The session aims to encourage discussion among scientists from different study fields and to integrate our understanding of ocean floor. The session is co-chaired by K. Tadokoro (Nagoya Univ.), O. Ishizuka (AIST), T. Toki (Univ. Ryukyus), and N. Takahashi (JAMSTEC).

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SCG56-25] Observational plans of the South Sandwich Arc by R/V Hakuho Maru: Toward understanding formation and evolution of the world southernmost arc-trench system

*Asuka Yamaguchi[1], Kenichiro Tani[2], Minoru Ikehara[3] (1.Atomosphere and Ocean Research Institute, The University of Tokyo, 2.National Museum of Nature and Science, 3.Center for Advanced Marine Core Research, Kochi University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SCG56-26] Seismic imaging of the source zone of the 2011 Tohoku-oki earthquake

*Dapeng Zhao[1], Xin Liu[1] (1.Department of Geophysics, Tohoku University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SCG56-27] Drastic export of organic carbon to hadal trench driven by megathrust earthquake

*A. Kioka[1], T. Schwestermann[1], J. Moernaut[1], K. Ikehara[2], T. Kanamatsu[3], C. M. McHugh[4], C. dos Santos Ferreira[5], G. Wiemer[5], N. Haghipour[6], A. J. Kopf[5], T. I. Eglinton[6], M. Strasser[1,5] (1.Universität Innsbruck, Austria, 2.GSJ-AIST, Japan, 3.JAMSTEC, Japan, 4.Queens-CUNY, USA, 5.MARUM-U. Bremen, Germany, 6.ETH Zürich, Switzerland)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SCG56-28] How do trench-fill sediments subduct under the accretionary wedge?

*Atsushi Noda[1], Hiroaki Koge[2], Yasuhiro Yamada[3], Ayumu Miyakawa[1], Juichiro Ashi[2] (1.National Institute of Advanced Industrial Science and Technology, 2.Atomosphere and Ocean Research Institute, The University of Tokyo, 3.Japan Agency for Marine-Earth Science and Technology)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SCG56-29] Formation process of a slope basin in the Nankai Accretionary prism reconstructed from high-resolution SBP integrated with core data of ODP Site 1175 and Site 1176

*Yuichi Okuma[1], Asuka Yamaguchi[1], Hiroaki Koge[1], Rina Fukuchi[1], Juichiro Ashi[1] (1.Atmosphere and Ocean Research Institute, the University of Tokyo)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SCG56-30] About the turbidity current considered that it occurred in the northern Suruga Bay, Central Japan by the typhoon No.24. -The traces of the accidents and the phenomenon at the sea floor detected the OBSs Array-

*Nakao Nagisa[1], Hisatoshi Baba[2], Hiroshi Sato[3], Kayoko Tsuruga[4], Izumi Sakamoto[2], Takahito Nishimiya[5], Masanao Shinohara[3], Shintaro Abe[6] (1.Tokai University, 2.Department of Marine and Earth Science, Tokai University, 3.Earthquake Research Institute, University of Tokyo, 4.Tokyo University of

Marine Science and Technology, 5.Meteorological Research Institute, Japan Meteorological Agency, 6.Association for the Development of Earthquake Prediction)

Observational plans of the South Sandwich Arc by R/V Hakuho Maru: Toward understanding formation and evolution of the world southernmost arc-trench system

*Asuka Yamaguchi[1], Kenichiro Tani[2], Minoru Ikehara[3]

1. Atomosphere and Ocean Research Institute, The University of Tokyo, 2. National Museum of Nature and Science, 3. Center for Advanced Marine Core Research, Kochi University

The South Sandwich arc-trench system, located in between South America and Antarctica, is one of the unexplored subduction zones of the world. It was originated in Mesozoic fragmentation of Gondwana, and Neogene westward subduction of South American plate causes formation of South Sandwich volcanic arc and back-arc opening of West and East Scotia Sea. The formation of Scotia Sea is closely related to the opening of Drake Passage Gateway, and thus it caused the development of the Antarctic Circumpolar Current and affected the earth’ s climate. However, detail back-arc opening process of Scotia Sea is poorly understood. Sediment accumulated in the South Sandwich Trench is expected to contain large amount of diatom and IRD (ice-rafted debris), but the nature of the sediment in the trench is unknown because of the lack of sediment cores.
On 2019 December-2020 January, R/V Hakuho Maru will visit the South Sandwich Arc and Weddell Sea as a part of around the world cruise for her 30th anniversary. During this cruise, we plan to take 1) dredge samples of forearc high of South Sandwich Arc possibly recording initiation process of oceanic island arc, as well as 2) sediment cores in South Sandwich Trench as an input to a subduction zone in polar region. By comparing the findings during this cruise to accumulated knowledge on backarc-arc-trench system around Japan, we try to understand the formation and evolution of the world southernmost arc-trench system.

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Seismic imaging of the source zone of the 2011 Tohoku-oki earthquake

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The great 2011 Tohoku-oki earthquake (*Mw* 9.0) is the best-documented megathrust earthquake in the world, but its causal mechanism is still in controversy because of the poor state of knowledge on the nature of the megathrust zone. *Zhao et al*. (2011) used seismic tomography to study structural heterogeneity in the megathrust zone and suggested that lateral structural variations atop the subducting Pacific slab, such as the subducted seafloor topography, seamounts and sediments, affected nucleation of the 2011 Tohoku-oki earthquake. In contrast, *Bassett et al*. (2016) used residual topography and gravity data to constrain the Tohoku forearc structure and proposed that variations in the forearc lithology of the overriding Okhotsk plate were the main cause of along-strike variations of the Tohoku-oki slip behavior. In this work we constrain the structure of the Tohoku forearc using seismic tomography, residual topography and gravity data. We apply a tomographic method (*Zhao et al*., 2002) to invert 144,354 *P*-wave arrival-time data recorded at 382 permanent seismic stations in Tohoku from 4760 local shallow and intermediate depth earthquakes that occurred during January 2000 to June 2016.

Our results reveal a close relationship between structural heterogeneities in and around the megathrust zone and rupture processes of the 2011 Tohoku-oki earthquake (*Liu and Zhao*, 2018). Its mainshock nucleated in an off-Miyagi area with high seismic velocity, low seismic attenuation and strong seismic coupling, indicating a large asperity (or a cluster of asperities) in the Tohoku megathrust zone. Strong coseismic high-frequency radiations also occurred in high-velocity patches, whereas large afterslips took plate in low-velocity areas, which may reflect changes in fault friction and lithological variations. These results indicate that structural anomalies in and around the Tohoku megathrust originate from both the upper Okhotsk plate and the lower Pacific plate, which controlled the generation and rupture processes of the 2011 Tohoku-oki earthquake. This huge earthquake was caused by collision of harder rocks in both the upper and lower plates.

This work sheds new light on the causal mechanism of megathrust earthquakes. It also suggests that the location of a future great earthquake may be pinpointed by investigating the detailed structure of the megathrust zone.

In this presentation, we will also show our new results obtained by adding the data recorded by the S-net that has been installed in the eastern Japan forearc region under the Pacific Ocean.

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megathrust zone and mechanism of the 2011 Tohoku-oki earthquake (Mw 9.0). *Geophys. Res. Lett.* **38,** L17308.

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Keywords: The great Tohoku-oki earthquake, seismic tomography, Earthquake mechanism

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Drastic export of organic carbon to hadal trench driven by megathrust earthquake

*A. Kioka[1], T. Schwestermann[1], J. Moernaut[1], K. Ikehara[2], T. Kanamatsu[3], C. M. McHugh[4], C. dos Santos Ferreira[5], G. Wiemer[5], N. Haghipour[6], A. J. Kopf[5], T. I. Eglinton[6], M. Strasser[1,5]

1. Universität Innsbruck, Austria, 2. GSJ-AIST, Japan, 3. JAMSTEC, Japan, 4. Queens-CUNY, USA, 5. MARUM-U. Bremen, Germany, 6. ETH Zürich, Switzerland

Despite a growing understanding of pivotal role of the carbon cycle in governing the Earth system, the nature and quantification of carbon supply to hadal environments remains poorly constrained. The giant 2011 Tohoku-oki earthquake has been inferred to remobilise fine-grained, young surface sediment enriched in organic matter from the slope into the >7 km deep Japan Trench. Yet, this hypothesis and assessment of its significance for the carbon cycle has been hindered by limited data density and resolution in the hadal zone. Here we combine new high-resolution bathymetry data with subbottom profiler images and sediment cores taken during 2012–2016, in order to map for the first time the spatial extent of the earthquake-triggered event deposit along the hadal Japan Trench. We quantify a sediment volume of ~0.2 km^3 deposited from spatially-widespread remobilisation of young surficial seafloor slope sediments triggered by the 2011 earthquake and its aftershock sequence. The mapped volume and organic carbon content in sediment cores encompassing the 2011 event reveals that this single tectonic event delivered >1 Tg of organic carbon to the hadal trench. This carbon is comparable to high carbon fluxes described for other Earth system processes, shedding new light on the impact of large earthquakes on long-term carbon cycling in the deep sea.

Keywords: Hadal zone, Japan Trench, Organic carbon, Carbon cycle, Sediment remobilization, The 2011 Tohoku-oki Earthquake

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How do trench-fill sediments subduct under the accretionary wedge?

*Atsushi Noda[1], Hiroaki Koge[2], Yasuhiro Yamada[3], Ayumu Miyakawa[1], Juichiro Ashi[2]

1. National Institute of Advanced Industrial Science and Technology, 2. Atomosphere and Ocean Research Institute, The University of Tokyo, 3. Japan Agency for Marine-Earth Science and Technology

Ancient exhumed accretionary complexes sometimes have combinations of low-grade accretionary rocks from trench-fill turbidites, high-pressure/low-temperature metamorphic rocks including psammitic schists, and forearc basin deposits composed of sandy submarine fan deposits, whose provenance and depositional ages are similar to each other. For example of the southwestern Japan, sandstones in the Shimanto Accretionary Complex and psammitic schists in the Sanbagawa Metamorphic Complex are derived from terrigenous trench-fill deposits showing the similar geochemical and geochronological characteristics each other; the former is composed of accretionary rocks at the shallow part of the subduction zone and the latter comprises metamorphic rocks subducted to deeper than 10~km. Generally, at accretionary-type subduction zones, because weak layers within sediments deposited on the oceanic plate are used as a decollement, the lower pelagic and hemipelagic sediments can subduct beneath accretionary wedge through the subduction channel, but the upper terrigenous sediments are accreted at the toe of the wedge. Growth of accretionary wedge enabled to develop a forearc basin between the wedge and the backstop. At tectonically erosive subduction zones, most of the trench-fill sediments can subduct beneath the frontal prisms, but accretionary wedge cannot be grew at the same time. Therefore, it is difficult to explain coexistence of growth of accretionary wedge derived from coarse-grained trench-fill sediments and subduction of them deeper than seismogenic zone at the same time. In this study, we attempt to identify an importance of seafloor roughness for transportation of trench-fill sediments to deep during subduction. For this purpose, we conducted sandbox analogue experiments by using an unfixed rigid backstop on a subduction channel with the cases of smooth surface (Exp. A) and rough surface representing a seamount or ridge on subducting lower plate (Exp. B). The results of Exp. A showed progressive thickening of the accretionary wedge pushed the backstop down, meaning stepping down of the decollement and narrowing the subduction channel. On the other hand, Exp. B showed a subducting seamount lifted up the backstop, stepped up the d{\'e}collement, and then widened the subduction channel. Subduction of a rigid material like a chain of seamounts is a possible mechanism to open subduction channels for transportation of terrigenous sediments from the trench to high-pressure condition. Significant sediment supply to the trench and rough surface of subducting oceanic plate are required to enable subduction of protolith of HP-LT metamorphic rocks, accretion of trench-fill sediments at the shallow part, and formation of forearc basin simultaneously.

Keywords: Subduction zone, Accretionary wedge, High-pressure/low-temperature metamorphic rocks, Forearc basin, Seamount, trench-fill sediments

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Formation process of a slope basin in the Nankai Accretionary prism reconstructed from high-resolution SBP integrated with core data of ODP Site 1175 and Site 1176

*Yuichi Okuma[1], Asuka Yamaguchi[1], Hiroaki Koge[1], Rina Fukuchi[1], Juichiro Ashi[1]

1. Atmosphere and Ocean Research Institute, the University of Tokyo

Upper plates of subduction zones record various phenomena associated with plate subduction. Geological records of slope basins overrapping accretionary prisms are useful to reconstruct tectonic activities of decollements and/or splay faults. In general, low-frequency sources are preferred for seismic reflection profiling to avoid attenuation in the water. However, low-frequency sources permit limited resolution of profiles due to trade-off relationship of frequency and resolution. For this reason, only limited studies focused on detail structures of the shallow portion of the deep-sea slope basins (e.g., Tsuji et al., 2014, *EPS*). In this study, we conducted interpretation of subsurface structures and reconstructed the formation process of the slope basin on the Nankai accretionary prism using high-resolution cross section images obtained by deep towed subbottom profiler on the R/V Hakuho-maru KH-16-5 cruise around the Nankai Trough off Muroto. This slope basin is located at 80 kilometers to southwest of the cape Muroto and a depth of 3000 m, and 8 kilometers long in northwest-southeast and 6.5 kilometers long in northeast-southwest forming an ellipse shape. An obvious strike-slip fault including normal-slip orientation at 1 kilometer seaward from the basin and a splay fault at 2 kilometers from the strike-slip fault are confirmed by Underwood et al. (2003, *JSR*), there is a high possibility that the basin records those activities. Moreover, Kodaira et al. (2000, *Science*) reported the existence of a subducted seamount at north of the slope basin, which means that subduction of this seamount had an impact on formation of the basin. Two cores from Site 1175 and Site 1176 were obtained by Ocean Drilling Program (ODP) Leg 190 around the basin, we also compared the result of interpretation to depositional structures and age. The high-resolution cross section shows a splay fault, strike-slip fault and hillock associated with minor faults including a strike-slip fault with reverse fault component at the center of the hillock. In the landward region from the strike-slip fault on the hillock, structures indicating relative subsidence of landward margin of the basin were confirmed. Additionally, basin strata show the evidence of landward migration of a depocenter in that region, which is coincident with the structures in the seismic profiles (Shipboard Scientific Party, 2001). The dip angle near the Site 1175 increase with depth, which suggest continuous tilting. Only normal faults exist in the landward region from the top of the hillock. Especially, four normal faults getting through to the seafloor are attributed to successive faulting because the displacement of those faults increase with depth. In addition, landslide deposit flowed from landward slopes is ascertained in the cross section. On the other hand, the reverse fault group being part of a splay fault is included in the trenchward region from the strike slip fault. The subbottom profile shows the evidence of obvious reverse and normal faulting around that region. Notably, reverse faulting is dominant in trenchward-half of the hillock, although no faults are getting through to the seafloor. The reflecting surfaces correspond with volcanic ash or sand layers by comparison both reflection surfaces and stratigraphic succession of cores on the Site 1175 and Site1175. Depositional age from analysis of ash suggest that the tilting in landward region from the strike-slip fault was getting low in activity and calmed within 28 ka. It is difficult to presume the moment of initiation of tilting due to depth limit of SBP, however, the basin already started tilting when the 105 ka surface deposited because that tilting of the surface confirmed around Site 1175. Additionally, the number of faults cutting surface younger than 28 ka is less than those cutting older than that surface, and no faults except the well-developed strike-slip fault at the center of the hillock reach the

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seafloor. Therefore, those results indicate that a high likelihood of that the tilting at shallow portion of the basin caused by faulting of the splay fault, and suggest that the tilting had initiated before deposition of 105 ka surface and stopped by 28 ka at the latest. In this way, deep towed SBP integrated with core data has a great potential for reconstructing high time-resolution basin growth and fault activity.

Keywords: Slope basins, Accretionary prism, Sub-bottom profiler

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About the turbidity current considered that it occurred in the northern Suruga Bay, Central Japan by the typhoon No.24. -The traces of the accidents and the phenomenon at the sea floor detected the OBSs Array-

*Nakao Nagisa[1], Hisatoshi Baba[2], Hiroshi Sato[3], Kayoko Tsuruga[4], Izumi Sakamoto[2], Takahito Nishimiya[5], Masanao Shinohara[3], Shintaro Abe[6]

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In August 2018, Structural exploration based on "The integrated research project for the Fujikawa fault zone" began in the northern Suruga Bay. We installed 18 pop-up type Ocean Bottom Seismographs (OBSs) in this survey line (from Shimizu to Heda). In addition, we installed 4 OBSs in other survey lines for the observation of seismic activities around the Suruga Bay.

The typhoon No.24 passed off in the vicinity of the Suruga Bay from September 30th to October 1st 2018. After passing off that, various accidents of OBS occurred. Those accidents of OBS are as follows:

1. 4 OBSs drifted on the coast.

2. The movement of the installation position of the 2 OBSs was confirmed.

3. 1 OBS did not have a transponder response and it was missing.

4. The two OBSs have a transponder response, but they do not pop-up.

From this and the above, in this study, we considered OBS to have an accidentally due to a phenomenon occurred at the seafloor in the northern part of Suruga Bay by typhoon 24.

We analyzed using seismic wave, submarine topography and mud and considered them.

・According to the waveform record obtained by OBS, the accidenty spread from the central part of Suruga Bay of the extension of the Fujikawa estuary.

・It was a tilt that caused turbidity flow to occur by hanging from the Fujikawa estuary to the survey line.

・When the bottom sampling was done at the installation point and recovery point, the same particle size was present.

From the above,the cause of the accidenty in the OBS in the northern Suruga Bay is presumed to have flowed into the Suruga bay, where the sediments originating from the Fujikawa streamed OBSs.

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From this, there is a high possibility that a turbid flow has occurred in northern Suruga Bay.

Keywords: Suruga Bay, OBS, turbidity current

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Mon. May 27, 2019 10:45 AM - 12:15 PM JST | Mon. May 27, 2019 1:45 AM - 3:15 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-CG60] Investigation of inputs to subduction zones: Influence of tectonic processes on the incoming plate

convener:Makoto Yamano(Earthquake Research Institute, the University of Tokyo), Tomoaki Morishita(School of Geoscience and Civil Engineering, College of Science and Technology, Kanazawa University), Gou Fujie(Japan Agency for Marine-Earth Science and Technology), Chairperson:Shigeaki Ono(Japan Agency for Marine-Earth Science and Technology)

Various tectonic processes occur on the seaward side of the trench associated with bending of the incoming oceanic plate, e.g., fracturing of oceanic crust, infiltration of water, and intraplate volcanism. Investigation of these processes and their influence on the incoming plate provides important information on the boundary condition at the trench, inputs to subduction zones. Variation in inputs should significantly affect geophysical/geological phenomena around the plate interface and geochemical cycles in subduction zones. We welcome contributions from a broad range of earth science (geophysics, geology, petrology, and so on) discussing topics related to inputs to subduction zones such as occurrence of tectonic processes due to bending of the incoming plate, modification of the incoming plate by the processes, relationship between the processes and the inherited structure of the incoming plate, and influence of the processes on the subduction plate interface. We hope discussions are made on studies of a variety of subduction zones, including the Japan Trench and the Nankai Trough, and comparative studies among different subduction zones.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SCG60-01] Geophysical-petrological studies of the Chile triple junction and their significance: MIRAI research cruise MR-1806Leg2

*Masataka Kinoshita[1,5], Hikaru Iwamori[1,5], Tomoaki Nishikawa[2], Ryo Anma[3], Sofia Lagarrigue[4], Natsue Abe[5], Yuka Yokoyama[6], Andres Veloso Espinosa[4], Alessandra Isabella Rivero Cortes[7], Gabriela Pia Lazcano Prado[7], Ivan Andres Arriagada Bascuñan[7], Satoru Haraguchi[5], Kosuke Ota[9], Yuji Orihashi[8], Kaishi Nakao[8], Shogo Numata[8], Hajime Shiobara[1], Hiroko Sugioka[10], Aki Ito[5], Nicolás Pérez-Estay[11] (1.Earthquake Research Institute, University of Tokyo, 2.DPRI, Kyoto Univ., 3.Tokushima Univ., 4.Pontificia Universidad Catolica de Chile, 5.JAMSTEC, 6.Tokai Univ., 7.Andres Bello University, 8.Hirosaki Univ., 9.AORI, Univ. Tokyo, 10.Graduate School of Science, Kobe Univ., 11.Ministerio de relaciones exteriores, Chile)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SCG60-02] Heat flow measurement on the seaward side of the Kuril Trench off Hokkaido

*Kouta Sasaki[1], Makoto Yamano[1], Yoshifumi Kawada[2], Masataka Kinoshita[1], Kiichiro Kawamura[3] (1.Earthquake Research Institute, the University of Tokyo, 2.International Research Institute of Disaster Science, Tohoku University, 3.Yamaguchi University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SCG60-03] Comparison of experimental and intermediate-depth earthquake b-value: difference in hydration degree of the oceanic mantle between Tohoku and Hokkaido

★Invited Papers

*Saeko Kita[1], Thomas P. Ferrand[2] (1.International Institute of Seismology and Earthquake Engineering, BRI, 2.ERI, University of Tokyo)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SCG60-04] Variations in bend faulting and the nature of the incoming oceanic plate off northeast Japan arc

*Gou Fujie[1], Koichiro Obana[1], Yojiro Yamamoto[1], Tomoaki Yamada[2], Takehi Isse[2], Shuichi Kodaira[1], Seiichi Miura[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Earthquake Research Institute, Univ. of Tokyo)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SCG60-05] Seismicity in the trench-outer rise region off Fukushima and Ibaraki, southern Japan Trench

*Koichiro Obana[1], Gou Fujie[1], Yojiro Yamamoto[1], Yuka Kaiho[1], Yasuyuki Nakamura[1], Seiichi Miura[1], Tsutomu Takahashi[1], Shuichi Kodaira[1] (1.Research and Development Center for Earthquake and Tsunami, Japan Agency for Marine-Earth Science and Technology)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SCG60-06] Influence of water–rock interactions on the strength of outer-rise faults

★Invited Papers

*Ken-ichi Hirauchi[1] (1.Department of Geosciences, Faculty of Science, Shizuoka University)

Geophysical-petrological studies of the Chile triple junction and their significance: MIRAI research cruise MR-1806Leg2

*Masataka Kinoshita[1,5], Hikaru Iwamori[1,5], Tomoaki Nishikawa[2], Ryo Anma[3], Sofia Lagarrigue[4], Natsue Abe[5], Yuka Yokoyama[6], Andres Veloso Espinosa[4], Alessandra Isabella Rivero Cortes[7], Gabriela Pia Lazcano Prado[7], Ivan Andres Arriagada Bascuñan[7], Satoru Haraguchi[5], Kosuke Ota[9], Yuji Orihashi[8], Kaishi Nakao[8], Shogo Numata[8], Hajime Shiobara[1], Hiroko Sugioka[10], Aki Ito[5], Nicolás Pérez-Estay[11]

1. Earthquake Research Institute, University of Tokyo, 2. DPRI, Kyoto Univ., 3. Tokushima Univ., 4. Pontificia Universidad Catolica de Chile, 5. JAMSTEC, 6. Tokai Univ., 7. Andres Bello University, 8. Hirosaki Univ., 9. AORI, Univ. Tokyo, 10. Graduate School of Science, Kobe Univ., 11. Ministerio de relaciones exteriores, Chile

The Chile triple junction (CTJ) is a unique place where a spreading center of mid-ocean ridge is subducting near the Taitao peninsula. Around CTJ, presence of high heat flow on the continental slope (Cande et al., 1987, J. Geophys. Res.) and near-trench young granitic rocks on the Taitao peninsula (Anma and Orihashi, 2013, Geochem. J.) suggests the thermal and petrological impact of subducting ridge on the continental side. The tectonic history of the southeast Pacific since early Cenozoic to the present suggests that ridge subduction continuously occurred along the Chile trench, which migrated northward (Cande and Leslie, 1986, J. Geophys. Res.), which can contribute to growth of the continental crust (Iwamori, 2000, EPSL).
In January 2019, the MR18-06 cruise Leg 2 was conducted at the Chile Triple Junction, as a part of 'EPIC' expedition by using R.V Mirai of JAMSTEC. During the leg, we completed 4 SCS lines, 6 piston coring, 6 heat flow measurements, 2 dredges, and underway geophysics observations, as well as deployment of 13 OBSs. The primary object of heat flow measurement at CTJ is to better constrain the thermal regime around CTJ by adding new data right above CTJ. The key question is whether CTJ is thermally dominated by ridge activity (magmatic, tectonic, and/or hydrothermal) or by subduction initiation (tectonic thickening, accretion, and/or erosion). The ultimate goal is to model the temperature at the plate interface from the heat flow and other data, and to infer how the thermal regime at CTJ contributes the seismogenic behavior at the M~9 megathrust zone.
Our preliminary analysis shows high and variable heat flow around CTJ. It is generally consistent with previous heat flow along line 751 (Cande et al., 1987). With SCS and piston core data, a reasonable thermal model can be constructed around CTJ. (Acknowledgment) we thank the Hydrographic Department of Chile (SHOA), for allowing to enter the Chilean EEZ and territory for our survey.

Keywords: heat flow, Chile Triple Junction

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Heat flow measurement on the seaward side of the Kuril Trench off Hokkaido

*Kouta Sasaki[1], Makoto Yamano[1], Yoshifumi Kawada[2], Masataka Kinoshita[1], Kiichiro Kawamura[3]

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To understand thermal structure of subduction zone, heat flow on the surface of incoming oceanic plate serves as an important boundary condition. On the surface of oceanic plate, observed value of heat flow is generally consistent with prediction of the plate cooling model (e.g., Stein and Stein, 1992). Yamano et al. (2014) revealed extensive high heat flow anomaly on the seaward side of the Japan Trench, where the very old Pacific plate (~135 Myr) subducts beneath northeast Japan, and some possible causes of the anomaly have been examined. Fujie et al. (2013, 2015) pointed out seismic velocity structure anomalies in the crust and the uppermost mantle seaward of the Japan and Kuril trenches and attributed them to increase in water content as a result of bending of the incoming oceanic plate. Kawada et al. (2014) examined influence of hydrothermal circulation in a permeable layer in the oceanic crust as a possible source of the high heat flow anomaly. They showed that hydrothermal circulation in the permeable layer thickening toward the trench axis in concordance with the seismic velocity anomaly pumps up heat efficiently and raises heat flow on the seafloor.

Infiltration of water into the crust is inferred seaward of the Kuril Trench as well based on the seismic velocity anomaly. Nakanishi (2011) argued that the direction of bending-related faults on the oceanward slope of the Kuril and Japan trenches is well correlated with the angle between the trench axis and the ancient spreading ridge axis, which varies along the trenches. It is also speculated that the trench-ridge angle is a major controlling factor of incoming plate hydration (Fujie et al., 2018). These studies suggest that it is indispensable to examine heat flow distribution seaward of the Kuril Trench, where few data have been obtained, for investigation of water and heat transport processes associated with plate bending.

In this study, we conducted heat flow measurement on the seaward of the Kuril trench off Hokkaido on KH-18-5 cruise of R/V Hakuho-maru. We measured geothermal gradient with a 3 m long temperature probe at eight sites and with a piston corer at four sites within about 120 km of the trench axis. We attempted penetration of the temperature probe several times at each site at intervals of 300 to 500 m. Few penetrations were successful within 60 km of the trench axis probably because thick layers of volcanic ash prevented the probe from penetrating into the sediment. Thermal conductivity was measured on piston core samples.

Most of the obtained 25 new heat flow values are roughly consistent with typical values for ocean basins older than 100 Myr (~50 mW/m^2), while high heat flow, 90 to 100 mW/m^2, was observed at one station about 70 km from the trench axis. This result indicates that the degree of heat flow anomaly on the seaward side of the Kuril Trench is lower than that in the counterpart of the Japan Trench.

Keywords: heat flow, Kuril Trench, oceanic crust, hydrothermal circulation, Japan Trench, Pacific plate

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Comparison of experimental and intermediate-depth earthquake b-value: difference in hydration degree of the oceanic mantle between Tohoku and Hokkaido

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We examine b-values of the lower-plane events than beneath Tohoku. Using the acoustic emission (AE) experimental result, the b-values for intermediate-depth intraslab earthquakes in the Pacific slab beneath the Tohoku and Hokkaido regions, northeastern Japan and find a difference in the b-values of lower-plane events in the double seismic zone. Lower-plane events reveal significantly larger b-values beneath Tohoku (0.96) than Hokkaido (0.86), implying that the brittle deformation beneath Hokkaido is more localized and leads to higher ratio of relatively large lower-plane events by Ferrand et al. [2017, Nature Communications], we also found that the b-values for experimental earthquakes increase with increasing antigorite content in serpentinized peridotite. A comparison of experimental and natural earthquake b-values implies that lower- plane peridotite is more hydrated beneath the Tohoku region, which is consistent with the difference in oceanic-plate velocity structures near the trench identified in Ocean Bottom Seismometer studies off Tohoku and Hokkaido by Fujie et al. [2017, Nature communications]. Since the density of fracture zones offshore Tohoku is larger than offshore Hokkaido, the extent of hydration of the oceanic mantle beneath Tohoku could be larger than beneath Hokkaido.

Keywords: intraslab earthquake, b-value, Acoustic emission , Wadati-Benioff zone, oceanic mantle, peridotite

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Variations in bend faulting and the nature of the incoming oceanic plate off northeast Japan arc

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As the inputs to subduction zone, the nature of the incoming oceanic plate, such as relief, thermal state, lithology, and the water content, affects subduction zone processes, including arc magmatism and interplate and intraplate seismic activities. Thus, regional variations in the nature of the incoming oceanic plate have a potential to cause regional variations in such subduction zone processes.

To reveal the nature of the incoming oceanic plate and its regional variations off northeastern Japan arc, we have conducted extensive controlled-source seismic experiments at the northwestern margin of the oceanic Pacific plate. First, we conducted seismic experiments at around the junction of the Kuril and Japan trenches. We observed seismic structural changes owing to the plate bending-related faults just prior to subduction at both trenches and found the structural changes caused by bend faulting are more significant in the Japan trench side than that in the Kuril Trench side, indicating that plate hydration before subduction is remarkably higher in the Japan Trench than in the Kuril Trench. These observed differences can be explained by the type of the bend faults, newly created faults (Japan Trench) or reactivated abyssal-hill faults (Kuril Trench). As the type of bend faults are determined by the angle between the current trench and the ancient spreading ridge, this angle is one of key factors controlling the hydration of the incoming oceanic plate.

In 2017 and 2018, we conducted additional seismic experiment at the trench-outer rise areas of the southern Japan Trench off Fukushima. This was our first seismic survey in the trench-outer rise region of the southern Japan trench. The strike of the Japan trench differs between the northern part and the southern part, indicating that the angle between the current trench axis and the ancient spreading ridge also differs between the northern part and the southern part. In addition, unlike the northern part of the Japan trench, a large seamount chain exists in the trench-outer rise region of the southern Japan Trench. The primary aim of our new seismic survey in the southern part of the Japan Trench is to clarify the differences between the northern and the southern part of the Japan trenches.

We applied traveltime tomographic inversion to the wide-angle reflection and refraction seismic data and developed a P-wave velocity (Vp) model. The obtained Vp model clearly shows the reduction in Vp near the trench axis caused by bend faulting. The Vp reduction patterns are closely akin to that in the northern Japan trench area. The angle between the current trench and the ancient ridge axis differs between the northern and the southern Japan trench, but the type of bend faults are the same. Our new observation confirmed that the type of bend faults is a key controlling factor on the bend faulting and plate hydration prior to subduction.

In addition to the structural changes caused by bend faulting, we observed curious features in crustal Vp structure. In the area far from the trench axis off Fukushima, our Vp model shows velocity reversal within the oceanic crust which is suggested by the "shadow zones" of the crustal refractions. We have observed similar velocity reversal within the oceanic crust in the areas far off Iwate, but not in the areas far off Miyagi. These observations suggest that the oceanic crust are intrinsically inhomogeneous in the

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northwestern part of the Pacific plate.

In this presentation, we will show the variations in the Vp model in the northwestern part of the Pacific plate including the structural changes caused by bend faulting and the velocity reversal within the crust, and discuss the possible impact as the subduction inputs.

Keywords: outer rise, controlled-source seismic survey, oceaic plate

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Seismicity in the trench-outer rise region off Fukushima and Ibaraki, southern Japan Trench

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After the 2011 Tohoku-oki earthquake, seismicity within the incoming Pacific plate is active in the trench-outer rise region along the Japan Trench. These earthquakes were characterized by normal-faulting focal mechanisms and could provide information about potential source faults of large outer-rise normal-faulting earthquakes. We have conducted earthquake observations in the southern part of the Japan Trench, off Fukushima and Ibaraki region(36º—38º N) by using ocean bottom seismographs (OBSs). The observations were conducted from March to July, 2017. We have deployed 35 OBSs including 14 ultra-deep type OBSs, which can be deployed in the trench-axis area where the maximum water depth was about 7800 m. Earthquakes were detected from continuous OBS records and phase arrival times were picked manually. Then, we relocated earthquakes by using double-difference tomography technique. In the tomography analysis, we used the initial velocity model based on an active seismic study conducted in the study area. Finally, we have obtained hypocenter location of about 1400 earthquakes. We also estimated focal mechanisms by using P-wave first-motion polarities in vertical component seismograms. The results show several linear earthquake clusters in the trench-outer rise region extended in roughly N-S and NNE-SSW directions. Pre-dominance of the normal-faulting focal mechanisms indicate that the earthquakes in the trench-outer rise region were explained by bending-related normal-faulting. The earthquake cluster oriented N-S direction was almost parallel to the strike of the northern Japan Trench, whereas NNE-SSW oriented linear clusters were almost parallel to the strike of the southern Japan Trench. Although the strike of the Japan trench changes from N-S in the north to NNE-SSW in the south at around 38º N, linear clusters parallel to both directions suggest existence of the complicated fault system in the trench-outer rise region in this area. Previous OBS observations along the Japan Trench showed that there was almost no seismicity along the plate boundary and within the overriding plate closed to the trench axis. The trench landward seismicity close to the trench axis observed only within the subducting Pacific plate. However, shallow earthquakes, which could occur along the plate boundary or within the overriding plate, close to the trench axis were observed landward slope of the Japan Trench south of 36.7º N. Seafloor geodetic studies indicated that seaward motion in the landward slope along the southern part of the Japan Trench, while landward motion were observed along the central part of the Japan trench. The characteristic shallow seismicity beneath the landward slope close to the trench axis might relate to the different displacement of the trench landward slope in the southern part of the Japan Trench.

Keywords: oceanic plate, outer rise, Japan trench

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Influence of water–rock interactions on the strength of outer-rise faults

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Knowledge of the amount of water stored in oceanic plates is important for understanding subduction zone water budgets (e.g., Hatakeyama et al., 2017, *Sci. Rep.*). Beneath the outer rise, the incoming oceanic plate bends down into the trench, resulting in the formation of extensional normal faults (i.e., outer-rise faults). Seismic reflection studies have shown that these normal faults penetrate into the upper mantle and act as a permeable fluid pathway. How deep outer-rise faults can develop primarily depends on the depth extent of strain localization within the oceanic lithosphere. Infiltration of seawater into outer-rise faults may promote the growth of mechanically weak hydrous phases such as talc and serpentines, perhaps leading to further strain localization. In order to understand effects of water–rock interactions on the strength of the upper mantle, I have conducted high-pressure deformation experiments on simulated peridotite fault gouges in the presence of hydrothermal water (Hirauchi et al., 2016, *Nat. Commun.*). I found that at a temperature of 500˚C and a confining pressure of 1 GPa, the development of talc-bearing, localized shear zones leads to an order-of-magnitude reduction in strength. This finding indicates that water–rock interactions along outer-rise faults play a role in deepening the fault depth and increasing water budgets in the oceanic upper mantle.

Keywords: outer-rise faults, fault strength, hydrous minerals

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Mon. May 27, 2019 1:45 PM - 3:15 PM JST | Mon. May 27, 2019 4:45 AM - 6:15 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-CG60] Investigation of inputs to subduction zones: Influence of tectonic processes on the incoming plate

convener:Makoto Yamano(Earthquake Research Institute, the University of Tokyo), Tomoaki Morishita(School of Geoscience and Civil Engineering, College of Science and Technology, Kanazawa University), Gou Fujie(Japan Agency for Marine-Earth Science and Technology), Chairperson:Makoto Yamano(Earthquake Research Institute, University of Tokyo)

Various tectonic processes occur on the seaward side of the trench associated with bending of the incoming oceanic plate, e.g., fracturing of oceanic crust, infiltration of water, and intraplate volcanism. Investigation of these processes and their influence on the incoming plate provides important information on the boundary condition at the trench, inputs to subduction zones. Variation in inputs should significantly affect geophysical/geological phenomena around the plate interface and geochemical cycles in subduction zones. We welcome contributions from a broad range of earth science (geophysics, geology, petrology, and so on) discussing topics related to inputs to subduction zones such as occurrence of tectonic processes due to bending of the incoming plate, modification of the incoming plate by the processes, relationship between the processes and the inherited structure of the incoming plate, and influence of the processes on the subduction plate interface. We hope discussions are made on studies of a variety of subduction zones, including the Japan Trench and the Nankai Trough, and comparative studies among different subduction zones.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SCG60-07] Seismic image of the incoming oceanic crust entering the central part of the Japan Trench: structural variation caused by petite-spot, bend fault and seamount

*Shuichi Kodaira[1,2], Akane Ohira[1,2], Gou Fujie[1], Tetsuo No[1], Yasuyuki Nakamura[1], Yuka Kaiho[1], Seiichi Miura[1] (1.R&D Center for Earthquake and Tsunami Japan Agency for Marine-Earth Science and Technology, 2.Graduate School of Environment and Information Sciences, Yokohama National University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SCG60-08] Dependence of calculation parameters on tsunami height from the outer-rise earthquakes

*Toshitaka Baba[1], Naotaka YAMAMOTO CHIKASADA[2], Yasuyuki Nakamura[3], Gou Fujie[3], Koichiro Obana[3], Seiichi Miura[3], Shuichi Kodaira[3] (1.Graduate School of Science and Technology, Tokushima University, 2.National Research Institute for Earth Science and Disaster Resilience, 3.Japan Agency for Marine-Earth Science and Technology)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SCG60-09] Bathymetry data analysis and multi-channel seismic reflection survey in the 1933 Sanriku earthquake (Mw 8.4) rupture region

*Tomoko Hanyu[1], Jin-Oh Park[1], Yukari Kido[2] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SCG60-10] Sedimentation process and deformation process before sinking of sediment on oceanic plate: examples in northwest Pacific Ocean and Sumatra

★Invited Papers

*Kiichiro Kawamura[1] (1.Yamaguchi University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SCG60-11] Exploring more asthenospheric melt: the preliminary report of KS-18-9 cruise, R/V Shinseimaru

*Naoto Hirano[1], Taku Yutani[2,1], Yuki Katsuragi[1], Jeffrey Anthony Oalmann[3], Fidel Costa Rodriguez[3], KS-18-9 Onboard Scientific Party (1.Tohoku University, 2.University of Bayreuth, 3.Nanyang Technological University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SCG60-12] Inputs of Argon on oceanic plate at subduction zones

*Shigeaki Ono[1] (1.Japan Agency for Marine-Earth Science and Technology)

Seismic image of the incoming oceanic crust entering the central part of the Japan Trench: structural variation caused by petite-spot, bend fault and seamount

*Shuichi Kodaira[1,2], Akane Ohira[1,2], Gou Fujie[1], Tetsuo No[1], Yasuyuki Nakamura[1], Yuka Kaiho[1], Seiichi Miura[1]

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The structure of an incoming oceanic plate influences various seismic behavior in subduction zones. In the outer-rise region of the Japan Trench, young intraplate volcanism, called “petit-spot” volcanism, has been reported (e.g., Hirano et al., 2006). However, to date, only a few geophysical studies have focused on petit-spot volcanism and its modifying effects on the structure of the oceanic crust. In 2017, Japan Agency for Marine-Earth Science and Technology (JAMSTEC) conducted an active-source seismic survey in the trench-outer-rise region of the Japan Trench during cruise KM17-05 of R/V *Kaimei* (Ohira et al., 2018). For refraction studies, a large tuned airgun array with a total volume of 10,600 cubic inches was towed at 10 m depth and fired every 100 m. The seismic data were recorded on 40 OBSs deployed along a 100-km-long line (line A4) with a spacing of 2 km. The multi-channel seismic (MCS) reflection data were collected by R/V *Kairei* using a 6,000-m-long, 444-channel streamer cable during cruise KR11-05 and KR15-07. On the MCS reflection section, we imaged opaque reflections at the top of the oceanic crust and a weak or absent Moho reflection under petit-spot volcanoes. The P-wave velocity model obtained from first-arrival traveltime tomography showed the large velocity reduction at the top of the oceanic crust near petit-spot volcanoes. This velocity reduction can be interpreted as fractures, hydration, and high porosity associated with petit-spot volcanic activity, as well as by the development of bend faulting (e.g., Fujie et al., 2018) and ancient fractures (Fujie et al., 2016). Our results suggest that petit-spot volcanism is one of the contributing factors leading to structural variation and modification of the incoming oceanic plate prior to its subduction. In 2018, additional new seismic reflection data from 25 –50 km interval of profiles were acquired during cruise KM18-06 of R/V Kaimei to cover the outer-rise region from 38°N to 36°N at the south of the petit-spot region. The new data provide along-strike structural variations attributed to petite-spot, bend fault and seamount.

Keywords: Japan Trench, Outer-rise, Seismic survey

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Dependence of calculation parameters on tsunami height from the outer-rise earthquakes

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Huge subduction zone earthquakes often induced outer-rise earthquakes occurring on the sea side from the trench axis. An outer-rise earthquake of M8 class which becomes a pair of the 2011 Tohoku earthquake has not yet been occurred. We should pay much attention on the next outer-rise earthquakes and resulting tsunamis in the Japan Trench. A data base (DB) retrieval type system is common for real-time tsunami prediction. It is necessary to incorporate various kinds of earthquake scenarios into DB without deficiencies. However, we have no clear answer to questions such as to how many every kilometer to be set in the depth of the fault stored in the DB in order to guarantee the prediction accuracy of a tsunami. Therefore, in this study, sensitivity analysis of calculation parameters was carried out for tsunamis caused by the outer-rise earthquakes.

We set nine basic fault models of the outer-rise earthquakes with reference to the results of crustal structure surveys and ocean bottom seismic observations. Each basic fault model was composed of multiple small subfaults of about 20 km in length, and the top end of the small subfaults were all set to be 0.1 km under the seafloor, the slope angle was 60 ˚, and the rake angle was 270 ˚. The strike angle of the subfaults were based on seafloor topography and crustal structure surveys. Magnitude (M) of the modeled outer-rise earthquake was calculated from the total fault length (L) using an outer-rise earthquake scaling law complied by Álvarez-Gómez et al. (2012). The fault width (W) was constrained at the lower end of the seismogenic layer, but it was given as L/W = 1 until reaching the lower end. The thickness of the seismogenic layer was set at 35 km. Slip amount was calculated from the fault area and M. Crustal deformation due to the faulting was calculated assuming a semi-infinite homogeneous elastic medium (Okada, 1985). The initial sea surface distribution was obtained considering the effect of tsunami excitation by horizontal movement of the slope (Tanioka and Satake, 1996) and the hydraulic filter (Kajiura, 1963) on the calculated seafloor crustal deformation. For tsunami calculations, the nonlinear shallow water equations were solved on a finite difference scheme.

Tsunamis were calculated by changing the calculation parameters and methods of the basic model one by one. The investigated cases were when using the dip angle of (1) 45 ˚or (2) 75 ˚against the dip angle of 60 ˚of the basic model, (3) when using the model approximated by single subfault, (4) when ignoring the effect of horizontal movement of the slope , (5) when ignoring the hydraulic filter, (6) when using different fault scaling laws, and (7) when using the nonlinear dispersive equations in the tsunami calculations. For the coastal tsunami height, the residuals from the basic model were evaluated by the root mean square error normalized by average tsunami height (NRMSE).

In this study, the difference in the coastal maximum tsunami height between the basic model and the derived model was large when (6) the fault scaling law was different (NRMSE ~ 0.50). This is followed by (7) without dispersion (NRMSE = 0.28), (5) without hydraulic filter (NRMSE = 0.21), (1)(2) when using the different dip angle in the subfault (NEMSE ~ 0.15), and (3) when approximating with a single fault (NRMSE = 0.10). Since the outer rise earthquake is a high-angle fault occurring in the relatively flat ocean, the effect of horizontal movement of the slope is relatively small (NRMSE = 0.025).

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Keywords: Outer rise earthquake, Tsunami, Numerical simulation

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Bathymetry data analysis and multi-channel seismic reflection survey in the 1933 Sanriku earthquake (Mw 8.4) rupture region

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In the northern part of the Japan Trench, the 1933 Showa-Sanriku earthquake (Mw 8.4), a normal-faulting earthquake such as large tensional outer-rise earthquake, occurred 37 yr after the 1896 Meiji-Sanriku tsunami earthquake (Mw 8.0) that ruptured plate-interface. Both earthquakes generated tsunamis that caused serious damages along the Sanriku coast of northeast Japan. As such, similar large-scale outer-rise earthquake is predicted to occur after the 2011 Tohoku-Oki earthquake (Mw 9.0). However, evolution process of the outer-rise earthquake fault has been poorly understood so far. From seismological data, Kanamori (1971) indicated that the faulting, with the average slippage on the fault plane, dipping 45˚ towards N 90˚W, amounts to 3.3 m, took place over the entire thickness of the lithosphere that caused the Showa-Sanriku earthquake. However, the large fault that penetrated from seafloor to upper mantle has not been identified yet. In order to obtain detailed images of the normal faults that cause the outer-rise earthquakes of the Japan Trench, we will carry out a multi-channel seismic reflection survey using R/V Shinsei-maru in April 2019. Before the survey, fine scale bathymetry data sets (90 meters grid), which were compiled and provided by JAMSTEC (after Kido et al., 2011), are used for the analysis of seafloor structure. In this study, we applied second-order differentiation to detect the horst-graben structures with slope at a steep angle.

The characteristics of horst-graben structures and inherited seafloor spreading fabric in our study are well concordant to those of Nakanishi (2011). In the region between 37.5˚N–40˚N, the horst-graben structures with trend of N20˚E–N30˚E are sometime broken continuity by the abyssal hills with trend of N50˚E–N70˚E and fault structures with trend of N20˚W. In a part of this region, between 38˚N–39˚N, was considered that this region was formed as a result of the ridge propagation (Nakanishi, 2011). The structure boundary on the crustal surface and Moho is observed by the OBS survey (Fujie et al., 2016) that located at a fracture zone associated with the ridge propagation, although the length of the distorted crustal surface and Moho across the fracture zone is extended about 60 km. Note that, Nakanishi (2011) suggested that the fault structures with trend of N20˚W are inherited seafloor spreading fabric and reactivated by the subduction. On the other hand, Kobayashi et al. (1998) interpreted that these faults are formed by the orientation change of the plate strength which is caused by the trend change of the trench axis from south to north along the Japan Trench. A few faults with slope angle of more than 50 degrees are recognized, but there is lack of continuity. Around the 39.5˚ N, continuous horst-graben structures with slope angle of about 30 degrees are confirmed. These continuous horst-graben structures have average vertical displacement of about 200 m. The longest horst-graben structure has length of about 250 km, and the northern portion of this fault reaches the hypocenter of Showa-Sanriku earthquake. It remains uncertain whether this structure is actually continuous or just apparently continuous. Because of the overlying sediment and lower resolution than that of seismic reflection data, the accurate slope angle and vertical displacement could not be obtained from only the bathymetry data. While, the large horst-graben structures could be detected by the bathymetry data and analysis of the bathymetric data is useful for planning the observation lines and pick-up the specific observation data set from the database. We will present the results of the bathymetry data analysis and preliminary results of the multi-channel seismic reflection survey in April 2019, and discuss the normal fault behavior associated with the outer-rise earthquakes.

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Keywords: Japan Trench, Outer-rise, Normal fault associated with the outer-rise earthquakes, Bathymetry data, Multi-channel seismic reflection survey

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Sedimentation process and deformation process before sinking of sediment on oceanic plate: examples in northwest Pacific Ocean and Sumatra

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The sediments covering subducting oceanic plate are pressed into continents. Sometimes it forms an accretionary prism, and they may collapse into submarine landslides in some cases. Also, it may become a fault zone during the further subducting process. Thus, the sediment on the subducting oceanic plate plays an important role in the continental deformation process in the subduction zones. From the above viewpoint, it is a currently required research topic to compare sedimentological, mineralogical and mechanical characteristics of sediment on the subducting plate before and after subducting. In this paper, I report the characteristics of sediments before subducting in the Northwest Pacific and off Sumatra in detail.

As a sedimentary feature, in the northwest Pacific, the effect of the bottom current is large, and it appears in sediments and ocean bathymetry as shown below. In this area, the Pacific plate is subducting into the Izu-Ogasawara Trench on the south part, the Japan Trench and the Kuril Trench in the northern part. In this area, a strong north - south bottom current along the trench axis has been observed at about 6000 m in water depth (Lee et al., 2003, etc), from the north to the south on the land side (Owens and Warren, 2001). Furthermore, in the deep ocean of the Pacific Ocean, flow from west to east is reported (Fujio and Yanagimoto, 2005).

18 sediment samples have been collected using a 4-m piston corer system. The samples are composed mainly of diatomaceous hemipelagic clay and volcanic ash layers. The volcanic ash layer is dated using the glass refractive index measurement. Various sedimentary structures are found in the clay layer, and in particular, on the trench axis, eroded surfaces are seen, suggesting the influence of bottom currents along the trench axis. The effect of the bottom current also is detected in the magnetic susceptibility anisotropy data. In addition, it is suggested that topographical features by the bottom current is also found from an asymmetric depression and/or moat (depth of several tens of meters, width of several kilometers) around a knoll. Thus, from sediments and submarine topography, The sediment and topographic features would suggest that we could understand the predominant bottom current directions in the northwest Pacific during the geological time scale of several thousand years.

As a mechanical feature, burial consolidation and/or diagenesis are one of the important processes in sediments before subducting. It is known that when deposits are consolidated during burial, dehydration progresses in response to stress and the microstructure gradually changes accordingly. They are called to be a card house structure in the shallow part, a book house structure in the middle part, and a shale-like (preferred horizontally orientation) structure in the deep part. They would be proceed by creeping by particle rotation and sliding and are generally considered to be secondary consolidation that occurs after primary compaction caused by reduction of excess pore fluid pressure. Burial consolidation causes gradual hardening of sediments, but the rate of change of its mechanical properties varies depending on various factors such as deposition rate, geothermal gradient, pore water chemical composition, particle composition. For example, the shale-like structure occurs at an void ratio of about 1.0 in the input

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sediments of the Izu-Ogasawara trench and occurs at about 0.5 off Sumatra. In addition, in the Izu-Ogasawara Trench and the input sediments off the coast of Sumatra, various deformation structures of the normal fault system are observed as a deformed structure before subducting.

By clarifying the sedimentary features such as the input sediments and the surrounding seabed topography, it is possible to interpret the difference of the deposition rate, the distribution area of the layer thickness of the sediment and so on. In addition, the mechanical characteristics represent the pre-additional deformation process before subducting, that is, in the area where the accretionary prism body is developing. The detailed characteristics of the sediments before subducting as described above will be important information for comparing deposits after subducting.

Keywords: Input sediments, Northwest Pacific, Sumatra

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Exploring more asthenospheric melt: the preliminary report of KS-18-9 cruise, R/V Shinseimaru

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The petit-spot magmas originate from the asthenosphere, ascending along the flexed zone of the outer-rise prior to plate subduction (Hirano *et al.*, 2006, *Science* 313, 1426; Valentine & Hirano, 2010, *Geology* 38, 55; Yamamoto *et al.*, 2014, *Geology* 42, 967; Machida *et al.*, 2015, *EPSL* 426, 267). This forms a unique opportunity to examine the asthenosphere below the ocean in a region outside of the well-examined but spatially restricted areas of MORs and hotspots. Recent researches, however, indicates that most of petit-spot erupted on concavely flexed plate are highly reacted with the depleted lithosphere during the magma ascending to surface. Geochemical composition of entrained xenolith from depleted mantle is disturbed by wall-rock interaction (Pilet *et al.*, 2016, *Nature Geosci.* 9, 898). From the observation that silica-poor alkaline melt is shifted to silica-rich subalkaline melts as a result of metasomatic interaction with lithospheric peridotite, the wall-rock interaction with silica-poor and strongly alkaline melts produces melts such as the majority of those at petit-spot lavas in NW Pacific (Pilet *et al.*, 2008, *Science* 320, 916). Experimental studies conducted by Machida *et al.* (2017, *Nature Comm.* 8, 14302), moreover, reported that the NW Pacific petit-spot melts were last equilibrated with peridotite at 1.5–2 GPa corresponding to the mid-depth or lower part of NW Pacific lithosphere as well. The melt fractionation must occur at depths greater than the mid-lithosphere because the geobarometer of peridotitic xenoliths shows the deepest 43 km (Yamamoto *et al.*, 2014) in spite of the lack of olivine phenocrysts. The most of petit-spot magma fractionated in mid- or lower lithosphere with some metasomatic reactions with depleted mantle at lower lithosphere during the magma-ascending to surface.

We newly discovered the directly ascending petit-spot melt from asthenosphere (Sato *et al.*, 2018, *Int'l. Geol. Rev.* 60, 1231). The lavas, silica-poor and strongly alkaline with phenocrystic olivines, are completely discriminated from the majority of previously reported petit-spot. They selectively erupt atop the outer-rise wherein the lithosphere behaves entirely in an extensional regime during the ascent of melt from asthenosphere. We conducted several dredge samplings in order to access the asthenosphere more directly, by the research cruise KS-18-9, R/V *Shinseimaru*, in August 2018, supported by AORI, Tokyo University, and the JSPS Japanese-German Graduate Externship. Special thanks to shipboard scientific party (S. Machida, N. Akizawa, T. Ishii, A. Matsumoto, M. Kaneko, Y. Sato, Y. Nakano, T. Yutani, K. Azami, S. Sakai, Y. Katsuragi), captain A. Tsuji, and crews on KS18-09, R/V Shinsei.

The petit-spot rocks are dredged at a lava field displayed by multibeam survey without any topographic highs, which are small blocks surrounding very fresh glass with less palagonitic alteration and manganese coating, implying the lavas are quite young. The quenched glass rinds were analysed for major and trace elements by an electoron microprobe at University of Bayreuth, Germany (co-work with T. Yutani), and an inductively coupled plasma–mass spectrometer (LA-ICP-MS) at Nanyang Technological University, Singapore (co-work with F. Rodriguez, J. Oalmann, Y. Katsuragi), respectively. As we gained "directly ascending petit-spots" from several volcanoes on this cruise, it is possible to recognize their source and melting process from their geochemical variations. The strongly alkaline lavas, directly ascending petit-spot, show clear trend in Zr/Hf, Sm/Hf ratios and HREEs, implying the carbonatite addition with the depth in source mantle. We present here the several processes of lithospheric flexure, metasomatized

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lithosphere, magma-fractionation, and finally, upwelling directly from asthenosphere occur prior to trench-oceanward slope, which would be significant components into the incoming oceanic plate.

Keywords: petit-spot, asthenosphere, Pacific plate, alkali-basalt, outer rise

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Inputs of Argon on oceanic plate at subduction zones

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It is known that noble gases are key tracers to understand the evolution of the mantle because of their inertness nature and isotope variations. However, a mechanism of recycle of noble gases in the deep mantle is still open question. Argon is one of noble gases and has three isotopes, ^{36}Ar, ^{38}Ar, and ^{40}Ar. Holland and Ballentine [2006] proposed that Ar from the mantle is identical to seawater component. This indicates that the seawater recycling dominates a behavior of Ar in the mantle. In contrast, the systematic analysis for noble gases indicates that ocean island basalt has a primordial signature which is different from atmosphere component [Mukhopadhyay 2012]. The recycling of Ar between the Earth’ s surface and the deep mantle has been discussed using the isotope data of noble gases. However, it is difficult to understand a mechanism of recycling of Ar because of a lack of knowledge for physical and chemical properties of Ar at high pressure and high temperature.

In this study, we used density functional theory to investigate the melting temperature and thermal pressure of Ar. We also performed the high-pressure experiments to determine the room-temperature equation of state for Ar. The combination of the first-principles molecular dynamics calculations and the high-pressure experiments led us to determine reliable physical properties, such as the equation of state and the melting temperature, over a wide range of pressures and temperatures.

The equation of state of Ar has been investigated to 382 GPa and 3000 K using the diamond anvil cell experiments and the first-principles molecular dynamics method. A large volume dependence of the thermal pressure of Ar was revealed at pressures higher than 200 GPa. A significant temperature dependence of the calculated effective Grüneisen parameters was confirmed at high pressures. This indicates that the conventional approach to analyze thermal properties using the Mie-Grüneisen approximation is likely to have a significant uncertainty in determining the equation of state for Ar, and that an intrinsic anharmonicity should be considered to analyze the equation of state. A melting temperature of Ar was estimated from calculation data, and a significant pressure dependence was confirmed. If the pressure-temperature path of the subducted slab is lower than critical condition, ~750 K and ~7.5 GPa, solid Ar can be carried down into the deep mantle. Melting of solid Ar in the upwelling mantle plume occurs at the bottom of the transition zone.

Keywords: Argon, Oceanic plate, Mantle, Equation of state

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Mon. May 27, 2019 1:45 PM - 3:15 PM JST | Mon. May 27, 2019 4:45 AM - 6:15 AM UTC | Convention Hall A 2F

[S-CG61] Dynamics in mobile belts

convener:Yukitoshi Fukahata(Disaster Prevention Research Institute, Kyoto University), Toru Takeshita(Department of Natural History Sciences, Graduate School of Science, Hokkaido University), Hikaru Iwamori(Geochemical Evolution Research Program, Japan Agency for Marine-Earth Science and Technology), Chairperson:Toru Takeshita, Kenta Kobayashi

The dynamic behaviours of mobile belts are expressed across a wide range of time scales, from the seismic and volcanic events that impact society during our lifetimes, to orogeny and the formation of large-scale fault systems which can take place over millions of years. Deformation occurs on length scales from microscopic fracture and flow to macroscopic deformation to plate-scale tectonics. To gain a physical understanding of the dynamics of mobile belts, we must determine the relationships between deformation and the driving stresses due to plate motion and other causes, which are connected through the rheological properties of the materials. To understand the full physical system, an integration of geophysics, geomorphology, and geology is necessary, as is the integration of observational, theoretical and experimental approaches. In addition, because rheological properties are greatly affected by fluids in the crust and fluid chemical reactions, petrological and geochemical approaches are also important. After the 2011 great Tohoku-oki earthquake, large-scale changes in seismic activity and regional scale crustal deformation were observed, making present-day Japan a unique natural laboratory for the study of the dynamics of mobile belts. This session welcomes presentations from different disciplines, such as seismology, geodesy, tectonic geomorphology, structural geology, petrology, and hydrology, as well as interdisciplinary studies, that relate to the dynamic behaviours of mobile belts.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SCG61-01] Fault zone development in the West Tottori area, Japan

*Kenta Kobayashi[1] (1.Department of Geology, Faculty of Science, Niigata University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SCG61-02] **Inerastic deformation around focal area of the 2000 Western Tottori EQ (M7.3) detected by “0.1 manten” Hyper Dense Seismic Observation (2)**

★Invited Papers

*Satoshi Matsumoto[1], Yoshihisa Iio[2], Shin'ichi Sakai[3], Aitaro Kato[3], Takuo Shibutani[2], Yuto Hayashida[4], Group for 0.1 manten Hyper dense seismic observation (1.Institute of Seismology and Volcanology, Faculty of Sciences, Kyushu University, 2.Disaster Prevention Reasearch Institute, Kyoto University, 3.Earthquake Research Institute, University of Tokyo, 4.Graduate School of Science, Kyushu University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SCG61-03] Non-double couple micro-earthquakes in the focal area of the 2000 Western Tottori earthquake (M7.3) by "0.1 manten" hyper dense seismic observation

*Yuto Hayashida[1], Satoshi Matsumoto[2], Yoshihisa Iio[3], Shin'ichi Sakai[4], Aitaro Kato[4], Group for "0.1 Manten" hyper dense seismic observation Group registration (1.Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2.Institute of Seismology and Volcanology, Faculty of Sciences, Kyushu University, 3.Disater Prevention Research Institute, Kyoto University, 4.Earthquake Research Institute, the University of Tokyo)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SCG61-04] Stress field in the Western Tottori and Western Shimane regions deduced by the dense seismic observations

*Yoshihisa Iio[1], Manten seicmic observation group, Manten seismic observation group in the Western Tottori region (1.Disater Prevention Research Institute, Kyoto University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SCG61-05] Modeling the spatiotemporal change in stress field around Hinagu fault zone through the 2016 Kumamoto earthquake sequence, in central Kyushu, Japan

*Ayaho Mitsuoka[1], Satoshi Matsumoto[2], Azusa Shito[2], Yusuke Yamashita[3], Manami Nakamoto[4], Masahiro Miyazaki[3], Shin'ichi Sakai[5], Yoshihisa Iio[3], Group for urgent joint seismic observation of the 2016 Kumamoto earthquake (1.Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2.Institute of Seismology and Volcanology, Faculty of Sciences, Kyushu University, 3.Disaster Prevention Research Institute, Kyoto University, 4.Association for the Development of Earthquake Prediction, 5.Earthquake Research Institute, The University of Tokyo)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SCG61-06] **Development of the Median Tectonic Line Fault zone in Mie Prefecture, Southwest Japan : A Possible Interpretation for Strain Localization and Softening**

*Toru Takeshita[1], Dong Van Bui[1], Thomas Anthony Czertowicz[1], Shun Arai[2], Takafumi Yamamoto[3], Jun-ichi Ando[3], Norio Shigematsu[4], Koichiro Fujimoto[5] (1.Department of Natural History Sciences, Graduate School of Science, Hokkaido University, 2.Department of Earth Science, Graduate School of Science, Tohoku University, 3.Department of Earth and Planetary Systems Science, Hiroshima University, 4.AIST, 5.Tokyo Gakugei University)

Fault zone development in the West Tottori area, Japan

*Kenta Kobayashi[1]

1. Department of Geology, Faculty of Science, Niigata University

Several kinds of investigations were carried out in the NW-SE trending aftershock area of the 2000 Tottori-ken Seibu earthquake (Mj7.3) and along the Nichinanko lineament (L=15km) which runs the SW of the aftershock area. The earthquake occurred in a place where no active fault is identified, with the exception of some short lineaments (e.g. Kanayama lineament: L=2km) in the direction of NW-SE. After the earthquake, many NW-SE to WNW-ESE trending surface ruptures were found in the aftershock area (e.g. Ryokusuien in central part of the area). They indicated sinistral slip sense. On the other hand, brittle fault rock zones are distributed in Late Cretaceous to Paleogene granitic rocks. Miocene rhyolite, basalt-andesite and aplite dikes intrude the granitic rocks, also deformed along the faults. Most fault planes with WNW strike indicate sinistral slip, and most of those with ENE strike show dextral slip. The determined paleo stress field is strike slip type of N-S tension, congruents with the 2000 Tottori-ken Seibu earthquake. However, along a few fault planes with WNW strike the early dextral slip is detected (e.g. Ryokusuien). Brittle fault rock zones are also distributed along the NW-SE trending Nichinanko lineament. Along the lineament, a wider mixture zone is formed. Fault planes with NW strike indicate sinistral slip.

XRD analysis showed that the gouge in the central part of the aftershock area is mainly composed of illite and chlorite (Kobayashi et al., 2006; Manaka et al., 2012), while the gouges in the NW and SE parts of the aftershock area (Kaneki et al., 2019) and those along the Nichinanko lineament (Manaka et al., 2012) are rich in halloysite. Chemical processes are different between these fault rock zones. In the central part of the aftershock area, most gouges were formed at a higher temperature than the neighborhood. On the other hand, the latest gouge is rich in smectite at Ryokusuien.

These facts suggest that the maturity of the fault zone along the aftershock area has been a low level, WNW strike fault planes (R1 shears) and ENE strike fault planes (R2 shears) formed predominantly. Therefore, the early kinematic (dextral) and chemical (illite-chlorite forming hydrothermal alteration) processes are remained. On the other hand, the activity along the Nichinanko lineament has been a higher level in a shallower depth (halloysite-smectite forming environment), NW strike fault planes (Y surfaces) formed predominantly, the remarkable Nichinanko lineament developed. In addition, the Komachi-Ohdani lineament system (L=12km) which runs the NE of the aftershock area also developed. How these fault zones have developed over a long period of time will be discussed.

Keywords: Tottori Prefecture, active fault, fault rocks, earthquake

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Inerastic deformation around focal area of the 2000 Western Tottori EQ (M7.3) detected by “0.1 manten” Hyper Dense Seismic Observation (2)

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Seismic observation with high resolution and sensitivity is a key to solve a question how the crust deforms inelastically and accumulate stress in the seismogenic zone. We have completed a seismic observation for one year at one thousand sites (0.1 Manten seismic observation) in an aftershock area of the 2000 Western Tottori earthquake (M7.3). The seismic network with radius of about 18 km covered entire aftershock area of the M7.3 event. Automatic-detecting procedure was applied to the seismograms in order to detect small earthquakes. Over 5000 events of natural earthquakes were obtained during the observation. Sensitivity of the network is high and its detection limit for small earthquake was about magnitude of -1.0. Focal mechanism of the earthquake with magnitude range below zero could be determined. In this study, we showed inelastic deformation due to seismic activity of the small earthquake around the fault of the main shock.
The detected aftershock activity is higher at north of the large slip area of the main shock than at other area. Taking into account the activity just after the main shock, we found inelastic strain rate inferred from the aftershock reveals spatial heterogeneous distribution. The rate is smaller than inverse of the lapse time from the main shock, indicating that inelastic deformation due to the aftershock continue long duration compared with other part of the fault. This area corresponds to the hypocentral area of the preceding activity toward the main shock of the Western Tottori earthquake. These suggests that the high inelastic strain rate area at the north of the asperity of the main shock behaved as low strength area relaxing stress at the part and resulted stress loading to the asperity. Comparing the rate with it estimated from the preceding activity to the main shock, the rate at present is similar order to one before the mainshock. It suggests a possibility that loading processes exists below the low-decay rate zone where seismic activity observed prior to the main shock.

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Non-double couple micro-earthquakes in the focal area of the 2000 Western Tottori earthquake (M7.3) by "0.1 manten" hyper dense seismic observation

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Earthquakes with non-double couple (NDC) component could provide information such as geometric fault complexity, tensile failure, and fluid flow in faulting.

In this study, we found definite micro-earthquakes with NDC in the aftershock area of the 2000 Western Tottori earthquake (M 7.3) based on polarity analysis for first P-wave motion data from “0.1 manten” hyper dense seismic observation. The observation composed of a thousand seismic stations successfully provided with high resolution focal mechanisms of a lot of micro-earthquakes in the area.

We attempted to model the events with NDC by tensile-shear faulting, shear-tensile faulting, and multiple events with pure double couple focal mechanisms. We analyzed 8 events that distributes the entire after shock area.

Plausible models for the events occurring at shallower and deeper depth are the faulting with tensile crack and the multiple shear faulting models, respectively. The results suggest that fluid contributes to the crack opening at the shallow part. In contrast, fluid pressure does not sufficient to open tensile crack at the deep part. Therefore, the depth of the boundary may relate to the pressure of fluid at the earthquake fault. In addition, the events with large NDC component were located around co-seismic large slip area of the mainshock of the Western Tottori earthquake. This suggests that fluid exits around the co-seismic slip area.

Keywords: non-double couple earthquake, focal mechanism, the 2000 Western Tottori earthquake

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Stress field in the Western Tottori and Western Shimane regions deduced by the dense seismic observations

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We estimate the stress field in the Western Tottori and Western Shimane regions by precisely analyzing focal mechanisms from dense seismic observations installed in and around the seismic belt in the San-in district, Japan. In this region, we installed a Manten seismic observation network with 50 high-gain short period seismometers in 2009, and another Manten seismic observation network with 81 high-gain short period seismometers in 2015. In this study, we utilize data from these Manten seismic observation networks and nearby permanent seismic stations, and also those obtained by the group for the dense aftershock observations of the 2000 Western Tottori Prefecture earthquake. It was inferred by previous studies that the azimuths of the maximum compressional stress axis in the seismic belt are oriented in a WNW–ESE direction, while they are aligned in almost the EW direction i in the south of the seismic belt, in the inland plate along the Nankai Trough. This spatial change in the stress field in and around the seismic belt was qualitatively explained by the aseismic slip in a ductile fault zone in the lower crust beneath the seismic belt. The results obtained in this study are summarized as follows. In the region from the aftershock area of the Western Tottori prefecture earthquake to the vicinity of Sanbe-san, rotation of $\sigma 1$ direction was observed. On the south side of the region, the direction of $\sigma 1$ is N 90 ˚E to N 110 ˚E, whereas in the region it is N 100 ˚E to N 140 ˚E, which is a rotation of 20 to 30 ˚. Rotation is large on the west side of the aftershock area of the Western Tottori prefecture earthquake and in the vicinity of Sanbe-san and small between them. In the area around the Shinji Rift zone on the north side of this area, although the number of data is small, the direction of $\sigma 1$ is N 120 ˚E to N 140 ˚E, and the rotation is the largest among the entire area. In this way, in this area, the rotation of the direction of $\sigma 1$ is seen in the central part of the San-in earthquake zone, and among them, the rotation is locally large in the west side of the aftershock area of the Western Tottori prefecture earthquake and in the vicinity of Sanbe-san. In addition, $\sigma 1$ turns greatly around the Shinji Rift zone north of the seismic belt.

In the lower crust beneath the vicinity of the seismic belt, a low velocity zone of about 50 km in width is estimated at a depth of 25 km (Tsuda et al., 2017). In the upper crust, large low velocity anomalies are seen along the Shinji Rift Belt. The stress field in this area may be formed by shortening in the orthogonal direction of the Shinji groove belt in addition to the slow slip immediately beneath the seismic belt Kawanishi et al. (2009) estimated the stress field with the seismic zone as a region, but it became clear that there is an internal structure in it.

Keywords: stress, lower crust, focal mechanism, intraplate earthquake, seicmic observation

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Modeling the spatiotemporal change in stress field around Hinagu fault zone through the 2016 Kumamoto earthquake sequence, in central Kyushu, Japan

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For a purpose of understanding physical process of earthquake generation, knowledge of stress condition around a fault is required. We estimated stress field and discussed its spatiotemporal change around Hinagu fault zone that was the hypocentral area of the 2016 Kumamoto earthquake sequence.
The 2016 Kumamoto earthquake sequence occurred around Hinagu and Futagawa fault zones in Kumamoto prefecture, central Kyushu Island, Japan. The largest foreshock with Mj 6.5 (Mj: magnitude by Japan Metrological Agency) on April 14, 2016 was located Hinagu fault zone. The mainshock (Mj 7.3) generated slip at both Hinagu and Futagawa fault on April 16, 2016. After that, many earthquakes occurred around these faults until now.
In this study, we estimated the spatiotemporal change in the deviatoric stress field and its differential stress. For discussing the temporal change in the target region, we divided time sequence into three periods: (1) prior to the sequence (i.e. before Mj 6.5 event), (2) between the foreshock and the mainshock, and (3) after the mainshock. We compared the deviatoric stress fields with the co-seismic stress change by faulting of this sequence. From focal mechanism solutions from January 1, 1993 to December 31, 2017, we estimated the deviatoric stress field using the method by Matsumoto [2016]. We adopted fault slip models of the fore- and mainshock, which is the slip distribution projected result by Asano and Iwata [2016] on the fault geometries determined from the distribution of hypocenters. We performed a grid search procedure for the differential stress at each spatial block with horizontal size of 0.05˚in latitude and longitude, and 5 km in depth.
As a result, we captured the stress condition in the both period (1) and (3). Before the foreshock (i.e. period (1)), the differential stress around the fore- and mainshock faults is higher than the other region, its value is from several MPa to several tens of MPa. On the other hand, the differential stress in south area of Hinagu fault zone ranges from about 0.1 to 1 MPa. We found the foreshock and mainshock occurred in the state of high differential stress.
After the mainshock (i.e. period (3)), the spatial heterogeneity of the differential stress still remained. However, the differential stress at the area around the hypocenters of the fore- and mainshock is about half of that before the foreshock. At the southeast area of Hinagu fault, the differential stress is about twice of that before, so potential of occurring earthquake becomes relatively high compared with the prior state to this sequence.

Keywords: 2016 Kumamoto earthquake, stress field, fault strength

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Development of the Median Tectonic Line Fault zone in Mie Prefecture, Southwest Japan : A Possible Interpretation for Strain Localization and Softening

*Toru Takeshita[1], Dong Van Bui[1], Thomas Anthony Czertowicz[1], Shun Arai[2], Takafumi Yamamoto[3], Jun-ichi Ando[3], Norio Shigematsu[4], Koichiro Fujimoto[5]

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We have investigated the development of the Median Tectonic Line (MTL) fault zone in the upper-plate Ryoke granitoids in Mie Prefecture, southwest Japan. In the study area, although c. 80 m thick cataclasite develops in direct proximity to the MTL, mylonitic rocks were pervasively formed before the formation of cataclasite, which can be divided into protomylonite distributed from the MTL to the point 300 m north from it and mylonite distributed from the latter point to the one at c. 800 m further north from the MTL. However, in the protomylonite zone, ultramylonite with the thickness up to c. 50 m is developed in direct proximity to the MTL, which occur as clasts in the cataclasite zone. We also have found that the protomylonite originates from tonalite, while the mylonite originates from granite. Hence, the boundary between the protomylonite and mylonite exactly coincides with the protolith boundary.

We analyze both microstructures and c-axis fabrics in recrystallized quartz grains from the protomylonite and mylonite zones along the MTL. In the protomylonite, sizes of recrystallized grains formed by subgrain rotation (SGR) recrystallization are low ranging between 7-14 microns. In particular, in the ultramylonite, the recrystallized grain sizes ranges between 4-11 microns. The quartz c-axis fabrics mostly show a Y-maximum pattern. On the other hand, the mylonite zone can be divided into two subzones in terms of quartz microstructures. In the subzone from 300 m to 490 m from the MTL, the microstructures are characterized by elongated grains (S-type) with finer recrystallized grain sizes varying between 11-20 microns formed by SGR. On the other hand, in the zone from 490 m to 800 m from the MTL, the microstructures are characterized by relatively equant grains (P-type) with coarser recrystallized grain sizes varying between 49-107 microns and lobate grain boundaries formed by grain-boundary migration (GBM) recrystallization. In both mylonite subzones, a Y-maximum quartz c-axis fabric dominates.

We further analyze microstructures of K-feldspar, and infer deformation temperatures based on the two-feldspar geothermometry after Stormer (1975) and Stormer and Whitney (1985) in the mylonite zone which originated from granite. While K-feldspar porphyroclasts are broken in the S-type mylonite subzone, they are plastically deformed to a sigma shape in the P-type mylonite subzone. Myrmekite pervasively develops at the periphery of K-feldspar porphyroclasts from the entire mylonite zone. Using the chemical compositions of K-feldspar and plagioclase in myrmekite, we infer the deformation temperatures in the mylonite zone. At the northernmost P-type mylonite subzone, the deformation temperatures are calculated at 500 ˚C, which decrease to 400 ˚C at the boundary between the P- and S-type mylonite subzones, and further decrease in the S-type mylonite zone, ranging between 350-400 ˚C.

Plastic deformation is dominant in the granite than in the tonalite at higher temperatures than 500 ˚C, leading to the formation of mylonite in the former area alone, perhaps because granite including abundant K-feldspar is rheologically weaker than tonalite. Subsequently, with decreasing temperature,

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plastic deformation becomes localized in the southern part of the mylonite zone. At 400 ˚C, only the S-type mylonite subzone continues to deform, and the protomylonite starts to deform at higher stresses than in the S-type mylonite subzone. With further decreasing temperatures, the plastic deformation of S-type mylonite subzone is abandoned at 350 ˚C, and the further plastic deformation only occurs in the ultramylonite at 300-350 ˚C, leading to the formation of very fine-recrystallized quartz grains and type-I crossed girdle quartz c-axis fabric with R-maxima, which is further followed by cataclasis. We currently do not have a good idea on why the zone of plastic deformation suddenly jumps from the southernmost S-type mylonite subzone, which is 300 m apart from the MTL, to the protomylonite zone in direct proximity to the present MTL, forming ultramylonite. However, since a type-I crossed girdle quartz c-axis fabric with R-maxima is developed in the ultramylonite, it can be inferred that water weakening of quartz either by decreasing the strength of slip systems or facilitating dynamic recrystallization occurs in the protomylonite zone, which could have been caused by infiltration of water along newly formed fractures.

Keywords: Median Tectonic Line, mylonite, quartz c-axis fabric

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Mon. May 27, 2019 3:30 PM - 5:00 PM JST | Mon. May 27, 2019 6:30 AM - 8:00 AM UTC | Convention Hall A 2F

[S-CG61] Dynamics in mobile belts

convener:Yukitoshi Fukahata(Disaster Prevention Research Institute, Kyoto University), Toru Takeshita(Department of Natural History Sciences, Graduate School of Science, Hokkaido University), Hikaru Iwamori(Geochemical Evolution Research Program, Japan Agency for Marine-Earth Science and Technology), Chairperson:Tomomi Okada, Ryosuke Ando(Graduate School of Science, University of Tokyo)

The dynamic behaviours of mobile belts are expressed across a wide range of time scales, from the seismic and volcanic events that impact society during our lifetimes, to orogeny and the formation of large-scale fault systems which can take place over millions of years. Deformation occurs on length scales from microscopic fracture and flow to macroscopic deformation to plate-scale tectonics. To gain a physical understanding of the dynamics of mobile belts, we must determine the relationships between deformation and the driving stresses due to plate motion and other causes, which are connected through the rheological properties of the materials. To understand the full physical system, an integration of geophysics, geomorphology, and geology is necessary, as is the integration of observational, theoretical and experimental approaches. In addition, because rheological properties are greatly affected by fluids in the crust and fluid chemical reactions, petrological and geochemical approaches are also important. After the 2011 great Tohoku-oki earthquake, large-scale changes in seismic activity and regional scale crustal deformation were observed, making present-day Japan a unique natural laboratory for the study of the dynamics of mobile belts. This session welcomes presentations from different disciplines, such as seismology, geodesy, tectonic geomorphology, structural geology, petrology, and hydrology, as well as interdisciplinary studies, that relate to the dynamic behaviours of mobile belts.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SCG61-07] What caused the Main Himalayan Thrust (MHT) to ramp? Insights from analogue and numerical models

*Subhajit Ghosh[1,2], Arijit Laik[2], Santanu Bose[2,3], Nibir Mandal[4] (1.Earthquake Research Institute, The University of Tokyo, 1-1-1 Yayoi, Bunkyo-Ku, Tokyo 113-0032, 2.Department of Geology, University of Calcutta, 35, Ballygunge Circular Road, Kolkata 700019, India, 3.Department of Geology, Presidency University, 86/1 College Street, Kolkata 700073, India, 4.Department of Geological Sciences, Jadavpur University, Kolkata 700032, India)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SCG61-08] Control of fault weakening on the structural styles of underthrusting-dominated non-cohesive tectonic wedges

*Arthur Bauville[1], Mikito Furuichi[1] (1.Department of Mathematical Science and Advanced Techology, JAMSTEC)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SCG61-09] Complexity of the 2016 *M* 7.8 Kaikoura, New Zealand, earthquake from seismic observation: inferences of overpressured fluid involvement

*Tomomi Okada[1], Satoshi Matsumoto[2], Yoshihisa Iio[3], Federica Lanza[4], Clifford H Thurber[4], Miu Matsuno[1], Yuta Kawamura[2], Tadashi Sato[1], Stephen C Bannister[5], John Ristau[5], Martha K Savage[6], John Townend[6], Jarg Petttinga[7], Francesca Ghisetti[8], Richard H Sibson[9] (1.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University, 2. Institute of Seismology and Volcanology, Faculty of Sciences, Kyushu University, 3. Disater Prevention Research Institute, Kyoto University, 4.University of Wisconsin-Madison, U.S.A., 5.GNS Science, New Zealand, 6.Victoria University of Wellington, New Zealand, 7.University of Canterbury, New Zealand, 8.TerraGeoLogica, New Zealand, 9.University of Otago, New Zealand)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SCG61-10] Dynamic Rupture Simulation Reproduces Spontaneous Multifault Rupture and Arrest During the 2016 Mw 7.9 Kaikoura Earthquake

*Ryosuke Ando[1], Yoshihiro Kaneko[2] (1.Graduate School of Science, University of Tokyo, 2.GNS science)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SCG61-11] Ductile deformation explains the physics of friction and genesis of earthquakes

*James Daniel Paul Moore[1], Stefan Nielsen[2], Lars N Hansen[3] (1.Earth Observatory of Singapore, 2.University of Durham, 3.University of Oxford)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SCG61-12] The seismic moment, stress drop, and strain energy release for the rupture of asperities

*Mitsuhiro Matsu'ura[1] (1.Institute of Statistical Mathematics)

What caused the Main Himalayan Thrust (MHT) to ramp? Insights from analogue and numerical models

*Subhajit Ghosh[1,2], Arijit Laik[2], Santanu Bose[2,3], Nibir Mandal[4]

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Occurrence of any conspicuous ramp on the low angle basal detachment causes hindrance on the overall wedge progression and behaves as an asperity by localizing stress in the inter-seismic gaps. The mid-crustal ramp on the Main Himalayan Thrust (MHT) results in strain partitioning by focusing seismicity, including 2015 magnitude 7.8 Gorkha earthquake in the central Nepal Himalaya. However, the ramp structure is laterally discontinuous; even absent in some parts of the Himalaya (e.g. western Bhutan). Interestingly, it has been widely shown that the geometry of the basal detachment (in terms of presence or absence or geographic location of the ramp) provides first order control on the along strike variations in the structure, topography, low-temperature thermochronological ages, precipitation, exhumation and erosion patterns. Motivated by the absence of any mechanical explanation for these peculiar observations, we compare physical and numerical experiments with the geology of the frontal eastern Himalaya to show how the mechanically weak coal bearing Gondwana horizon controls the position of the basal detachment in space and time. Our modelling results confirm that the initial spatial distribution of the Gondwana horizon strongly influences the position of the mid-crustal ramp at different geographic location which resulted in segmented MHT structure (Fig. 1). The numerical modelling largely validates the physical experiments and explains the rock uplift and river incision pattern recorded in the Nepal Himalaya.

Keywords: mid-crustal ramp, Main Himalayan megathrust, seismicity asperity, Basal friction, Analog sandbox, Numerical model Underground

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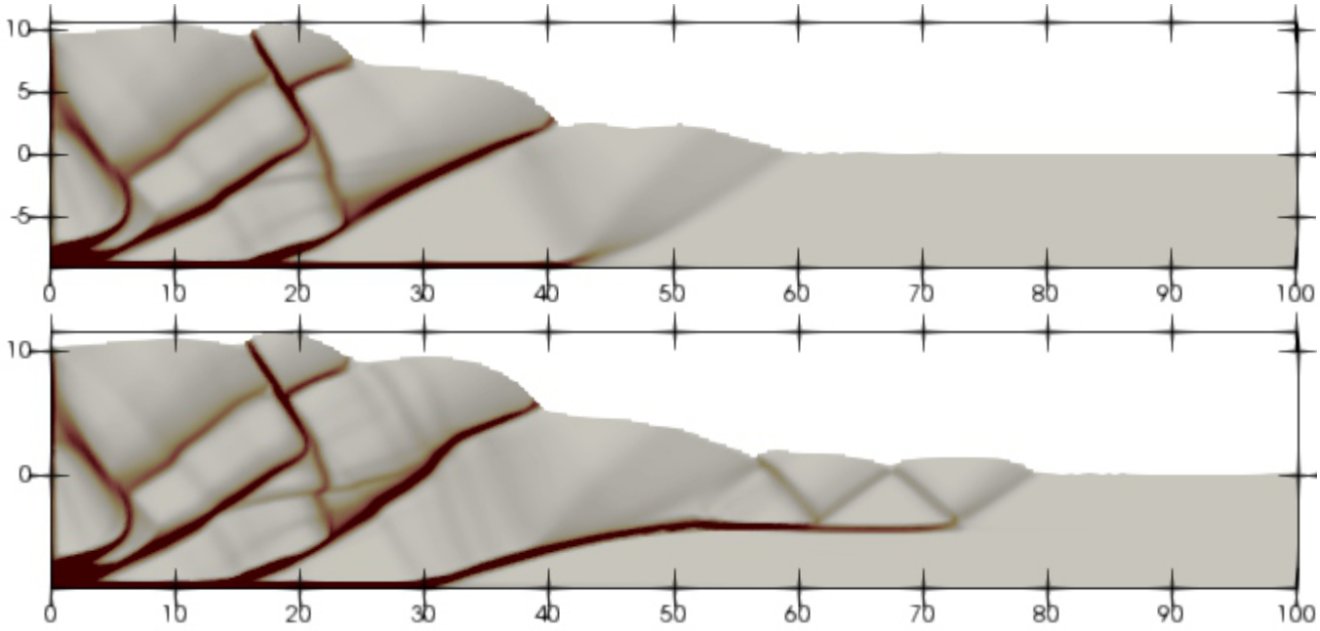


Fig. 1 Numerical sandbox simulation with visco-plastic rheology. Sequential thrust progression in a model containing a weak zone (Φ_W = 10°). The weak zone shifted the thrust progression to a shallower depth. Plastic strain mapping clearly marks the location of ramping of the basal detachment.

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Control of fault weakening on the structural styles of underthrusting-dominated non-cohesive tectonic wedges

*Arthur Bauville[1], Mikito Furuichi[1]

1. Department of Mathematical Science and Advanced Techology, JAMSTEC

Underthrusting is a typical process at compressive margins responsible for nappe stacking and sediment subduction. Despite being essential for orogenesis, and the subduction cycle, the mechanics of underthrusting is still incompletely understood. The critical taper theory predicts that underthrusting occurs only in the limit where $\mu_b'=\mu'$, with μ' and μ_b' the inner and basal effective coefficient of friction, respectively. Paradoxically, in nature, underthrusting is associated with weak faults. For instance, at erosive subduction margins, sediments are dragged in subduction, while normal faulting in the middle prism suggests the plate boundary is weak. Wang et al., (2010) have proposed that dynamic fault strength variations during the earthquake cycle can reconcile these observations. In their model, underthrusting occurs during earthquakes when the fault is strong and normal faulting occurs in the prism during the interseismic period when the fault is weak. However, recent evidence (Gao and Wang, 2016) suggests that plate boundaries are relatively weak also during earthquakes.
In this contribution, we investigate the control of permanent fault weakening on the dynamics of a strong-based ($\mu_b'=\mu'$,) non-cohesive tectonic wedge. We control the wedge material strength by a spatially constant fluid overpressure factor (λ^*, and fault strength by a strain weakening factor (χ). We investigated the problem in two steps. First, we used the critical taper theory to determine a mechanical mode diagram that predicts structural styles. This diagram is deduced from the function $\Delta\alpha(\beta,\chi,\lambda^*)$ which is the difference in taper angle at a given β, between the compressively critical taper of a strong-based wedge and the extensionally critical taper of a weak-based wedge ($\mu_b'=(1-\chi)\mu'$). Then, we performed numerical simulations of accretionary wedge formation to establish the characteristics of these structural styles regarding wedge and fault geometry. We determined there is a continuum of structural styles with three end-members occurring at the theoretically determined mechanical mode transitions.

Style 1 is characterized by thin tectonic slices and little to no underthrusting.
Style 2 is characterized by thick slices and nappe stacking.
Style 3 is characterized by the complete underthrusting of the incoming sediments.

The model gives a mechanical explanation that reconciles underthrusting with weak faults. In agreement with observations, the model predicts the occurrence of style 2 in strong-based sandbox experiment. Finally, we argue that style 3 is triggered by any mechanism, such as material weakening, erosion or sedimentation, that limits the surface angle such that the incoming material is always significantly under-critical.

Keywords: Accretionary prism, Underthrusting, Critical taper theory, Numerical simulations

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Complexity of the 2016 *M* 7.8 Kaikoura, New Zealand, earthquake from seismic observation: inferences of overpressured fluid involvement

*Tomomi Okada[1], Satoshi Matsumoto[2], Yoshihisa Iio[3], Federica Lanza[4], Clifford H Thurber[4], Miu Matsuno[1], Yuta Kawamura[2], Tadashi Sato[1], Stephen C Bannister[5], John Ristau[5], Martha K Savage[6], John Townend[6], Jarg Petttinga[7], Francesca Ghisetti[8], Richard H Sibson[9]

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The *M* 7.8 Kaikoura earthquake occurred in the northern South Island on 3 Nov., 2016, involving the rupture of > 20 faults. To understand the complexity of the Kaikoura earthquake, details of fault geometry, seismic velocity distribution and stress field are necessary. We have undertaken seismic tomography and stress tensor inversion using focal mechanisms along the c. 200 km length of the rupture zone.

Data from both 51 temporary stations and 22 GEONET stations were collected from March 2011 to December 2017. Hypocenter locations and the three-dimensional velocity structure were determined using the method of Zhang and Thurber (2003 and 2006).

The hypocenter of the Kaikoura earthquake and aftershocks near the Kekerengu fault locate along lineaments where seismic velocity changes horizontally.

In the uppermost crust, lower velocities occur beneath the Emu Plain and Cape Campbell. Higher velocities occur in and around Kaikoura.
In the middle to lower crust, high Vp/Vs occurs not only in and around the hypocenter but also along the northern part of the rupture zone.
In the lowermost crustal or uppermost mantle, high Vp occurs east of the Kekerengu fault and south of the Hope fault and beneath the Canterbury plains faults. This high Vp likely corresponds to the Pacific plate.

These complexities in the seismic velocity structure may relate to the multi-rupture character of the Kaikoura earthquake. In particular, spatial correlations between rupture areas and high Vp/Vs suggests the involvement of overpressured fluid in the nucleation and propagation of rupture segments, which is also supported by the reactivation of unfavourably oriented strike-slip ruptures, many lying at c.70˚ to regional sigma-one stress trajectories.

Keywords: 2016 Kaikoura earthquake

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Dynamic Rupture Simulation Reproduces Spontaneous Multifault Rupture and Arrest During the 2016 Mw 7.9 Kaikoura Earthquake

*Ryosuke Ando[1], Yoshihiro Kaneko[2]

1. Graduate School of Science, University of Tokyo, 2. GNS science

The 2016 Kaikoura (New Zealand) earthquake is characterized as one of the most complex multifault rupture events ever observed. We perform dynamic rupture simulations to evaluate to what extent relatively simple forward models accounting for realistic fault geometry can explain the characteristics of coseismic observations. Without fine parameter tuning, our model reproduces many observed features including the multifault rupture, overall slip distribution and direction, and the locations of the maximum slip and rupture arrest. In particular, our model shows spontaneous arrest of dynamic rupture at the both ends of the ruptured fault system due to smaller prestress levels expected from a regional tectonic stress field. Both the simulated and the observationally inferred source time functions show similar double peaks with a larger second peak. The results illuminate the importance of the 3-D fault geometry in understanding the dynamics of complex multifault rupture.

Keywords: Dynamic rupture, Boundary integral equation method, Fault geometry

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Ductile deformation explains the physics of friction and genesis of earthquakes

*James Daniel Paul Moore[1], Stefan Nielsen[2], Lars N Hansen[3]

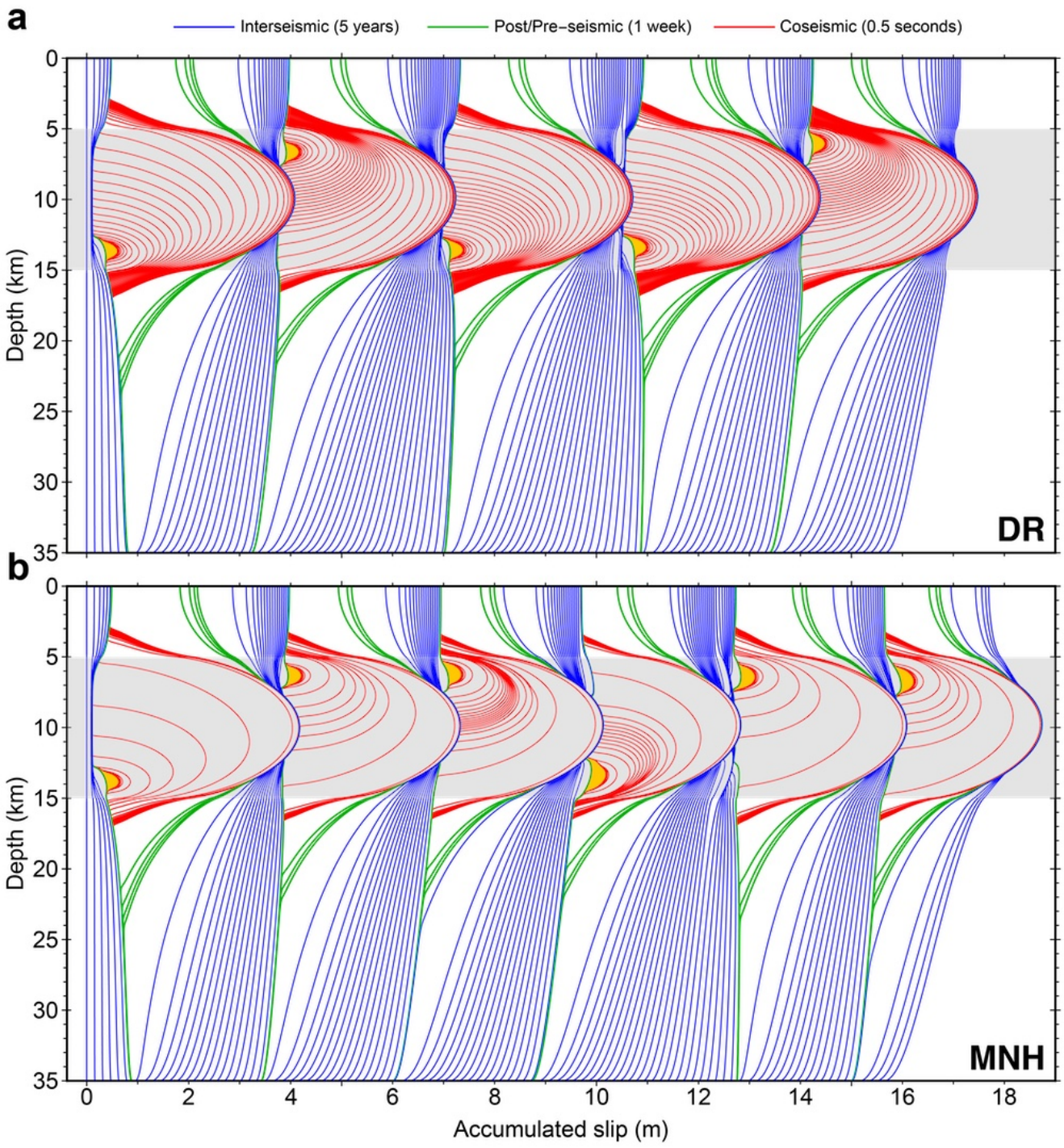
1. Earth Observatory of Singapore, 2. University of Durham, 3. University of Oxford

Seismic hazard presents a significant global threat to both life and property, with increased urbanisation in the twenty-first century only intensifying the risk as populations concentrate near fault lines. It is therefore imperative to develop a clear understanding of the physical origins of earthquakes, with their associated hazards, and use that knowledge to work towards building more resilient societies. To this end, we show that ductile deformation on contact regions within fault zones explains the physics of fault friction, and the genesis of earthquakes. We find the empirical framework of rate-and-state friction may be derived from grain-scale creep processes, and that earthquakes are the macroscopic manifestation of ductile deformation at microscopic contacting regions. The governing equations are well behaved at low slip rates, the seismogenic layer emerges as a consequence of the pressure-temperature dependence of ductile creep processes, and we offer an explanation for the temporal distribution of earthquake clustering.

The physical origins of the laws of friction that govern the genesis of earthquakes have long been the subject of discussion and debate. Here we demonstrate that the empirical framework of rate-and-state friction is a natural consequence of grain-scale processes, and that fault slip is the macroscopic manifestation of creep on contact asperities, modulated by grain-size processes, at the microscopic scale.We find that common rate-and-state parameters derived from laboratory data and geodetic observations are entirely commensurate with known flow laws: diffusion creep, dislocation-accommodated grain-boundary sliding, and dislocation creep. Additionally, we find that the temperature, grain size, and stress dependence of these flow laws naturally give rise to the full spectrum of fault behaviour from stable creep, through slow slip and tremor, to bilateral ruptures. In particular a seismogenic layer emerges spontaneously from the interplay of these creep mechanisms, for which the stability is primarily determined by the grain-size dependence of the active flow law. Our framework unifies the work of friction experiments for localised deformation and flow laws governing distributed deformation, whilst simultaneously addressing a number of shortcomings of the Dieterich-Ruina form of rate-and-state friction, such as the non-physical divergence as the sliding velocity tends to zero. We present very close equivalence between rate-and-state friction and established flow laws, and provide an explanation for the emergence of the seismogenic layer.

Keywords: Earthquake, Friction, Rheology

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The seismic moment, stress drop, and strain energy release for the rupture of asperities

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1. Institute of Statistical Mathematics

Seismic moment and stress drop are known as the most fundamental physical quantities characterizing seismic events. The seismic moment of an event is clearly defined as the product of its rupture area (S), average fault slip (D), and the rigidity of the surrounding elastic medium (Aki, 1966; Kostrov, 1974), but the stress drop is not (Madariaga, 1979), which depends on adopted source models. In the simplest case of a circular crack model with uniform stress drop, the stress drop is proportional to D and the inverse of the square root of S, and so independent of seismic moment (e.g., Kanamori & Anderson, 1975). However, with the simplest model, Nadeau & Johnson (1998) found a clear dependence of average stress drop on seismic moment from a detailed analysis of repeating earthquakes along the Parkfield segment of SAF. This empirical scaling relationship for average stress drop is contrary to what is commonly assumed in seismology: that is the stress drop is independent of earthquake size.

Since then, many seismologists (e.g., Sammis & Rice, 2001; Anooshehpoor & Brune, 2001; Beeler, Lockner & Hickman, 2001; Johnson & Nadeau, 2002) tried to explain the observed size-dependence of stress drop by theoretically considering the loading and rupture processes of asperities, but didn't succeed. The size-dependence of stress drop seems to result from an inappropriate assumption for background slip rates [1]. Aside from that, in these theoretical studies, the asperity is modeled as a completely locked small patch surrounded by freely creeping zones. In such modeling, steady tectonic loading causes stress singularity just inside the locked patch and broad slip-deficit distribution on the surrounding freely creeping zones. The rupture of the asperity suddenly releases the concentrated stress at the small locked patch and causes fault slip so as to cancel the slip deficit distributed on the surrounding zones without stress drop. Even in such a case, we can clearly define the seismic moment by multiplying the integral of coseismic slip over the whole fault plane by the rigidity of the surrounding medium. In contrast, the definition of average stress drop is multiple (Noda, Lapusta & Kanamori, 2013), which suggests that the static stress drop on fault may not be the fundamental physical quantity.

Recently, on the basis of theoretical consideration to the equation of motion in continuum mechanics, we derived a fundamental equation that the volume integral of static stress changes caused by a seismic event over the whole elastic region is mathematically equivalent to its moment tensor [2]. Applying the fundamental equation to the energetics of shear faulting, we can obtain a quantitative relationship between the work done for shear faulting and the change in elastic strain energy in the surrounding region. This means that we should use the volume integral of static stress changes or the total strain energy change as the fundamental physical quantity characterizing seismic events.

References:
[1] Matsu'ura, M., Nomura, S., Ogata, Y., & Uchida, N. (2017), Reciprocal relationship between seismically estimated slip rates and geodetically estimated slip-deficit rates at plate interfaces: Physical interpretation and logical consequence, IAG-IASPEI 2017 Meeting, J05, Kobe, Japan.
[2] Matsu'ura, M., Noda, A., & Terakawa, T. (2018), Two different representations of moment tensor and the energetics of shear faulting, 10th ACES International Worlshop, O24-3, Awaji Island, Japan.

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Keywords: Seismic moment, Stress drop, Strain energy release, Asperity model

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Mon. May 27, 2019 3:30 PM - 5:00 PM JST | Mon. May 27, 2019 6:30 AM - 8:00 AM UTC | 103 1F

[M-IS08] Geopark

convener:Takayuki Ogata(Disaster Prevention Research Center for Island Regions, University of the Ryukyus), Tatsuto Aoki(School of Regional Development Studies, Kanazawa University), Noritaka Matsubara(Graduate School of Regional Resource Management, University of Hyogo), Keiichi Tadokoro(Research Center for Seismology, Volcanology and Earthquake and Volcano Research Center, Nagoya University), Chairperson:Takeyuki Ueki(Faculty of Risk and Crisis Management, Chiba Institute of Science), Marekazu OHNO(Unzen Volcanic Area Geopark promotion office), Takayuki Arima(Department of Tourism Management, Faculty of Economics, Teikyo University)

This session targets interdisciplinary and multidisciplinary discussion on geopark, involving geoheritage, geodiversity, geoconservation, geotourism, sustainable development, governance, risk management, science communication and geoscientific education. These topics contribute to scientific and attractive activities in geoparks.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MIS08-01] Normal faults observed in the Yonaguni-jima Island, Okinawa Prefecture, southwestern Japan

*Makoto Otsubo[1], Kiyokazu Oohashi[2], Takayuki Ogata[3], Tadahiro Shibata[4] (1.Geological Survey of Japan, 2.Yamaguchi University, 3.University of the Ryukyus, 4.Agency for Cultural Affairs)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MIS08-02] Example of Study of the Itoigawa-Shizuoka Tectonic Line using “NIED Quake map!”

*Ko Takenouchi[1], Yousuke Ibaraki[1], Takahiko Ogawara[1], Hiroshi Miyajima[1], Makoto Matsubara[2], Azusa Nishizawa[2], Shin Aoi[2], Yoshihiro Hiramatsu[3], Kazuyuki Nakagawa[4] (1.Fossa Magna Museum, 2.National Research Institute for earth Science and Disaster Resilience, 3.Kanazawa University, 4.Jiji Press)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MIS08-03] The Opening of ‘NIED Quake map!’ and result of questionnaire survey about interest of local seismicity

*Makoto MATSUBARA[1], Azusa Nishizawa[1], Shin Aoi[1], Ko Takenouchi[2], Yoshihiro Hiramatsu[3], Kazuyuki Nakagawa[4] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Fossa Magna Museum, Itoigawa City, 3.School of Geosciences and Civil Engineering, College of Science and Engineering, Kanazawa University, 4.Jiji Press)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MIS08-04] Bandaisan Geopark's traveling exhibitions and lectures on "Debris avalanche in the world"

*Hiroshi Sato[1], Tadahide UI[2] (1.Mt.Bandai Museum, 2.CeMI)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MIS08-05] PLANETARY SCIENCE Education in Geoparks-Science Festival for Youth Formation experiment of Izumo Plain in Shimane convention

*Kunihiro Abe[1] (1.Shimane Penunsula Shinjiko Narumi, Kuibiki Geopark Promotion Committee)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MIS08-06] ESD in Geopark: Systems thinking and Systems competence for renovating the school curriculum of local area study.

*Ryuta YAMAMOTO[1] (1.Center for professional development of teachers Shizuoka University)

Normal faults observed in the Yonaguni-jima Island, Okinawa Prefecture, southwestern Japan

*Makoto Otsubo[1], Kiyokazu Oohashi[2], Takayuki Ogata[3], Tadahiro Shibata[4]

1. Geological Survey of Japan, 2. Yamaguchi University, 3. University of the Ryukyus, 4. Agency for Cultural Affairs

Yonaguni-jima Island, Okinawa prefecture is an island located at the westernmost tip of Japan and belongs to the Southern part of the Ryukyu arc. In Yonaguni-jima Island, many normal faults cut the Miocene Yaeyama Group and the Quaternary Ryukyu Group to make the diamond island shape. The fault found at the Sanninudai located in the southeastern part of the Yonaguni-jima Island has all parts of the fault zone; fault gouge part, fault damage zone, wall rock zone. The fault found at the Sanninudai can be activated by the stress field similar to the one in the Okinawa Trough (active back arc basin). Our results indicate that the stress field in the Yonaguni-jima Island may be different from the one in island part of the South Ryukyu arc (e.g., Miyako-jima Island and Ishigaki-jima Island). The relationship between the width of the fault zone and the length of the fault and the relationship between the total displacement and the width of the fault core are similar to them of the typical characteristics of faults. Based on our results, we discuss the possibility that the fault found at the Sanninudai is a suitable site to understand the crustal dynamics (back arc opening) of subdaction zone.

Keywords: Backarc basin, Normal fault, Okinawa Trough, Quaternary, Ryukyu Arc

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Example of Study of the Itoigawa-Shizuoka Tectonic Line using “NIED Quake map!”

*Ko Takenouchi[1], Yousuke Ibaraki[1], Takahiko Ogawara[1], Hiroshi Miyajima[1], Makoto Matsubara[2], Azusa Nishizawa[2], Shin Aoi[2], Yoshihiro Hiramatsu[3], Kazuyuki Nakagawa[4]

1. Fossa Magna Museum, 2. National Research Institute for earth Science and Disaster Resilience, 3. Kanazawa University, 4. Jiji Press

1. Background
The Itoigawa Geopark in Niigata Prefecture features an educational park centered on a fault exposure of the Itoigawa-Shizuoka Tectonic Line (ISTL) called the Fossa Magna Park which was first opened in 1990. It is a roughly 10 minute walk from the main parking lots along National Route 148 to the fault exposure. One of the interpretive panels near the exposure features a QR code inviting visitors to examine the 'NIED Quake map!', a page which records seismic activity managed by the National Research Institute for Earth Science and Disaster Resilience (NIED). This report presents one example of academic study using the 'NIED Quake map' with high school students.

2. Earthquake and Fault Study Example (Private High School in Kanagawa Prefecture)
(1) Explanation of the Fossa Magna and Earthquakes (Via Outdoor Interpretive Panels)
The students learn that the ISTL forms the western fault boundary of the Fossa Magna, that has a very close connection to the formation of the Japanese Archipelago, and that the movement of faults causes earthquakes and particularly large fault movements cause the faults to reach the surface where they are called active faults, and that these movements over time form and shape the land around us.
(2) Information from 'Quake map!'
The students use their own smartphones to access the 'NIED Quake map!' site where they can observe the earthquake activity for past ten years in the Itoigawa Area. Through this the students understand the following:
There are many earthquakes occurring around us, even if we don't feel them.
There are distinct areas where earthquakes do and don't occur.
There are earthquakes which concentrate in a line or elliptical shape.
Inland earthquakes occur at depths shallower than 10 km.
There are earthquakes which occur both along and away from active faults.
Along the same active fault, there are areas that do and do not have earthquakes.
Itoigawa experiences no historically large earthquakes, so there is no active fault.
Areas which experienced historic earthquakes have a greater concentration of earthquakes.
Afterwards, the students look at the 5 year, 1 year, 30 day, weekly and 24 hour maps. On the 24 hour map they can see recent earthquakes, where many students are surprised by how many earthquakes occur without being felt.
(3) Fault Exposure
The students see that the fault exposure is crumbling and the rocks have been broken. The gaps among the fault breccia are filled with even more broken fine material (fault gouge) which can be easily depressed with a finger. In fault gouge, striations which show the direction of fault movement can be observed, so the students can understand how fault gouge was formed by the crushing of rock by fault movement. An earthquake of magnitude 7 causes a change in elevation of about 1.5 to 2 m, so the gap seen along the ISTL (over 6,000 m) can be understood to have formed over 3000-4000 fault movements. Through this the students can imagine how deep the Fossa Magna is. They can also understand how faults

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expand.

3. Conclusion
The earthquake distribution map of 'NIED Quake map!' allows for visual understanding of Japan's most tectonically active places and is a valuable tool for understanding the connection between earthquakes and faults. Studying the fault exposure allows seeing only the result of geological processes, but using 'Quake map', the students get a better image of these processes and how they are continuing beneath us. Hopefully further experience in using 'Quake map' for high school students can be used to improve its use in earthquake risk reduction education.

Keywords: Itoigawa Geopark, Fossa Magna Park, Itoigawa-Shizuoka Tectonic Line, NIED Quake map!

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The Opening of ‘NIED Quake map!’ and result of questionnaire survey about interest of local seismicity

*Makoto MATSUBARA[1], Azusa Nishizawa[1], Shin Aoi[1], Ko Takenouchi[2], Yoshihiro Hiramatsu[3], Kazuyuki Nakagawa[4]

1. National Research Institute for Earth Science and Disaster Resilience, 2. Fossa Magna Museum, Itoigawa City, 3. School of Geosciences and Civil Engineering, College of Science and Engineering, Kanazawa University, 4. Jiji Press

1. Introduction
The Seismological Society of Japan (SSJ) established the committee to support the activity of Geopark in order to notify people of the current condition of seismology with the same perspective of people. Geoparks are single, unified geographical areas where sites and landscapes of international geological significance are managed with a holistic concept of protection, education and sustainable development. There are many both natural and cultural heritages of earthquakes in Geoparks. However, there is also a lack of introduction to recognize the local seismicity.
National Research Institute for Earth Science and Disaster Resilience (NIED) opened the web site named as 'NIED Quake map!' to visualize the local seismicity at a geosite in July 2018. It is easy to observe current seismicity detected by Monitoring of Waves in Land and Seafloor (MOWLAS) and historical earthquakes. This shows the seismicity in central Japan around the Itoigawa Global UNESCO Geopark through the QR code on the guide plate at the Fossa Magna Park.

2. 'NIED Quake map!'
This page first shows the local seismicity in one year. The color and size show the depth and magnitude of the earthquake, respectively. The latest earthquake is shown with the star. There are volcanoes, active faults, and rivers to grasp the place. People can recognize the seismicity within the ground with seeing both the memorized large earthquakes and no feeling microearthquakes.

3. Results of views
We confirm about 20-30 accesses from the outside. In the case of the field trip by the group at Fossa Magna Park, there were 50-60 accesses.

4. Cooperation with geopark
NIED concluded the Comprehensive Partnership Agreement with Japan Geopark Network (JGN) on the use of the data and research results at the Geoparks on October 13, 2018. NIED also concluded the memorandum regarding the use of the 'NIED Quale map!' NIED plan to open web sites according to request from the Geoparks through JGN.

5. Questionnaire survey about interest of local seismicity and expansion of 'NIED Quake map!'
The committee of the SSJ gave seminars of seismology for Geoparks. We explained the use of the historical earthquakes in 2018 and conducted the questionnaire survey for regions composing the Japan Geopark Network, which consists of the UNESCO Geoparks, the Japan Geoparks, and associate members for proceeding to be Japan Geoparks. We obtained the answer from 26 Geoparks and seven associate members. We note as Geopark both Geopark and the associate members.
There are geosites of historical earthquake in 46 % of Geoparks. About 91 % of Geopark have interest in the local seismicity, however, there are some display of local seismicity in only 27 Geoparks. About 82 % Geoparks have an interest to introduction of local seismicity, however, it depends on the cost. Geoparks

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only share the cost for display of local seismicity since NIED construct and manage the web site of the 'NIED Quake map!' NIED plans to construct and supply the web sites in accordance with the request from the Geoparks

Keywords: NIED Quake map!, display of local seismicity

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Bandaisan Geopark's traveling exhibitions and lectures on "Debris avalanche in the world"

*Hiroshi Sato[1], Tadahide UI[2]

1. Mt.Bandai Museum, 2. CeMI

Bandaisan Geopark was built with the aim of showing visitors how the landform and people's lives were affected by the mountain collapse which occurred 2 times in 50,000 years ago and 1888. Mt. Bandai Museum is the core exhibition facility.
The year 2018 marked a turning point, 130 years after the collapse, and 30 years after the museum opened.
Since rock avalanches (debris avalanche) occur only about once in 100 years in Japanese Island, a special exhibition was held at the Museum to highlight the avalanche, which is not well known to the public. In addition, the traveling exhibition was also carried out in the volcanic museum in the whole country.
Believing that this traveling exhibition would promote cooperation and mutual understanding among the geoparks that participated in the event, we also held symposiums for public and lectures for school children.
In this presentation, the outline of planned exhibition, symposium and lectures are introduced, and the difference of understanding of volcano by region is introduced from the participant’ s questionnaire carried out in delivery lectures.

Keywords: Mt. Bandai, Geopark, Debris avalanche

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PLANETARY SCIENCE Education in Geoparks-Science Festival for Youth Formation experiment of Izumo Plain in Shimane convention

*Kunihiro Abe[1]

1. Shimane Penunsula Shinjiko Narumi, Kuibiki Geopark Promotion Committee

The Shinji Lake Nakaumi Geopark, Shimane Peninsula, has been certified as a Japan Geopark for the third year. The Geopark certification in Shimane Prefecture will be second after the Oki Global Geopark. Although the popularity of the Oki Geopark has been recognized by the prefectural residents, the Shinji Lake Nakaumi is still strong in the Shimane Peninsula. In conjunction with cognitive activities, the Promotion Council is strongly required to utilize geoparks and to promote educational activities. The 18th Annual Science Festival for Youth at the Shimane Convention, the booth of the Shimane Peninsula and the Shinji Lake Nakaumi Geopark exhibited in Shimane Prefecture, the booth of the "Shinji Lake, the birth of the Izumo plain" and it is compatible to, 360 ×270 ×By making the basin topography of the Hiikawa and Shinmon River with the sand in the mold of 120cm, fixing the watering hose to the headwaters of the two rivers, and continuing watering, the sediment is gradually deposited in the waters sandwiched between the Chinese mountains and the Shimane Peninsula, according to the sedimentary experiment by running water. It is the one to understand the state that the Shinji Lake is formed with the passage of time while observing the process that the Izumo plain is done. The west side of Izumo Taisha is a plain and it is not a sea area. The effects of the eruption of Mijar volcano, located in the Kamimon Basin, cannot be ignored. Photos and materials of the Shinji Lake Nakaumi of the geopark that the Izumo plain was formed between the Shimane Peninsula and the Chugoku Mountains located in the north by the volcanic activity of Mt. Hiikawa, the Kamikadawa River, the granite of the Chugoku Mountains, and the Sanjar Mountain which formed the Izumo plain known for Tsukiji Matsu The experiment was performed while contrasting it with the rock sample.

Keywords: Shimane Peninsula and Shinjiko Nakaumi Estuary Geopark, Formation of the Izumo Plain, Deposition experiment, Watering

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ESD in Geopark: Systems thinking and Systems competence for renovating the school curriculum of local area study.

*Ryuta YAMAMOTO[1]

1. Center for professional development of teachers Shizuoka University

Geopark education in Japan have much contact with school in its area. The revised national curriculum concentrated on compentence-oriented learning. Geopark have a way to adopt the competence-oriented learning in the learning field of local area study with systems thinking and systems competence.

Keywords: ESD, local area study, Systems thinking, Competence, SDGs, School Curriculum

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Mon. May 27, 2019 1:45 PM - 3:15 PM JST | Mon. May 27, 2019 4:45 AM - 6:15 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[M-IS11] Aqua planetology

convener:Yasuhito Sekine(Earth-Life Science Insitute, Tokyo Institute of Technology), Tomohiro Usui(Earth-Life Science Institute, Tokyo Institute of Technology), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Takazo Shibuya(Japan Agency for Marine-Earth Science and Technology), Chairperson:Yasuhito Sekine(Dept. Earth & Planetary Sci., University of Tokyo), Tomohiro Usui, Takazo Shibuya(JAMSTEC)

This proposed session covers a wide range of topics related to aqua planetology, including chemical reactions involving water on planetary bodies, water-rock reactions within planetesimals, distribution of water in the early Solar system and the origin of water on terrestrial planets, hydrological and biogeochemical processes on Earth, geochemical cycles and habitability on Mars and icy moons, exploration of water in the solar system, and theory to understand how to build a habitable aqua planet.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MIS11-01] An interior structure model of Pluto resolving its mysteries

*Shunichi Kamata[1], Francis Nimmo[2], Yasuhito Sekine[3], Kiyoshi Kuramoto[1], Naoki Noguchi[4], Jun Kimura[5], Atsushi Tani[6] (1.Hokkaido University, 2.University of California, Santa Cruz, 3.Tokyo Institute of Technology, 4.Tokushima University, 5.Osaka University, 6.Kobe University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MIS11-02] Isotopic measurement of gas hydrate sample simulating environment of icy satellite and icy planet: Equipment development and consideration for observation method

*Kushi Kudo[1], Atsushi Tani[1], Naohiro Yoshida[2,3] (1.Graduate School of Human Development and Environment, Kobe University, 2.Department of Chemical Science and Engineering, School of Materials and Chemical Technology, Tokyo Institute of Technology, 3.Earth–Life Science Institute)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MIS11-03] Dynamics of icy crust of the Enceladus with tidal heating and asymmetric distribution of heat generation in the rocky core

*Kaho Harada[1,2], Takashi Nakagawa[3], Manabu Morishige[2], Shigenobu Hirose[2] (1.Keio University, 2.JAMSTEC, 3.University of Hong Kong)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MIS11-04] Chlorine-bearing aqueous fluid at crust/mantle boundary in mid-ocean ridge hydrothermal system: a case study of crustal diopsidite from Oman ophiolite

★Invited Papers

*Norikatsu Akizawa[1], Akira Miyake[2], Akira Tsuchiyama[2] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Graduate School of Science, Kyoto University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MIS11-05] Phase relation of the $MgSO_4$-H_2O system under high pressure

*Tadashi Kondo[1], Keita Harada[1], Miki Sirata[1], Takumi Kikegawa[2] (1.Department of Earth and Space Science, Graduate School of Science Osaka University, 2.Institute for Material Structure Science, KEK)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MIS11-06] The Origin of Earth's Volatile Composition: Effects of Impact-induced Atmospheric Erosion and Core Formation

*Sakuraba Haruka[1], Hiroyuki Kurokawa[2], Hidenori Genda[2], Kenji Ohta[1] (1.Tokyo Institute of Technology, 2.Earth-Life Science Institute)

An interior structure model of Pluto resolving its mysteries

*Shunichi Kamata[1], Francis Nimmo[2], Yasuhito Sekine[3], Kiyoshi Kuramoto[1], Naoki Noguchi[4], Jun Kimura[5], Atsushi Tani[6]

1. Hokkaido University, 2. University of California, Santa Cruz, 3. Tokyo Institute of Technology, 4. Tokushima University, 5. Osaka University, 6. Kobe University

Investigating the mechanism maintaining a subsurface ocean is necessary to understand the condition under which aqua planets can form. Recent planetary exploration missions suggest the presence of subsurface oceans in several outer Solar System bodies. Most of them are icy satellites of giant planets, and tidal heating is considered to play a major role in maintaining their subsurface oceans. The presence of a subsurface ocean is also suggested for Pluto, though tidal heating is negligible. In order for heat-depleted Pluto to possess a subsurface ocean, thermal convection should not occur in the ice shell above the ocean, suggesting its high viscosity. This suggestion is consistent with studies of viscous relaxation of the ice shell. This may be due to a high concentration of contaminants, such as ammonia, in the ocean, resulting in an extremely low temperature ocean; however, ammonia is not observed on Pluto’ s surface, and comets, whose bulk chemistry should be similar to that of Pluto, contains ammonia only little. Thus, the reason why Pluto possesses a subsurface ocean is a mystery.

Here we propose a thin gas hydrate layer exists between the ice shell and a subsurface ocean, and it prevents freezing of a subsurface ocean. Gas hydrates act as a thermal insulator because of its low thermal conductivity. We perform numerical calculations of long-term thermal evolution and show that a warm ocean and a cold ice shell can be maintained for a long time and that the freezing of the ocean is ineffective. We also perform numerical calculations of long-term viscoelastic deformation and show that the significant viscous relaxation requires billions of years. Our proposal does not require large amounts of contaminants. Comets contain a few % of methane with respect to water, for example, and this concentration is sufficient for creating a thin gas hydrate layer prohibiting the ocean freezing. Some gas species are easily trapped in gas hydrates while others are not, and this selective trapping may explain a large difference in volatile compositions of comets and Pluto’ s surface. The subsurface ocean maintenance mechanism we propose here would also be applicable to larger icy bodies other than Pluto. In addition, our proposal may explain the diversity of surface chemistry of Kuiper Belt Objects.

Keywords: Pluto, Subsurface ocean, Gay hydrates

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Isotopic measurement of gas hydrate sample simulating environment of icy satellite and icy planet: Equipment development and consideration for observation method

*Kushi Kudo[1], Atsushi Tani[1], Naohiro Yoshida[2,3]

1. Graduate School of Human Development and Environment, Kobe University, 2. Department of Chemical Science and Engineering, School of Materials and Chemical Technology, Tokyo Institute of Technology, 3. Earth–Life Science Institute

According to recently observation using Cassini, icy satellites and icy planets are known for having plume including the organic matter, liquid internal ocean and rocky crust (e.g. Porco et al. 2006; Waite et al. 2006, 2009, 2017). From this fact, extraterrestrial life is regarded as being likely to exist in icy satellites and icy planets. Especially in plume gas species, methane (CH_4) is regarded as one of the candidate of signature of biological activity due to CH_4 formation reaction by methanogen. However CH_4 gas in plume is consisted of not only microbial origin but also primitive CH_4 and hydrothermal formation and this fact does not let CH_4 detection is sufficient for conclusion for existence of biological activity by microbe. Therefore, we consider evaluation of the elementary process of CH_4 isotopic fractionation ($\delta^{13}C$, δD of CH_4) via room experiment important for isotopic observation of icy satellite and icy planet in nearly future.

In this study, we focus on CH_4 hydrate which is reservoir to produce the plume (Kieffer et al. 2006) and want to evaluate isotopic fractionation with its formation. Isotopic fractionation with hydrate formation has been found at only δD of CH_4 (~10‰) at the Earth condition (P: ~10 MPa) (e.g. Hachikubo et al. 2007, 2015; Lapham et al. 2012). In the case of condition of icy satellite and icy planet, pressure range of icy satellite and icy planet is wider than of the Earth, and therefore we need to estimate isotopic fractionation at 10–100 MPa scale. Thus we started design for cell for hydrate formation experiment at ice crust condition (P: ~150 MPa). In presentation, we will mainly introduce progress of the equipment development and observation method.

As next stage, we are also planning analyze isotopic fractionation of surface rocky core, and CH_4 translation process using 3-D flow simulation for evaluate CH_4 isotope changing in icy satellite and icy planet. We will subject to Enceladus, Europe and Triton as target.

Keywords: isotopic observation, isotopic fractionation, methane, icy satellite and icy planet, gas hydrate

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Dynamics of icy crust of the Enceladus with tidal heating and asymmetric distribution of heat generation in the rocky core

*Kaho Harada[1,2], Takashi Nakagawa[3], Manabu Morishige[2], Shigenobu Hirose[2]

1. Keio University, 2. JAMSTEC, 3. University of Hong Kong

We investigate the dynamics of icy crust of the Enceladus, that is the sixth-largest moon of the Saturn, for understanding the diversity of the surface geology found from the planetary explorations. Especially, we have an interest in the ‘Tiger Stripes’ found around the south pole with heat release of 15.8 GW. The mechanism of formation of the Tiger Stripes is recognized as active terrains caused by thermal convection of icy crust driven by tidal heating. However, such active terrains caused by the tidal heating could not be explained by the tidal heating solely because they are only found around the south pole. Several researches concerning the convective dynamics of icy crust on the Enceladus have suggested some north-south asymmetries, for example in the thickness of icy crust or viscosity, but they have not been well-understood for the origin.

Here, to resolve the formation mechanism of Tiger Stripes, we propose the hypothesis on the north-south asymmetric distribution of heat producing elements in Enceladus’ s rocky core. We assume that the more heat producing elements can be concentrated into the southern hemisphere. Since, regarding the formation mechanism of the Enceladus, the rocky core would not be likely to experience the large-scale melting events such as the magma ocean, the Enceladus still tends to maintain the chemical structure of the early distribution. Hence, the current chemical structure of rocky core may be heterogeneous, which can lead to north-south asymmetric distribution of heat generation. We test the hypothesis for using a numerical model of icy crust dynamics including tidal heating and north-south asymmetric distribution of heat generation in the rocky core. For tidal heating of the icy crust, we impose an analytical solution of tidal deformation considering viscoelasticity in a thin shell on the surface (e.g., Ojakangas and Stevenson, 1989). For north-south asymmetric distribution in heat generation in the rocky core, we set the temperature of the bottom of the icy crust as 273 K in the northern hemisphere, 283 K in the southern hemisphere.

Our results indicate that heat upwelling around the south pole and heat downwelling around the north pole when we assume tidal heating and north-south asymmetric distribution of heat generation. Rather, the asymmetric distribution of heat generation is more important for finding the more active dynamics around the south pole. A quantitative test indicates that the plume heat flow coming from the south pole region is about 300 GW, which is about 20 times as large as the observational constraints (15.8 GW). This suggests that the amplitude of heterogeneous heat generation is too large. Again, although the amplitude of heat transfer of plume in southern hemisphere is too large, the geographical distribution of plumes can form the north-south asymmetric distribution of heat generation. Therefore, this hypothesis provided here would be promising to reveal the origin of the hydrogen plumes on the Enceladus found by the Cassini mission.

Keywords: Enceladus, Thermal convection, Tidal heating

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Chlorine-bearing aqueous fluid at crust/mantle boundary in mid-ocean ridge hydrothermal system: a case study of crustal diopsidite from Oman ophiolite

*Norikatsu Akizawa[1], Akira Miyake[2], Akira Tsuchiyama[2]

1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. Graduate School of Science, Kyoto University

Hydrothermal circulation in the mid-ocean ridge system is responsible for elemental enrichment, and modification of original chemical composition of the oceanic crust. In recent times, deep-rooted hydrothermal circulation down to crust/mantle boundary has been introduced regarding geological investigations and numerical models. The deep-rooted hydrothermal circulation in the mid-ocean ridge system can be one of the necessary mechanisms generating plate tectonics due to mantle hydration lowering mantle viscosity. In order to assess the mechanism of the mantle hydration in the mid-ocean ridge system, chemical composition of mantle-buffered hydrothermal fluids must be characterized. Here, we present a series of intense investigations for aqueous fluid inclusions in crustal diopsidites from Oman ophiolite. The crustal diopsidite is considered as a reaction product between gabbro (lowermost crustal material) and seawater-derived hydrothermal fluids en route from the mantle to the crust. Considering that Cr-rich minerals such as chromian spinel (Cr-spinel) and chromian garnet (uvarovites) are contained in the crustal diopsidites, the hydrothermal fluids involved were enriched in Cr. A few micrometer-sized inclusion of aqueous fluid with chromian spinel grains was frozen with a nitrogen gas-cooled cold stage, and investigated with a focused ion beam equipped with a scanning electron microscope and an energy dispersive X-ray spectrometer (cryo-FIB-SEM-EDS system). The results showed that the Cr-spinel-bearing aqueous fluid inclusion contains Cl. Regarding the mass and chemical composition of the Cr-spinels in the aqueous fluid inclusion, Cr content in the aqueous fluid was estimated at ~71400 ppm. Although Cr is considered relatively insoluble in aqueous fluids, solubility of Cr depends strongly on the activity of Cl due to complexation reactions with Cl. We propose a possibility that seawater-derived hydrothermal fluids penetrated throughout the crustal section reacted with Cl-bearing magma portion. Flow direction of the hydrothermal fluids probably changed from downward to upward in response to the heat release of the magma to the hydrothermal fluid.

Keywords: cryo-FIB-SEM-EDS, fluid inclusion, hydrothermal circulation, Cr-spinel, Chromium, microthermometry

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Phase relation of the $MgSO_4$-H_2O system under high pressure

*Tadashi Kondo[1], Keita Harada[1], Miki Sirata[1], Takumi Kikegawa[2]

1. Department of Earth and Space Science, Graduate School of Science Osaka University, 2. Institute for Material Structure Science, KEK

Resent planetary exploration projects suggest existence of internal ocean in the several icy satellites. Spectral analysis of surface material of such satellite indicate sulfate materials as solute in the water ocean. Salts change generally the phase relation such as melting temperature and generation of a kind of hydrate, and affects the internal structure of the satellite. For the $MgSO_4$-H_2O system, which was considered as a possible major component in internal ocean, Nakamura and Ohtani (2011) has proposed the phase relation under pressure condition up to 4.5 GPa with existence of epsomite($MgSO_4 \cdot {}_7H_2O$), and discussed a deep internal ocean in the Ganymede. However, the X-ray diffraction pattern they reported as epsomite includes many unidentified diffraction peaks. In this study, we re-examined the phase relation in the system $MgSO_4$-H_2O under pressure by optical observation, micro-Raman, X-ray diffraction at synchrotron facility. High pressure experiments was performed using diamond anvil cell(DAC) up to about 5GPa at room temperature for 5 to 25wt% $MgSO_4$ solution. The results show a quite different phase relation from Nakamura and Ohtani(2011) in $MgSO_4$-rich side and solidified phases. The eutectic composition is almost same as previous report, but pentahydrate($MgSO_4 \cdot 5H_2O$) is newly observed as coexisting phase with Ice VI-VII in solid, and also liquidus phase in $MgSO_4$-rich solution. We observed direct conversion from low-pressure pentahydrate to high-pressure pentahydrate which reported by Wang et al.(2018). We also evaluate the relative density difference between liquid and solid for all composition by gravitational method in DAC. Ice VI is always denser than liquid while hydrate is always less denser than liquid. We will discuss internal structure and evolution of icy satellite based on this new results.

Keywords: Europe, high-pressure experiment, structure of internal ocean

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The Origin of Earth's Volatile Composition: Effects of Impact-induced Atmospheric Erosion and Core Formation

*Sakuraba Haruka[1], Hiroyuki Kurokawa[2], Hidenori Genda[2], Kenji Ohta[1]

1. Tokyo Institute of Technology, 2. Earth-Life Science Institute

Unveiling the origin of Earth's volatile composition is crucial for understanding how Earth developed its habitable environment. Carbon (C), nitrogen (N), and hydrogen (H) are the backbone for the chemistry of life and main components of the atmosphere and oceans (e.g., Katling & Casting, 2017). The volatiles in rocky planets are thought to have been delivered by chondritic materials. However, the elemental composition of the bulk silicate Earth (BSE) shows the depletion of C and N relative to H, a high C/N ratio, and a low C/H ratio compared to chondrites (e.g., Hirschmann, 2016; Bergin et al., 2015).

The volatiles delivered to the accreting planet were potentially lost to space by impacts or sequestered in the core. In order to understand how these processes affect the Earth's volatile composition, we modeled both the main accretion stage and the late accretion stage. The former considered the elemental partitioning between the atmosphere, MO, and metal which segregates into the core (e.g., Hirschmann, 2016; Bergin et al., 2015). The latter considered the partitioning between the atmosphere, oceans, and carbonate (the crust) (e.g., Sakuraba et al., 2019). By calculating the evolution for the range of partitioning coefficient, solubilities, and impactor properties, we evaluated how the resulting volatile composition of BSE depends on these input parameters.

As a result, we succeeded to reproduce the elemental composition of major volatile elements in current BSE from a chondritic source when we chose the appropriate parameter values. While the elemental fractionation during the main accretion ended up with the excess of N/C, the preferential loss of N from the atmosphere during the late accretion reproduced BSE's volatile pattern. During the main accretion, C was most affected by the core segregation because C is the most siderophile among the volatile elements. During the late accretion, N was most affected by the atmospheric erosion because C and H were trapped in the surface reservoirs. The different BSE's composition patterns were obtained depending on parameters such as impactor's composition, impactor's size-distribution, and element partitioning properties. Our results suggest that the current Earth's composition can be obtained by the homogeneous accretion of chondritic planetesimals.

[1] Hirschmann, (2016) *American Mineralogist*, 101, 540.
[2] Bergin et al., (2015) *Proceedings of the National Academy of Sciences*, 112, 8965.
[3] Sakuraba et al., (2019) *Icarus*, 317, 48.

Keywords: volatile composition, magma ocean, impact-induced atmospheric erosion, core formation

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Mon. May 27, 2019 3:30 PM - 5:00 PM JST | Mon. May 27, 2019 6:30 AM - 8:00 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[M-IS11] Aqua planetology

convener:Yasuhito Sekine(Earth-Life Science Insitute, Tokyo Institute of Technology), Tomohiro Usui(Earth-Life Science Institute, Tokyo Institute of Technology), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Takazo Shibuya(Japan Agency for Marine-Earth Science and Technology), Chairperson:Yasuhito Sekine(Dept. Earth & Planetary Sci., University of Tokyo), Keisuke Fukushi, Tomohiro Usui

This proposed session covers a wide range of topics related to aqua planetology, including chemical reactions involving water on planetary bodies, water-rock reactions within planetesimals, distribution of water in the early Solar system and the origin of water on terrestrial planets, hydrological and biogeochemical processes on Earth, geochemical cycles and habitability on Mars and icy moons, exploration of water in the solar system, and theory to understand how to build a habitable aqua planet.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MIS11-07] Finding of oxidized sulfur species in carbonates from a Martian meteorite Allan Hills 84001 using μ-XANES

*Kajitani Iori[1], Gaku Tanabe[1], Ryoichi Nakada[2], Tomohiro Usui[3], Mizuho Koike[3], Fumihiro Matsuura[4], Tetsuya Yokoyama[1] (1.Tokyo Institute of Technology, 2.Japan Agency for Marine-Earth Science and Technology, 3.Institute of Space and Astronautical Science, 4.Earth-Life Science Institute)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MIS11-08] A study on Martian water environment based on the μ-XRF-XANES analysis for the secondary minerals formed in a nakhlite meteorite (Y 000593) vein

*Keika Suzuki[1], Hiroki Suga[1], Akira Yamaguchi[2], Tomohiro Usui[3], Oki Sekizawa[4], Kiyofumi Nitta[4], Yoshio Takahashi[1] (1.University of Tokyo, 2.National Institute of Polar Research, 3.JAXA, ISAS, 4.JASRI/SPring-8)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MIS11-09] Influence of water and clay minerals for slope angles on Mars

*Yuhki Matsuoka[1], Ikuo Katayama[1], Rina Noguchi[2], Tomohiro Usui[2] (1.Department of Earth and Planetary Systems Science, Hiroshima University, 2.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MIS11-10] **Dark Streak Features in Mongolia: Implications for Formation Mechanisms of Recurring Slope Lineae on Mars**

*Maya Nakamura[1,2], Yasuhito Sekine[1], Keisuke Fukushi[3], Noriko Hasebe[3], Davaadorj Davaasuren[4], Yoshio Takahashi[2], Hitoshi Hasegawa[5], Takuro Ogura[6], Koki Morida[3], Tuvshin Gerelmaa[4] (1.Earth-Life Science Institute, Tokyo Institute of Technology, 2.Department of Earth and Planetary Science, The University of Tokyo, 3.Institute of Nature & Environmental Technology, Kanazawa University, 4.Department of Geography, National University of Mongolia, 5.Department of Global Environment and Disaster Prevention, Kochi University, 6.Department of Socio-Cultural Environmental Science, The University of Tokyo)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MIS11-11] The occurrence of perchlorate salt in and around the Taklimakan Desert, China

*Haibo Qin[1,2], Shitong Yang[1], Qing Chang[3], Chihiro Miyamoto[1], Yoshio Takahashi[1] (1.Department of Earth and Planetary Science, Graduate School of Science, 2.State Key Laboratory of Environmental Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences, 3.Japan Agency for Marine-Earth Science and Technology)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MIS11-12] Measurement technique to quantify OH radicals photochemically generated on the ice surface

*Akihiro Yabushita[1], Hiroaki Nishimoto[1], Akira Harata[1] (1.Interdisciplinary Graduate School of Engineering Sciences, Kyushu University)

Finding of oxidized sulfur species in carbonates from a Martian meteorite Allan Hills 84001 using μ-XANES

*Kajitani Iori[1], Gaku Tanabe[1], Ryoichi Nakada[2], Tomohiro Usui[3], Mizuho Koike[3], Fumihiro Matsuura[4], Tetsuya Yokoyama[1]

1. Tokyo Institute of Technology, 2. Japan Agency for Marine-Earth Science and Technology, 3. Institute of Space and Astronautical Science, 4. Earth-Life Science Institute

The widespread evidence of liquid water on Mars has led to detailed studies of Martian habitable surface environments [1]. Among them is the geochemical study of carbonate in the 4-billion-year old meteorite Allan Hills (ALH) 84001 because the carbonate is interpreted to have formed from fluids in the early stage of Mars history (~4 Ga) [2]. This study examined speciation of sulfur in carbonates of ALH 84001 as a proxy to trace the chemical evolution of fluids that formed the ALH 84001 carbonates.

We conducted sulfur K-edge (2472 eV) micro X-ray absorption near edge structure (μ-XANES) analysis at BL27SU at SPring-8. X-ray beam was focused using a K-B mirror to a final spot size of 15 (H) ×15 (V) μm^2. Prior to the μ-XANES analysis, X-ray fluorescence mapping which was scanned in 20 μm step was obtained to determine the analytical spot with referring to the petrological observation and backscattered electron images using electron prove micro analyzer (EPMA).

A diagnostic signature of oxidized sulfur [S(VI)] was observed in all the analytical points, whereas X-ray absorption peaks corresponding to S(-II) and an organic sulfur (Di-n-octadecyl disulfide) were observed in some analytical spots. We propose two possible processes for the incorporation of S(VI) species in the carbonate grains of ALH 84001 on the Martian surface: (co-)precipitation of sulfate minerals with the carbonate or substitution of sulfate ion for carbonate ion (carbonate associated sulfate: CAS). The incorporation of trace amount of sulfate minerals is consistent with the widespread distribution of sulfate-bearing deposits in Noachian terranes [3]. However, any type of sulfate minerals has not been observed in the carbonate grains of ALH 84001 even using the transmission electron microscope observations [4]. On the other hand, the CAS-bearing carbonates are common on Earth, though the concentration of CAS in carbonate is typically low (~100s-1,000s ppm) [5]. We conducted thermodynamic calculations under conditions proposed to explain the ALH 84001 carbonates [6, 7]. The thermodynamic calculations indicated that sulfur mainly occurred as sulfate ion in water at Eh-pH conditions where the ALH 84001 carbonate precipitated. This result suggests a possibility that the observed S(VI) species could have occurred as CAS in the ALH 84001 carbonates under the fluid conditions ranging from 6 to 9 for pH and -0.25 to 0 for Eh (V).

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Keywords: Mars, ALH 84001, μ-XANES, sulfur

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A study on Martian water environment based on the μ-XRF-XANES analysis for the secondary minerals formed in a nakhlite meteorite (Y 000593) vein

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Martian meteorite nakhlite has attracted attention because it has various secondary mineral assemblages (such as iddingsite) formed by water-rock reaction on the Mars. The iddingsite holds physicochemical information of water when it formed on Mars. However, the formation processes of the minerals are not clear because both carbonates (precipitate under reductive alkaline conditions) and sulfates (precipitate under oxidative acidic conditions) that cannot coexist under an equilibrium condition were found. Among these minerals, sulfate minerals are considered as a terrestrial contamination in several researches in contrast to carbonate minerals accompanied with various secondary minerals such as saponite and serpentine. Here, we examined trace element distribution within the carbonate phases in Y 000593 by FE-SEM-EDS/FE-EPMA and synchrotron-based μ-XRF-XANES in order to determine the transition history of the Eh-pH conditions during the carbonate formation, which reconcile the coexistence of carbonate and sulfate phases in the iddingsite. The detailed understanding of environment (*e.g.,* fluid chemistry) allows us to give a new constraint on the physicochemical evolution of the water that altered the nakhlite body during the last ~6.5 million years.

The polished thin section (PTS: #58-1 in NIPR) of Y 000593 was used for this study. First, the identification of secondary mineral phases in the iddingsite were conducted by FE-SEM-EDS and FE-EPMA at the University of Tokyo. After that, we investigated distribution of trace elements by μ-XRF-XANES at BL37XU of SPring-8, and BL-4A/15A of KEK-PF. Subsequently, we tried to constrain the iddingsite formation environment (such as Eh-pH conditions) from the proportion of secondary minerals.

Carbonates ($FeCO_3$, $MnCO_3$, $CaCO_3$), iron oxides (FeOOH), clay minerals (Fe-rich saponite), and Si-rich vein were identified in the iddingsite from the outside to the center of vein by FE-SEM-EDS and FE-EPMA analysis. In particular, carbonate aggregates were mainly composed of $(Mn,Fe)CO_3$ and $(Ca,Fe)CO_3$. This result suggested that the iddingsite was altered by CO_2-rich reductive alkaline fluid (Eh≦0.2: pH=9.0~11) [Brookins, 1998]. The difference between distributions of Mn and Ca suggests that fluid with different Eh-pH conditions flowed several times or water condition was changed during carbonate formation because $(Mn,Fe)CO_3$ and $(Ca,Fe)CO_3$ cannot overlap in the Eh-pH diagrams ($(Mn,Fe)CO_3$ precipitate at Eh=-0.4~-0.0: pH=9.0~9.5; $(Ca,Fe)CO_3$ precipitate at Eh=-0.3~-0.1: pH=6.5~9.0). The μ-XANES analysis revealed that Cr(III) coexisted in $(Mn,Fe)CO_3$, since Cr cannot be enriched in MnO_2 in general. It is presumed that Mn precipitated originally as MnOOH, which was transformed into $MnCO_3$ in the presence of alkaline fluid. In $(Ca,Fe)CO_3$, 20% of Fe was present as FeOOH. It was implied that FeOOH is precursor of the $FeCO_3$. In addition, we detected S(VI) in the iddingsite, of which chemical species are the clay mineral adsorbent (Fe-rich saponite), $Mn^{2+}(Mn^{3+})O_4$, and $MnCO_3$ by XANES fitting. This results suggested that sulfate-bearing alkaline fluid flowed in the final stage of the iddingsite formation. Besides, its concentration decrease from the mesostasis phase. Therefore, S(VI) in the clay minerals portion related to the FeS in the mesostasis, and apart of FeS might flowed out as alkaline fluid.

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From this study, we conclude that the carbonates in iddingsite formed by reductive alkaline fluid (Eh≦0.2: pH=9.0-11), opposite to sulfate formation. However, it is still not clear whether these carbonate minerals were locally formed or widespread in the nakhlite from the spatial distribution point of view. Therefore, we are trying to observe the 3D structure/elemental distribution of the iddingsite by XAFS-CT method in order to clarify the fluid path related to the formation process of the carbonate minerals.

Keywords: Mars, Martian meteorite, Synchrotron radiation X-ray analysis

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Influence of water and clay minerals for slope angles on Mars

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An internal frictional angle is determined from a frictional coefficient, which is largely influenced by water and clay minerals. Pore water reduces effective stress, then slope angles becomes smaller. Therefore, slope angles are approximately 25 under hydrostatic condition in contrast with ~35 under dry condition. Most mineral exhibit a constant frictional coefficient μ=0.6-0.85, whereas clay minerals are characterized by a markedly lower frictional coefficient ~0.1 at presence of water (e.g. Behnsen and Faulkner, 2012; Moore and Lockner, 2004). Since a slope angle is roughly equivalent to an internal frictional angle, it is considered that slope angles are affected to become smaller by presence of water and clay minerals including water.
Clay minerals are widely recognized on Mars (Ehlmann and Edwards, 2014) by infrared spectroscopic tools. We focus on a slope angle of Martian topography and research the areas where water might exist.

We focus on Recurring Slope Lineae (RSL) which might suggest the existence of flowing water on Mars (e.g. McEwen et al., 2011; Stillman et al., 2017). Some RSL are found in Coprates Chasma, eastern part of Valles Marineris. We compared slope angles of RSL confirmed points with not confirmed points.
We measured slope angles about 10 points in Coprates Chasma. Slope angles are 31-37 in almost all points and there is no tendency by the presence of RSL and hydroxylated silicates. Therefore, we considered that the contributions of water and clay minerals for slope angles are not prominent in Coprates Chasma.
Furthermore, we verified whether there is contribution of water for slope angles on other areas where water might exist in the same way.

Keywords: Mars, water, slope angle

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Dark Streak Features in Mongolia: Implications for Formation Mechanisms of Recurring Slope Lineae on Mars

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Recurring Slope Lineae (RSL) are dark, narrow features that appear and lengthen on steep (~30°) slopes in warm seasons and fade in cold seasons of Mars (e.g., McEwen et al., 2011). Although the formation mechanism of RSL is still in debate, several processes have been proposed, including liquid brine flows triggered by melting of subsurface ice (a wet process) (e.g., Stillman et al., 2016), and granular flows on slopes (a dry process) (e.g., Schmidt et al., 2017). However, neither wet nor dry processes can explain all of the observables of RSL. In especially, the wet process seems to be inconsistent with the absence of absorptions due to liquid water on RSL and the fact that RSL appear only on steep slopes (McEwen et al., 2014).

Here, we report RSL-like dark streak features in cold, arid areas of Khangai Mountains, Mongolia, on Earth. In this area, discontinuous permafrost and underground ice melt seasonally (Szuminska, 2016). We find that dark streak features in this area show seasonal variation similar to RSL on Mars. Although the slope angles of the terrestrial analogues (~10°) are shallow, the observed similarities in morphology and seasonal activity suggest that the streak features in Mongolia can be promising terrestrial analogues of RSL on Mars.

We also conducted geological survey for the terrestrial RSL analogues found in Mongolia in August 2018. By analyzing the visual images taken by a unmanned aerial vehicle, a three-dimensional topographic structure was constructed. In the geological survey, we measured water contents of soils on site on and outside the dark streak features. The mineralogical compositions and grain size distributions were measured for the collected soil samples.

Although no water flowed during the survey, dark streak features appeared in the terrestrial RSL analog sites in Mongolia. The upstream of the dark streaks are dented in a few centimeters, which becomes shallower toward the downstream. These observations suggest that erosion of surface soils occurred along with the dark streak features in the past. This view is supported by our results of the flow accumulation analysis. Although the formation of the dark streaks relate with water flow, darkening itself is not caused by the presence of liquid water. Water contents in surface soils on the dark streaks show no significant difference from those outside the streaks within errors. The surface of the dark streaks contains less bright sands and more dark silts than the surfaces outside the dark streaks. These results suggest that selective traction of the bright sand-sized grains by surface runoff results in remnant of the dark silt-sized grains on the slopes, which darkens the streak features after dryness. The required friction velocity for the traction is estimated to be ~20 mm/sec, consistent with flow rate due to melting of ground ice in the research area.

Based on the formation mechanism of the terrestrial RSL analogues, we can address the two issues in the

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wet process for RSL formation on Mars; 1) no remote-sensing detection of liquid water, and 2) the fact that RSL appear only on steep slopes. At RSL sites on Mars, a thin layer of fine soils is considered to cover basaltic bedrocks on the slopes (Ruff and Christensen, 2002). If liquid brine flows due to melting of underground ice, this can remove fine sands on the slopes. Consequently, dark streak features appear on the slopes due to exposure of underlying basaltic bedrocks after dryness of brine. Given the difference in gravity between Earth and Mars, we suggest that a friction velocity of surface runoff similar to the terrestrial RSL analogs can be achieved when a slope with angle > ~25–30° on Mars, if the depth and width of water flow are same. Our results suggest that RSL on Mars would appear only on steep slopes due to its low gravity.

Keywords: Mars, Recurring Slope Lineae (RSL), Terrestrial analogues

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The occurrence of perchlorate salt in and around the Taklimakan Desert, China

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The formation and preservation of perchlorate (ClO_4^-) in arid and semi-arid deserts on Earth is of growing concern, because the desert could serve as a viable analog for Martian landscape where high perchlorate has been recently discovered. In this study, perchlorate in samples collected from the Taklimakan Desert, Xinjiang, NW China was extracted by water and then measured by IC-MS/MS. The Cl speciation was determined by Cl K-edge XANES analysis to provide direct spectroscopic evidences for the presence of perchlorate. Results showed that the moraine sample contains a higher perchlorate concentration and the ClO_4^-/Cl^- ratio in comparison with sand, river sediment and loess samples. Furthermore, $KClO_4$ was identified as the dominant perchlorate species in the hotspot of moraine sample by μ-XANES analysis, which is significantly different from the dominant presence of $Ca(ClO_4)_2$ and $Mg(ClO_4)_2$ species on Martial soil. This result could be explained by the lowest solubility for $KClO_4$, while other perchlorate salts would be easily leached and mobile on Earth in contrast to Mars where much lesser liquid water is present in the history and present-day. Thus, the finding in this study would provide important insights into the prevalence of perchlorate on Mars.

Keywords: perchlorate, distribution, XANES

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Measurement technique to quantify OH radicals photochemically generated on the ice surface

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Reaction processes of many molecules are presumably involved in oxidative atoms/molecules generated by photodecomposition of molecules adsorbed on cold dust grains. Hydroxyl (OH) radicals are considered as one of them. The chemistry of OH radicals plays a key role in the radiolysis and photolysis of water-rich ices of astrochemical origin. Measurements of OH radical in water-ice in the laboratory have been done by UV, EPR, X-ray absorption, and infrared absorption measurements. However, quantification of OH radicals on the ice surface has not yet been made. In the present work, we have tried to develop the measurement technique to quantify OH radicals photochemically generated on the surface of ice film. In this technique, OH are converted to the different molecule by utilizing the chemical reaction, and monitored through reflection absorption infrared spectroscopy. We have investigated the effect of ice temperature on abundance of OH radicals on the ice surface at 8-70 K. In addition, the effect of ice surface morphology on abundance of OH radicals has been studied by preparing the amorphous solid water and polycrystalline ice. The present study experimentally shows both the temperature and surface morphology plays an important role in abundance of OH radicals on the ice surface.

Keywords: OH radical, ice, vacuum-ultraviolet light, RAIRS, surface

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Mon. May 27, 2019 10:45 AM - 12:15 PM JST | Mon. May 27, 2019 1:45 AM - 3:15 AM UTC | 201A 2F

[M-IS13] Biogeochemistry

convener:Keisuke Koba(Center for Ecological Research, Kyoto University), Hideaki Shibata(Field Science Center fot Northern Biosphere, Hokkaido University), Naohiko Ohkouchi(Japan Agency for Marine-Earth Science and Technology), Youhei Yamashita(Faculty of Environmental Earth Science, Hokkaido University), Chairperson:Keisuke Koba(Kyoto University), Yoshiyuki Inagaki, Kazumichi Fujii

Biogeochemistry is an interdisciplinary study field including ecology, geochemistry, oceanography, limnology, hydrology, soil science and environmental sciences. Respective researches have tended to be conducted separately so far. This session aims to provide a common platform for biogeochemists of different disciplines, which facilitates the interactive discussion and information exchanges for further development of biogeochemical studies.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MIS13-01] Root meets clays: Tree root plasticity in podzolized soil

*Kazumichi Fujii[1], Naoki Makita[2], Martin Küttim[3], Shinya sugita[3] (1.Forestry and Forest Products Research Institute, 2.Shinshu University, 3.Tallinn University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MIS13-02] Nitrogen transformation process in newly created salt marsh in the aftermath of the 2011 Great East Japan Earthquake

*Keitaro Fukushima[1], Kazuma Hashimoto[2], Megumi Kuroiwa[3], Katsuhide Yokoyama[2], Yuichi Suwa[3] (1.Center for Ecological Research, Kyoto University, 2.Graduate School of Urban Environmental Sciences, Tokyo Metropolitan University, 3.Faculty of Science and Engineering, Chuo University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MIS13-03] Succession of soil nitrification potential at a glacier foreland in Svalbard

*Kentaro Hayashi[1], Yukiko Tanabe[2,3], Keisuke Ono[1], Maki Asano[4], Shohei Hattori[5], Masaki Uchida[2,3], Masahito Hayatsu[1] (1.Institute for Agro-Environmental Sciences, NARO, 2.National Institute of Polar Research, 3.SOKENDAI, 4.University of Tsukuba, 5.Tokyo Institute of Technology)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MIS13-04] Transition of soil organic carbon in a volcanic ash soil derived from Towada volcano, Japan

*JITHYA NAWODI WIJESINGHE[1], Jun Koarashi[2], Mariko Atarashi Andoh[2], Yoko Saito Kokubu[3], Noriko Yamaguchi[4], Takashi Sase[5], Mamoru Hosono[6], Yudzuru Inoue[7], Yuki Mori[1], Syuntaro Hiradate[1] (1.Soil Science Laboratory, Faculty of Agriculture, Kyushu University, Fukuoka 819-0395, Japan, 2.Nuclear Science and Engineering Center, Japan Atomic Energy Agency, Ibaraki 319-1195, Japan, 3.Tono Geoscience Center, Japan Atomic Energy Agency,Gifu 509-5102, Japan, 4.National Agriculture and Food Research Organization, Institute for Agro-environmental Sciences, 3-1-3 Kan-nondai, Tsukuba, Ibaraki 305-8604, Japan, 5.Boreal Laboratory for Phytolith Research, Iwate 028-7302,Japan, 6.Tokyo Natural History Research Structure,Tokyo 162-0052, Japan, 7.Faculty of Applied Information Technology, Nagasaki Institute of Applied Science,Nagasaki 851-0193, Japan)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MIS13-05] General pattern of carbon and nitrogen isotopic variation across a wide range of soils and its controlling factors

*Rota Wagai[1], Masako Kajiura[1], Yudzuru Inoue[2], Maki Asano[3], Chie Hayakawa[4] (1.NARO, Institute for Agro-Environmental Sciences, 2.Nagasaki Institute of Applied Science, 3.University of Tsukuba, 4.University of Tokyo)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[MIS13-06] Nutrient sources in some Japanese forest ecosystems: the contribution of precipitation, weathering and litter fall

*Yoshiyuki Inagaki[1], Kazumichi Fujii[1] (1.Forestry and Forest Products Research Institute)

Root meets clays: Tree root plasticity in podzolized soil

*Kazumichi Fujii[1], Naoki Makita[2], Martin Küttim[3], Shinya sugita[3]

1. Forestry and Forest Products Research Institute, 2. Shinshu University, 3. Tallinn University

Root functional traits could vary among plant species. Root traits are known to respond to a decrease in nutrient availability along with soil aging and plant succession, while root plasticity of single tree species to soil aging is still unclear on a soil profile scale. We investigated whether trees develop finer root architecture along with soil aging in coniferous forest dominated by single species (*Pinus sylvestris*) in Estonia. We measured depth distribution of root biomass and traits (specific root length and tissue density). We compared ca. 100, 300, and 500 years old soils (podzols) on two coastal dune chrnosequence that differ in abundance of soil clay or Al and Fe oxides; Hiiumaa island (facing Balt Sea) and Juminda (facing Finland Gulf), where ridge-swale topography has been developed by isostacy. On Juminda chronosequence where oxalate-extractable P (oxide-bonded) is accumulated in the shallow subsoil, fine roots are concentrated in oxide-rich soil horizons. On oxide-poor Hiiumaa chronosequence where P is translocated in the deeper soil, fine roots are concentrated in organic horizon. Tree roots could change root distribution and surface area depending on extent of P occlusion in clays or leaching in soil aging. Tree community shift toward finer root architecture along with migration of Al and Fe oxides or selection of individuals with finer root structure could occur.

Keywords: Isostacy, Fine root, Soil, Podzolization

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Nitrogen transformation process in newly created salt marsh in the aftermath of the 2011 Great East Japan Earthquake

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Dissimilatory nitrate reduction to ammonium (DNRA) is one of the most important processes of nitrate removal in an anaerobic condition. The 2011 Great East Japan Earthquake and subsequent tsunami attack widely created the intertidal salt marsh along the coast due to sea water intrusion and large ground subsidence. It is necessary to elucidate the ecosystem functions of the newly created salt march. Salt marsh is located in the conjunction point of river and sea, therefore the conversion of dissolved inorganic nitrogen concentrations and forms in the salt marsh may directly impact the productivity and biodiversity of marine ecosystems. However it is still unknown that the role of this specific salt marsh in nutrient dynamics. In September 2017, the surface sediments were collected at the intertidal and subtidal points of the salt marsh, and their potential rates of denitrification, DNRA, and anaerobic ammonium oxidation (Anammox) were estimated by using a 15N tracer technique. As for the nitrate-nitrogen removal in the sediments, the rate of DNRA was ranged from 24.8 to 177 nmol g-1 h-1, while the denitrification rate was ranged from 2.9 to 32.8 nmol g-1 h-1. Our results demonstrate that the DNRA would be significantly important in nitrate removal, and it also suggests that the conversion of inorganic nitrogen form nitrate to ammonium in the salt marsh might affect the species composition of phytoplankton and the primary production in the marsh and the coastal area connected with the marsh.

Keywords: salt marsh, dissimilatory nitrate reduction to ammonium, denitrification

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Succession of soil nitrification potential at a glacier foreland in Svalbard

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Glaciers in Svalbard particularly in the western part of the archipelago has experienced retreating since 20th century. It is concerned that the retreat has been accelerated recently. Glacier retreat on the land uncovers the ground surface under ice. This is a restart of soil genesis as the past soil was lost due to ice erosion. What does happen in nitrogen cycle of the redeveloping soil, and how does ongoing climate warming affect the redeveloping soil nitrogen cycle? In the present study, we focus on nitrification as a source of nitrate. Nitrification is a two-step microbial process consisting of ammonia oxidation to nitrite and nitrite oxidation to nitrate, in which ammonia oxidation is the rate limiting step. Nitrifiers are basically autotrophic and therefore contribute to soil nitrogen cycle from the early stage of soil genesis. It is also interesting that nitrifiers exist across the two domains, bacteria and archaea. The purposes of the present study are to investigate nitrification properties (ammonia oxidation potential [AOP] and flora of nitrifiers) and their time-series changes in the surface soil in the foreland of East Brøgger Glacier near Ny-Ålesund, Svalbard and to elucidate responses of the nitrification properties to environmental manipulations (passive warming and accompanied changes in soil moisture) using open top chambers (OTC). We have been conducting a field experiment at two permanent exclosures established by NIPR in the foreland, i.e., Site 1 (N78˚54'46", E11˚50'18") and Site 2 (N78˚54'54", E11˚49'38"). It is inferred from aerial photos that Site 1 lost its ice coverage between 1969 and 1977, and Site 2 in 1950s or 1960s. Although the foreland was abundant with rocks and stones, the surface was partly covered with mineral soil consisting of fine sand and silt. The field experiment started in July 2015. A passive warming plot and a control plot were set at each site. Twenty polyvinylchloride cores filled with 4-mm sieved and well mixed surface soil collected at each site were set at each of the warming and control plots, of which 5 cores were used to measure soil temperature and volumetric water content and the rest 15 cores were for determining nitrification properties of topsoil (0-2 cm) and subsoil (2-4 cm) collecting 3 cores every July. The field experiment will be end in the summer of 2020. AOP was determined as the nitrite production rate of soil by aerobic shaking incubation with substrate (ammonium sulfate) at 10 and 20 ˚C. Nitrifiers' flora, i.e., gene abundance and species composition of ammonia oxidizing bacteria and archaea will be identified after the completion of field experiment. Annual mean warming effects of the OTC were 0.4–0.5 ˚C at Site 1 and 0.5–0.7 ˚C at Site 2; however, stronger warming effect appeared in the snow season. OTC effects to soil moisture were moistening at the warming plots for the first year, but it turned into drying after that. The determined AOPs at Site 2 were roughly double of those at Site 1. Differences in AOP between the warming and control plots and between the topsoil and subsoil were not significant. The time-series changes in AOP were not monotonous. Meanwhile, AOPs at 20 ˚C were significantly larger than those at 10 ˚C for sites, topsoil and subsoil, and time-series changes. Annual mean soil temperatures at the two sites were from −1.5 to 0.3 ˚C, from 5 to 6 ˚C in the snowless season, and 14 ˚C as the maximum daily mean. The positive response of AOP to a high temperature of 20 ˚C implies that future climate warming accelerates soil nitrification in the foreland. Although it is early to conclude, the succession of AOP at 10 ˚C was unclear and that at 20 ˚C showed an increasing trend. This study was supported by Grants-in-Aid for Scientific Research (No. 26304018) provided by the Japan Society for the Promotion of Science. This study was also partly supported by the National Institute of Polar Research, Japan, through Project

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Research No. KP309.

Keywords: Nitrification, Ammonia oxidation potential, Glacier retreat, Tundra, Arctic soil, Open top chamber

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Transition of soil organic carbon in a volcanic ash soil derived from Towada volcano, Japan

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Soil organic carbon (SOC) is generated from organic components by receiving biological and chemical transformations in soils. In volcanic ash soils, mean resident time of SOC is generally long, so the mechanisms of the long lives are of interest for the development of techniques for carbon sequestration in soils. In the present study, we aim to elucidate the transformation process of SOC by fractionating SOC representing the transition stage of the original organic components and characterized the SOC fractions by isotopic and nuclear magnetic resonance spectroscopic analyses.

In this study, we analyzed SOC from a buried soil layer formed between 6,200 and 9,400 cal yBP, because the SOC can be well conserved without the influence of serious human activity. In addition, the age of those buried SOC can be determined by ^{14}C analysis with high accuracy. The soil samples were collected from a buried soil horizon (six samples collected from the depth between 152 and 182 cm at 5 cm intervals) close to Towada volcano, Japan. From each of the soil sample, SOC were extracted and fractionated by precipitation with controlling pH of the extracted solution (Hiradate *et al.*, 2007), resulting in humin, humic acid, and four fulvic acid fractions (two hydrophilic fulvic acid fractions: FA_1 and FA_2, and two hydrophobic fulvic acid fractions: FA_3, and FA_{IHSS}). The SOC fractions were freeze-dried and analyzed for determining $\delta^{13}C$ and $\delta^{15}N$ values by using isotope ratio mass spectrometer and for ^{14}C dating by using accelerator mass spectrometer. Solid-state ^{13}C CPMAS NMR analysis was also conducted to investigate the structural characteristics and quantify the carbon species of the SOC fractions.

The $\delta^{13}C$ values of humic acid, FA_1, FA_2, FA_3, and FA_{IHSS} fractions were -23.85±0.36, -20.75±0.32, -21.10 ±0.38, -22.81±0.41, and -23.22 ±0.33‰, respectively, while $\delta^{15}N$ values were 3.00±0.37, 8.16±1.73, 9.66±0.54 , 4.73±0.83, and 5.20±0.54‰, respectively. The ^{14}C age of humic acid, FA_1, FA_2, FA_3, and FA_{IHSS} fractions was 6130±300, 5630±240, 5400±200, 5410±230, and 5680±260 cal yBP, respectively. Decomposition and recycling of plant residues during the transformation of SOC result in enrichment of heavier carbon and nitrogen isotopes due to preferential stabilization (Wada *et al.*, 2013). Therefore, the increase of $\delta^{13}C$ and $\delta^{15}N$ values in SOC fractions corresponds to successive transformation of SOC. The slope of the relationship between $\delta^{13}C$ and $\delta^{15}N$ values was 1.69, and the results were similar to the result of Wada *et al.* (2013), indicating successive transformation of SOC from plant organic matter to hydrophilic fulvic acid fraction. The hydrophilic fulvic acid fraction would be more microbially processed than hydrophobic fulvic acid and humic acid fractions. Because the humic acid fractions were rich in aromatic structure, they would be formed in the early stage of the formation right after C fixation by plants and chemically stabilized in the soil horizon by fire event etc. The hydrophobic fulvic acid horizons, which are less rich in aromatic C but relatively rich in aliphatic C, would be formed by microbial transformation

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and stabilized by chemical and physical factor. The hydrophilic fulvic acid fractions, which are rich in *O* -alkyl C, would be microbially metabolized many times and stabilized physically in the soil horizons.

The validity of the chemical fractionation of SOC on the soil dynamics study has been discussed and sometimes regarded as questionable, but at least in our study on a buried volcanic ash soil, the chemical fractionation procedure successfully separated SOC receiving different metabolisms and having different genesis and chemical structural features.

Hiradate, S., Yonezawa, T., Takesako, H., 2007. Soil science and Plant Nutrition 57, 413-419.
Wada, E., Ishii, R., Aita, M.N., Ogawa, N. O., Kohzu, A., Hyodo, F., Yamada, Y., 2013. Ecological Research 28, 173-181.

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General pattern of carbon and nitrogen isotopic variation across a wide range of soils and its controlling factors

*Rota Wagai[1], Masako Kajiura[1], Yudzuru Inoue[2], Maki Asano[3], Chie Hayakawa[4]

1. NARO, Institute for Agro-Environmental Sciences, 2. Nagasaki Institute of Applied Science, 3. University of Tsukuba, 4. University of Tokyo

Organic matter (OM) in soil represents the largest carbon pool on land. The production of CO2 via microbial degradation of soil OM therefore has a strong impact on global C cycle and anticipated global warming. Previous studies have shown that any soil holds multiple OM pools of varying stability against microbial attack. Growing number of studies suggests protective effect of specific mineral phases and mineral matrix. OM, however, interacts with soil minerals in highly complex ways including co-precipitation of organic ligands with multivalent metals at molecular scale and physical aggregation of OM with mineral particles at micron and larger scales.

Here we examined the relationship between the isotopic compositions (C-13, C-14, and N-15) and mineralogical characteristics (surface area and elemental composition, pedogenic metal oxides) among density fractions using a range of surface soils of contrasting mineralogy including volcanic soils rich in short-range-order minerals and much more weathered soils from both agricultural and natural systems. Each soil was separated into 4-7 density fractions after mechanical shaking with sodium polytungstate. From LF to higher-density fractions, We assessed how C aging is related to C13 and N15 enrichment and to what extent these isotopic variations among the fractions were controlled by the mineralogical characteristics.

Keywords: Soil, Carbon sequestration, organo-mineral interaction, stable carbon and nitrogen isotope, Radiocarbon, mineralogy

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Nutrient sources in some Japanese forest ecosystems: the contribution of precipitation, weathering and litter fall

*Yoshiyuki Inagaki[1], Kazumichi Fujii[1]

1. Forestry and Forest Products Research Institute

Base cation such as calcium and potassium is important nutrient for tree growth in forest ecosystems. Major sources of base cation to forest soil are precipitation, weathering of parent material and litter fall. Weathering rate of base cation is estimated from the input from precipitation, runoff from stream and uptake by vegetation. For plant uptake two different properties, i.e., long-term accumulation in plant biomass and annual uptake should be quantified. Nutrient cycling of many Japanese forest ecosystems has been studied but information about the contribution of these sources is limited. This study compared three nutrient sources in four forest ecosystems in Japan. These forests are Oyasan (Gunma Pref.), Kamikamo (Kyoto Pref.), Kiryu (Shiga pref.) and Takatori (Kochi Pref.). We calculated nutrient budget of potassium, calcium and magnesium. The rate of rock weathering of base cation ranged from 0.22 to 4.37 kmolc ha^{-1} yr^{-1} and increased in the order of Kamigamo < Kiryu <Oyasan < Takatori. In potassium cycling, the contribution of litter fall was greater than that of weathering or precipitation. The runoff of calcium and magnesium from soil was greater in Takatori, where the rate of weathering was high. Although the rate of weathering varied substantially among forest ecosystems, the annual flux of litter fall was relatively constant. Similar calculation was applied for nitrogen cycling and the source from soil was treated as that from nitrogen accumulated during the past pedogenesis. Nitrogen input from the accumulated soil source was 36 % in Oyasan whereas that in other three forestswas 0%. Oyasan was considered as a nitrogen-saturated forest and the result of the study suggest the ecosystem relies on different nitrogen source.

Keywords: nutrient cycling, weathering, plant uptake, forest ecosystems

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Mon. May 27, 2019 1:45 PM - 3:15 PM JST | Mon. May 27, 2019 4:45 AM - 6:15 AM UTC | 201A 2F

[M-IS13] Biogeochemistry

convener:Keisuke Koba(Center for Ecological Research, Kyoto University), Hideaki Shibata(Field Science Center fot Northern Biosphere, Hokkaido University), Naohiko Ohkouchi(Japan Agency for Marine-Earth Science and Technology), Youhei Yamashita(Faculty of Environmental Earth Science, Hokkaido University), Chairperson:Keisuke Koba(Kyoto University), Yohei Yamashita, Kazuya Nishina, Kazumichi Fujii

Biogeochemistry is an interdisciplinary study field including ecology, geochemistry, oceanography, limnology, hydrology, soil science and environmental sciences. Respective researches have tended to be conducted separately so far. This session aims to provide a common platform for biogeochemists of different disciplines, which facilitates the interactive discussion and information exchanges for further development of biogeochemical studies.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MIS13-07] Ultrahigh-resolution mass spectral analysis of dissolved organic matter in rainfall, throughfall and soil water in temperate forest stands, western Japan

*Junichiro Ide[1], Keitaro Yamase[2], Seonghun Jeong[3], Noki Makita[4], Hiroshi Nishimura[5], Keitaro Fukushima[6], Kyoichi Otsuki[7], Mizue Ohashi[8] (1.Institute of Decision Science for a Sustainable Society, Kyushu University, 2.Forestry and Forest Products Research Institute, Hyogo Prefectural Technology Center for Agriculture, Forestry and Fisheries, 3.Graduate School of Bioresources and Bioenvironmental Sciences, Kyushu University, 4.Faculty of Science, Shinshu University, 5.Research Institute for Sustainable Humanosphere, Kyoto University, 6.The Center for Ecological Research, Kyoto University, 7.Faculty of Agriculture, Kyushu University, 8.School of Human Science and Environment, University of Hyogo)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MIS13-08] Basin-scale transport of allochthonous humic-like fluorescent dissolved organic matter by the North Pacific Intermediate water

*Youhei Yamashita[1], Jun Nishioka[2], Hajime Obata[3], Hiroshi Ogawa[3] (1.Faculty of Environmental and Earth Science, 2.Institute of Low Temperature Science, Hokkaido University, 3.Atmosphere and Ocean Research Institute, The University of Tokyo)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MIS13-09] Bacterial contribution to dissolved organic matter in a large monomictic lake (Lake Biwa) indicated by amino acids enantiomers

*Yasuhiko T. Yamaguchi[1], Chikage Yoshimizu[2], Ichiro Tayasu[2], Keisuke Koba[3], Kazuhide Hayakawa[1] (1.Lake Biwa Environmental Research Institute, 2.Research Institute for Humanity and Nature, 3.Center for Ecological Research, Kyoto University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MIS13-10] High-sensitivity tracer assay for oxygen consumption rate in ocean and lakes using ^{17}O as a tracer

*Urumu Tsunogai[1], Shogo Kashiwagi[1], Masanori Ito[1], Fumiko Nakagawa[1], Chiho Sukigara[1] (1.Graduate School of Environmental Studies, Nagoya University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MIS13-11] Ecology of bacterioplankton inhabiting oxygenated hypolimnia of deep freshwater lakes

*Yusuke Okazaki[1] (1.National Institute of Advanced Industrial Science and Technology)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MIS13-12] Nitrous oxide emission from the drainage and the production processes in oil palm plantation on peatland

*Kazuya Nishina[1], Lulie Melling[2], Ryuichi Hirata[1], Yoshiyuki Takahashi[1], Sakae Toyoda[3], Kotaro Terajima[3], Masayuki Itoh[4] (1.NIES National Institute of Environmental Studies, 2.SARAWAK Tropical Peat Research Institute, 3.Tokyo Institute of Technology, 4.University of Hyogo)

Ultrahigh-resolution mass spectral analysis of dissolved organic matter in rainfall, throughfall and soil water in temperate forest stands, western Japan

*Junichiro Ide[1], Keitaro Yamase[2], Seonghun Jeong[3], Noki Makita[4], Hiroshi Nishimura[5], Keitaro Fukushima[6], Kyoichi Otsuki[7], Mizue Ohashi[8]

1. Institute of Decision Science for a Sustainable Society, Kyushu University, 2. Forestry and Forest Products Research Institute, Hyogo Prefectural Technology Center for Agriculture, Forestry and Fisheries, 3. Graduate School of Bioresources and Bioenvironmental Sciences, Kyushu University, 4. Faculty of Science, Shinshu University, 5. Research Institute for Sustainable Humanosphere, Kyoto University, 6. The Center for Ecological Research, Kyoto University, 7. Faculty of Agriculture, Kyushu University, 8. School of Human Science and Environment, University of Hyogo

This study aimed to clarify alternations of the quality of dissolved organic matter (DOM) in rainwater moving through temperate forests. For this, we compared the molecular composition of dissolved organic matter (DOM) between bulk deposition (rainfall), throughfall and soil water in Japanese cypress (*Cryptomeria japonica*) and Japanese stone oak (*Lithocarpus edulis*) stands, which were regarded as coniferous and broad-leaved stands, respectively, during a rain event. Analyses of ultrahigh-resolution Fourier transform ion cyclotron resonance mass spectrometry revealed that the number of DOM molecular species detected was significantly greater in throughfall and soil water than in rainfall ($p < 0.05$). In contrast, the number of molecular species did not significantly differ between throughfall and soil water ($p > 0.05$). There were no significant differences in the number of molecular species in both throughfall and soil water between coniferous and broad-leaved stands ($p > 0.05$). These results suggest that a diverse array of DOM molecules are provided from the tree canopies and soils to the rainwater in both stands. Approximately 52%–59% of the total molecular species in throughfall samples ($n = 6$) were unique to throughfall. Additionally, approximately a half of the total molecular species in soil water samples ($n = 5$) were unique to soil water. The classification of molecular species into seven biomolecular classes using a van Krevelen diagram revealed that throughfall samples contained many of lipid and protein molecules compared to rainfall and soil water samples, whereas approximately 70% of the total molecular species in soil water were lignin-like molecules. The analysis of multidimensional scaling revealed that molecular species were significantly differentiated between rainfall, throughfall and soil water ($p < 0.05$). These results indicate that there are diverse molecules unique to throughfall and soil water and that the quality of DOM drastically changes in rainwater as it moves through temperate forests.

Keywords: Biomolecules, Carbon dynamics, Forest type, FT-ICR MS, Molecular diversity

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Basin-scale transport of allochthonous humic-like fluorescent dissolved organic matter by the North Pacific Intermediate water

*Youhei Yamashita[1], Jun Nishioka[2], Hajime Obata[3], Hiroshi Ogawa[3]

1. Faculty of Environmental and Earth Science, 2. Institute of Low Temperature Science, Hokkaido University, 3. Atmosphere and Ocean Research Institute, The University of Tokyo

The levels of humic-like fluorescent dissolved organic matter (FDOM) in the open ocean generally showed nutrient-type vertical profile. In the surface water, low levels of humic-like FDOM is due to degradation by sunlight. In the dark ocean, linear relationships between levels of humic-like FDOM and apparent oxygen utilization (AOU) have been observed throughout the global ocean, indicating that humic-like FDOM is produced in situ in the ocean interior as organic matter is oxidized by microbes and is resistant to microbial degradation with time scales of thermohaline circulation.

While, it has also been observed that some plots of humic-like FDOM vs AOU in the specific water masses, namely, the North Pacific Intermediate Water (NPIW) and the North Atlantic Deep Water (NADW), seemed to deviate from the general relationship between humic-like FDOM and AOU. The previous studies showed that concentrations of lignin phenols, a unique biomarker of vascular plants, were found to be higher in the NPIW and the NADW compared with other water masses. Thus, the deviations of plots between humic-like FDOM and AOU in the NPIW and the NADW can be considered to be derived from terrestrial (allochthonous) humic-like FDOM.

In this study, we determined a basin-scale distribution of humic-like FDOM from the Sea of Okhotsk to the western subtropical North Pacific. We found the linear relationship between levels of humic-like FDOM and AOU in the deep layer (>1000 m) of the western North Pacific. While, we also found plots in the mesopelagic layer, corresponding to the NPIW, were significantly deviated from the relationship observed in the deep layer. Such distributional pattern implies that allochthonous humic-like FDOM derived from the Sea of Okhotsk is transported widely to the intermediate layer of the North Pacific by the NPIW.

Keywords: North Pacific Intermediate Water, dissolved organic matter, allochthonous

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Bacterial contribution to dissolved organic matter in a large monomictic lake (Lake Biwa) indicated by amino acids enantiomers

*Yasuhiko T. Yamaguchi[1], Chikage Yoshimizu[2], Ichiro Tayasu[2], Keisuke Koba[3], Kazuhide Hayakawa[1]

1. Lake Biwa Environmental Research Institute, 2. Research Institute for Humanity and Nature, 3. Center for Ecological Research, Kyoto University

Dissolved organic matter (DOM) plays crucial roles in the biogeochemical cycles in aquatic environments. A number of past studies have strongly indicated that heterotrophic bacteria represent a major source to the ocean DOM pool, suggesting that microbial processes may underlie the mechanisms for DOM preservation ("microbial carbon pump"). In particular, enantiomeric (D/L) analysis of amino acids (AA) in DOM has been used to characterize sources of DOM, and high abundance of specific D-AA bacterial biomarkers have suggested that bacterially-sourced organic matter may be a key in formation of the ocean's recalcitrant DOM pool (e.g., McCarthy et al., 1998; Kaiser & Benner, 2008; Yamaguchi & McCarthy, 2018). In contrast to the marine environments, the distribution of D-AA bacterial biomarkers in DOM has been severely understudied in lacustrine environments. To our knowledge, there has been just one report of D-AA concentration in DOM for a freshwater lake water column (Kawasaki et al., 2013: in eutrophic Lake Kasumigaura, Japan).

Our study explores the use of D-AA bacterial biomarkers as an effective approach to estimate bacterial contribution to the DOM pools in lacustrine environments. First, we have developed a new analytical approach using GC-MS for D-AA concentration in the total DOM pool of lake water. This method can detect unusual D-AA molecules (e.g., D-Val, D-Phe, D-Tyr) together with the major four bacterial biomarkers (D-Ala, D-Glu, D-Asp, and D-Ser) which have been analyzed by the conventional HPLC method. Second, we determined vertical and seasonal variations in the D-AA concentrations of DOM in a large monomictic lake (Lake Biwa, Japan). To our knowledge, this study is the first report of D-AA concentrations of DOM in a meso/oligotrophic lake. Finally, we conducted an incubation experiment using natural microbial community in Lake Biwa to estimate the D-AA yields in freshly-produced bacterial DOM in the lake environment, which are essential for the calculation of bacterial contribution to the natural DOM pools.

From the vertical distribution of D-AA concentration during the stratified period (summer and fall), we estimated that a substantial fraction (30-40%) of the recalcitrant pool of dissolved organic carbon (DOC) is bacterial origin. In contrast, the bacterial contribution was less than 20% to the semi-labile DOC pool which accumulates in the lake epilimnion during summer. These results suggest that the "microbial carbon pump" (production of recalcitrant DOM by heterotrophic bacteria) is an important process in the biogeochemical cycles of lakes.

Keywords: Dissolved Organic Matter, Amino Acids, Enantiomers, Microbial Loop, Microbial Carbon Pump, Organic Geochemistry

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High-sensitivity tracer assay for oxygen consumption rate in ocean and lakes using ^{17}O as a tracer

*Urumu Tsunogai[1], Shogo Kashiwagi[1], Masanori Ito[1], Fumiko Nakagawa[1], Chiho Sukigara[1]

1. Graduate School of Environmental Studies, Nagoya University

We newly devellopped new high-sensitivity tracer assay for oxygen consumption rate in ocean and lakes using ^{17}O as a tracer.

Keywords: oxygen consumption rate, stable isotopes, tracer assay, anoxic water, photorespiration

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Ecology of bacterioplankton inhabiting oxygenated hypolimnia of deep freshwater lakes

*Yusuke Okazaki[1]

1. National Institute of Advanced Industrial Science and Technology

In marine and freshwater systems, there are 10^4–10^7 cells mL^{-1} of bacterioplankton in the water column, playing central roles in the microbial food web and biogeochemical cycling. In oligo-mesotrophic deep freshwater lakes, such as Lake Biwa, Baikal and The Laurentian Great Lakes, the hypolimnion is a dark, cold, aerobic water layer below the thermocline that accounts for a majority of the lake volume. Analogous to the deep ocean, the oxygenated hypolimnion is a realm for important biogeochemical processes, such as accumulation and decomposition of semilabile organic matter, nitrification, and methane oxidation. However, our knowledge for the diversity and ecology of the bacterioplankton in the oxygenated hypolimnion is still limited and even poorer than that in the deep ocean. To fill this gap, the present study comprehensively investigated the bacterioplankton community composition in the oxygenated hypolimnia of deep freshwater lakes.

To obtain data from lakes with varying depth, surface area, water temperature, trophic state, pH, lake origin and water retention time, 13 Japanese lakes and 7 European perialpine lakes have been sampled so far. The waters were collected vertically at the deepest point in each lake and the bacterial community composition was determined by 16S rRNA gene amplicon sequencing and catalyzed reporter deposition-fluorescence *in situ* hybridization (CARD-FISH). The result revealed that the oxygenated hypolimnion is inhabited by hypolimnion-specific bacterioplankton lineages that were phylogenetically different by phylum-level from commonly-known freshwater bacterioplankton lineages dominating in epilimnia. While most of the hypolimnion-specific lineages were uncultured and thus their eco-physiology was not well understood, the fact that they commonly predominate in global lakes suggests their importance in the microbial food web and biogeochemical cycling in deep freshwater lakes.

Among the hypolimnion-specific lineages, the CL500-11 lineage (phylum Chloroflexi) is particularly abundant, accounting for more than 10% of bacterioplankton cells in the hypolimnion in many lakes. CARD-FISH analysis revealed their relatively large cell size (1–2 μm), suggesting their contribution in biovolume is even greater. Together with the information collected from literatures and sequence databases, the results demonstrated that CL500-11 inhabit most freshwater lakes with the oxygenated hypolimnion, although their low abundances were observed in lakes with low pH, shallow depth, or short water retention time (<1 year). The results as well as metagenomic and geochemical insights from published studies allowed to hypothesize possible characteristics of substrates supporting CL500-11 growth, most likely nitrogen-rich autochthonous dissolved organic matter (DOM) ubiquitously available in the hypolimnion that may turnover within an annual timescale; for instance, DOM derived from the epilimnion transferred by winter vertical mixing, or DOM secondary produced in the hypolimnion, such as cellular debris from other microbes.

In conclusion, this study revealed that the microbial food web and biogeochemical processes in the oxygenated hypolimnia of deep freshwater lakes are driven by a specific bacterioplankton communities that have eluded previous studies only focusing on the surface waters. Future works should further investigate the ecophysiology of the individual lineages by a metagenomic-based approach or by establishment of their isolated cultures.

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Keywords: Limnology, Microbial Ecology

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Nitrous oxide emission from the drainage and the production processes in oil palm plantation on peatland

*Kazuya Nishina[1], Lulie Melling[2], Ryuichi Hirata[1], Yoshiyuki Takahashi[1], Sakae Toyoda[3], Kotaro Terajima[3], Masayuki Itoh[4]

1. NIES National Institute of Environmental Studies, 2. SARAWAK Tropical Peat Research Institute, 3. Tokyo Institute of Technology, 4. University of Hyogo

In South-East Asia, oil palm plantation has rapidly expanded in the past few decades even in peatland areas. In the light of nitrogen cycling, this land-use change would result in enrichment on the ecosystem N cycling due to the N fertilization for the maintaining oil palm growth and the wastewater emission from the palm mills in the plantation. Oil palm plantations converted from peat swamp forests require the drainage to keep cultivation and thus has unique hydrological characteristics. In such plantation, drainage water surface dominates up to 5% of plantation area and therefore it is important to evaluate the gas exchange between the drainage water and atmosphere.

In this study, we have conducted spatial sampling for dissolved N_2O concentration (dN_2O) in the oil palm plantation on drained peat soil in July 2018, in Sarawak, Malaysia in order to evaluate the indirect N_2O emission from palm oil plantation. We have intensively sampled the water samples from the drainage in the plantation (ca. 120 km^2) and the water samples from Raja river, which is adjacent to the plantation. 90% of samples (N = 84) in the drainage water showed over-saturation in dissolved N_2O concentration (up to 570%), suggesting that the drainage water in the oil palm plantation acts the source of N_2O to the atmosphere. The emission factor for indirect emission (EFr: i.e., dN_2O/nitrate concentration) showed relatively higher than the default EFr in IPCC. However, there were no clear linear relationships between the water qualities (including nitrate) and dN_2O. We have also analyzed the isotopic composition of dN_2O in both drainage and river samples. This analysis suggested the denitrification contributed dN_2O in the drainage water.

Keywords: Nitrous oxide, Oil palm plantation, Nitrogen stable isotope

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[J] Oral | M (Multidisciplinary and Interdisciplinary) : M-IS Intersection

Mon. May 27, 2019 9:00 AM - 10:30 AM JST | Mon. May 27, 2019 12:00 AM - 1:30 AM UTC | Convention Hall B 2F

[M-IS14] Global climate change driven by the Southern Ocean and the Antarctic Ice Sheet

convener:Osamu Seki(Institute of Low Temperature Science, Hokkaido University), Akira Oka(Atmosphere and Ocean Research Institute, The University of Tokyo), Ryu Uemura(University of the Ryukyus), Ryosuke Makabe(National Institute of Polar Research), Chairperson:Yuji Kato(Kochi University)

The Southern Ocean and Antarctic ice sheet, which are the giant reservoirs of heat, water, and materials, have a potential to play central roles in long-term global climate change. This system is composed of the following sub-systems; ice shelf which is a place of the interaction of ice sheet and ocean, flowing iceberg, seasonal sea ice zone, Antarctic bottom water which drives the thermohaline circulation, active biological production and Antarctic Circumpolar Current. These sub-systems are interacted with each other and have significant impact on changes in the global environmental system. This session aim to summarize recent observational and simulation studies from various fields relating to the past and present changes in the Antarctic Ice sheet and Southern Ocean, which are essential elements for unraveling the changes in the global climate system. Further, future science plans for understanding of the environmental changes of the Antarctic Cryosphere is also discussed.

9:00 AM - 9:25 AM JST | 12:00 AM - 12:25 AM UTC

[MIS14-01] Mass loss of the Antarctic ice sheet under the influence of ice-ocean interaction

★Invited Papers

*Shin Sugiyama[1] (1.Institute of Low Temperature Science, Hokkaido University)

9:25 AM - 9:40 AM JST | 12:25 AM - 12:40 AM UTC

[MIS14-02] Accurate chronology and climatic reconstruction around MIS 11 (interglacial period ~400,000 years ago) from Dome Fuji ice core, Antarctica

*Kenji Kawamura[1,2,3], Ikumi Oyabu[1], Shuji Aoki[4], Takakiyo Nakazawa[4], Ayako Abe-Ouchi[5,3], Fuyuki SAITO[3] (1.National Institute of Polar Research, Research Organization of Information and Systems, 2.SOKENDAI (The Graduate University of Advanced Studies), 3.JAMSTEC, 4.Tohoku University, 5.University of Tokyo)

9:40 AM - 9:55 AM JST | 12:40 AM - 12:55 AM UTC

[MIS14-03] Study on physics and layers of ice cores containing information of climate change over the past 720 k-years, and study on the "oldest ice"

*Shuji Fujita[1,2], Motohiro Hirabayashi[1], Iizuka Yoshinori[3], Hiroshi Ohno[4] (1.National Institute of Polar Research, Research Organization of Information and Systems(ROIS), 2.Department of Polar Science, The Graduate University for Advanced Studies (SOKENDAI), Japan, 3. Institute of Low Temperature Science, Hokkaido University, Japan, 4.Kitami Institute of Technology, Japan)

9:55 AM - 10:15 AM JST | 12:55 AM - 1:15 AM UTC

[MIS14-04] Reconstructions of the Antarctic Polar Front through the glacial/interglacials

★Invited Papers

*Hiroki Matsui[1], Yuji Kato[1,2], Itsuki Suto[3], Minoru Ikehara[1] (1.Center for Advanced Marine Core Research, Kochi University, 2.JSPS PD, 3.Graduate School of Environmental Studies, Nagoya University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[MIS14-05] **Integrated observations for marine earth science in the Indian sector of the Southern Ocean: Preliminary results of R/V Hakuho-maru KH-19-1 cruise**

*Minoru Ikehara[1], Kay I. Ohshima[2], Takuya Itaki[3], Hiroshi Sato[4], Masakazu Fujii[5], Michiyo Yamamoto-Kawai[6], Hiroki Matsui[1], Takahito Ikenoue[7], . Scientific Party of R/V Hakuho-maru KH-19-1 cruise (1.Center for Advanced Marine Core Research, Kochi University, 2.ILTS, Hokkaido University, 3.GSJ, AIST, 4.Senshu

University, 5.National Institute of Polar Research, 6.Tokyo University of Marine Science and Technology, 7.Marine Ecology Research Institute)

Mass loss of the Antarctic ice sheet under the influence of ice-ocean interaction

*Shin Sugiyama[1]

1. Institute of Low Temperature Science, Hokkaido University

The Antarctic ice sheet covers 8.3% of the global land surface with a mean ice thickness of 1937 m. The mass of the ice accounts for ~90% of freshwater on the earth and has a potential of 58.3 m sea level rise. Mass change of the ice sheet has a large impact on the Antarctic and global environment since meltwater discharge affects not only sea level, but also ocean circulation and marine ecosystems. Therefore, quantification of ice sheet mass balance and understanding the driving mechanisms are crucially important.

Our understanding of the Antarctic ice sheet mass balance has been greatly improved over the last two decades. Novel satellite measurement techniques enabled us to quantify year to year variations in the mass balance, as well as to investigate key processes such as ice speed, calving and ice shelf basal melting. These new observations have shown a trend of ice sheet mass loss since 1990s. The most significant changes are observed at fast flowing glaciers and ice shelves along the coast in West Antarctica. More detailed studies strongly suggest that the mass loss is due to increasing ice shelf basal melting and ice flow acceleration. To clarify the mechanism of the observed changes, further investigations are in progress on the ice sheet and in the ocean. Study results indicate that the ice sheet is losing mass under the influence of changing ocean, and meltwater discharge is affecting the ocean environment in turn.

In this presentation, we review progress in understanding of the Antarctic ice sheet mass balance and mechanisms driving the recent mass trends. Based on the existing knowledge, we discuss future research directions required for satellite and in-situ measurements as well as numerical investigations.

Keywords: Antarctic ice sheet, Ice sheet-ocean interaction, Mass balance, Ice shelf, Sea level

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Accurate chronology and climatic reconstruction around MIS 11 (interglacial period ~400,000 years ago) from Dome Fuji ice core, Antarctica

*Kenji Kawamura[1,2,3], Ikumi Oyabu[1], Shuji Aoki[4], Takakiyo Nakazawa[4], Ayako Abe-Ouchi[5,3], Fuyuki SAITO[3]

1. National Institute of Polar Research, Research Organization of Information and Systems, 2. SOKENDAI (The Graduate University of Advanced Studies), 3. JAMSTEC, 4. Tohoku University, 5. University of Tokyo

Marine Isotope Stage (MIS) 11 is characterized by long duration of glacial termination and interglacial, with higher sea level than today, despite moderate atmospheric CO_2 concentration and small variations in northern summer insolation (due to small orbital eccentricity). To investigate the roles of different forcings (e.g. orbital variations and greenhouse gases) on climate and ice sheets (sea level), paleoclimatic proxy records need to be accurately dated and precisely synchronized with each other. An accurate chronology for the past 360 ky was constructed through orbital tuning of O_2/N_2 ratio of trapped air in the Dome Fuji and Vostok ice cores with local summer insolation (Kawamura et al., 2007), and its improvement has been underway (Oyabu et al., this session). We have also been extending the O_2/N_2 chronology to older periods by analyzing the second Dome Fuji ice core, and constrain the timing and duration of the past interglacial periods.

Marine sediment cores from northern North Atlantic region exhibit millennial-scale variations, including abrupt climatic shifts and bipolar seesaw, during glacial periods and terminations in various proxy records (e.g. sea surface temperature and ice-rafted debris). By correlating the millennial-scale changes recorded in the marine sediment cores with those in the Dome Fuji ice core (CH_4 concentration and d18O of ice), it may be possible to transfer the Dome Fuji chronology to the marine cores from the North Atlantic. We first attempted to correlate planktonic $\delta^{18}O$ and IRD records from the marine core ODP 980 with the Dome Fuji CH_4 around MIS 11 and constrain the durations of interglacial periods recorded in the marine core, with some success. However, the current resolution of the Dome Fuji gas records (~2000 years on average) is not sufficient to undoubtedly identify all millennial-scale events, thus we will start new measurements to improve the resolution. In the presentation, we will show the results of the new measurements and synchronization, and discuss the timing, duration and mechanism of climatic changes over Termination V and MIS 11.

Keywords: Ice core, MIS 11, interglacial period, Dome Fuji

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Study on physics and layers of ice cores containing information of climate change over the past 720 k-years, and study on the "oldest ice"

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1. National Institute of Polar Research, Research Organization of Information and Systems(ROIS), 2. Department of Polar Science, The Graduate University for Advanced Studies (SOKENDAI), Japan, 3. Institute of Low Temperature Science, Hokkaido University, Japan, 4. Kitami Institute of Technology, Japan

Purpose and Background of the Research

Ice cores collected in inland of Antarctica is one of important information sources for histories of climatic changes that occurred over 1.5 M years. At ice core drilling sites, ice is older in deeper layers; such deep layers are subject to vertical compressions by ice flow. In addition, various time-dependent metamorphic processes undergoes by influences of the geothermal heat flux. If such very deep signals are once resolved with high time resolutions, we can uncover the history of rapid climate changes. Such ice-core-based knowledge will be crucial for building strategies to make sustainable society under global warming. However, current state of our knowledge is based on limited and discrete sampling from ice cores. High resolution continuous methods for analysis has just begun in recent years. In this study, we will use cutting-edge methods for high-resolution and continuous measurements for ice cores, based on crystal physics and continuous flow analysis (CFA); we will analyze layers of ice cores spanning ca. 200,000 years and ca. 720,000 years. Based on it, we will (i) produce valuable information of the climate in the past, (ii) clarify nature of the time-dependent metamorphic processes, (iii) synchronize multiple very deep ice cores, and (iv) predict quality of information from ice cores that cover 1.5 M years.

Research Methods

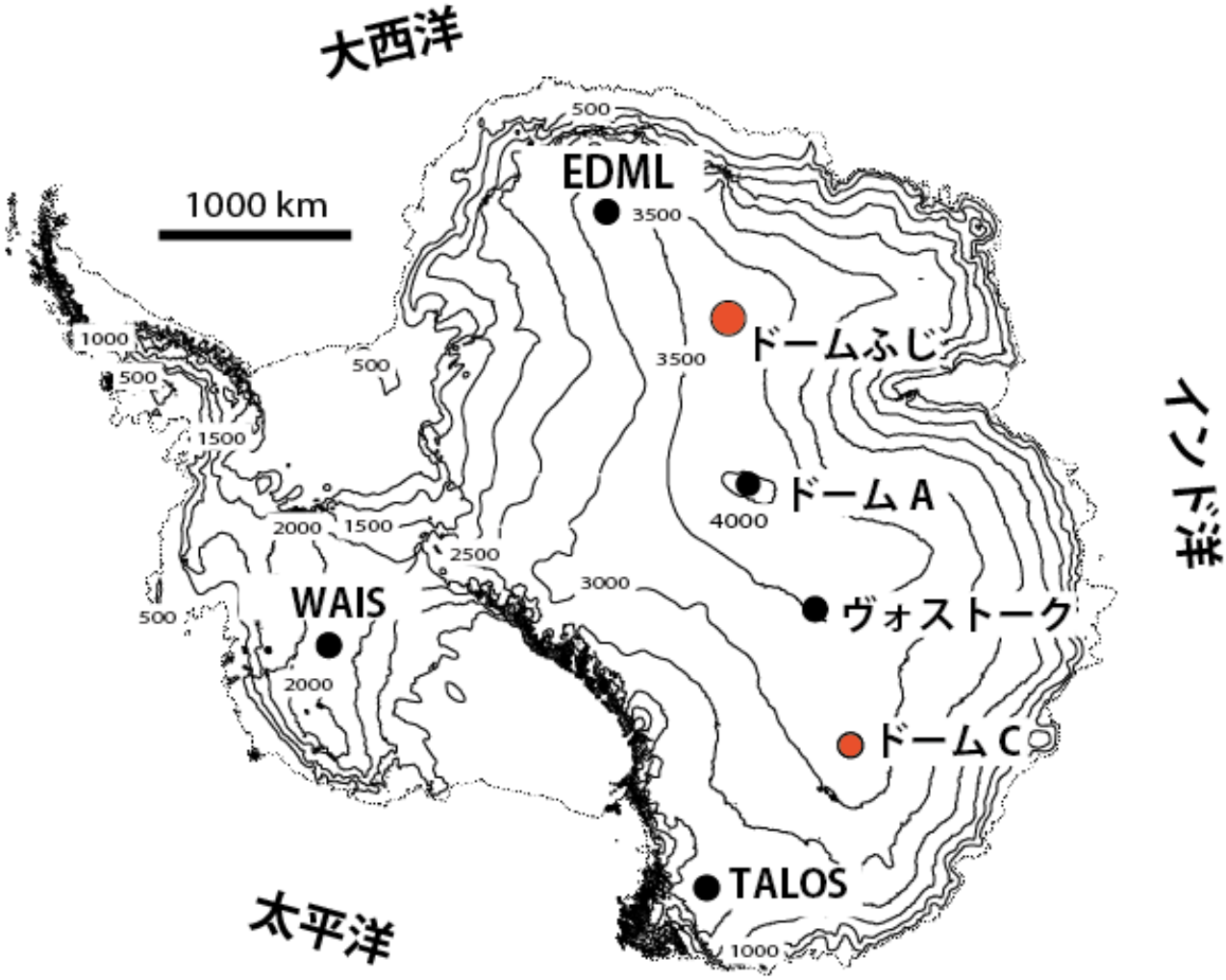
At an inland site called Dome Fuji in East Antarctica, ice core researchers organized by the National Institute of Polar Research, Japan, collected ice cores covering 720,000 years. We will analyze portions of the ice cores spanning ca. 200,000 years and ca. 720,000 years. Such very old portion constitute deepest ~1000 m span within the ~3000 m-thick ice sheet. Such layers are subject to vertical compressions. In this study, key questions are as follows:
(i) Can we synchronize these very old portions of ice between to major ice cores drilled at Dome Fuji and Dome C?
(ii) How old age of ice back in time, can we clarify detailed histories of rapid changes of climate?
As actions tackling the questions, we will use two major methods to read the layered strata. One of them is to read layers of crystal textures using a method to measure dielectric permittivity tensor with the millimeter wave resonators. Spatial resolutions of this method is ~20mm. Another method is "Continuous Flow Analysis" (CFA) method to read layers of Si, Na and Ca, with a resolutions of ~10 mm.

Expected Research Achievements and Scientific Significance

First, we will produce invaluable ice core data. The data will be used to tackle the key questions. Based on the data, we will synchronize two very old ice cores at Dome Fuji and Dome C, based on collaborations of the European deep ice study community. In addition, we will examine timing difference between the climatic change records between the two ice cores. We aim to accomplish the first reliable and detailed synchronization between very old ice cores up to 720,000 years back in time. we will study change of the climatic mode over the 720,000 years. Furthermore, we will study how very old ice older than 1 M years, can be preserved near the base of the ice sheet.

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Keywords: Antarctica, ice sheet, ice core, climate change, dating, paleoclimate



図：南極氷床上の主要な深層アイスコア掘削点

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Reconstructions of the Antarctic Polar Front through the glacial/interglacials

*Hiroki Matsui[1], Yuji Kato[1,2], Itsuki Suto[3], Minoru Ikehara[1]

1. Center for Advanced Marine Core Research, Kochi University, 2. JSPS PD, 3. Graduate School of Environmental Studies, Nagoya University

Understanding the Antarctic Circumpolar Current (i.e., Antarctic Polar Front and Subantarctic front), which connects major three Oceans and major components of the Southern Ocean and Antarctic ice sheets system, is important (from past to present). Modern polar front ranges from 44˚S to 64˚S and is defined by the southern bound of strong SST gradient (>1.5˚ over 100 km) (Freeman et al., 2016). The observed PF position from 2002 to 2014 does not show discernable trend (either northward or southward) in response to the global warming. For the Last Glacial Maximum (LGM), the PF moved northward by 5 degrees (e.g., Gersonde et al., 2005). However, there is difficulty to reconstruct paleo SST gradient because of paucity of surface sediments, and the alternative definition of the PF (e.g., 4 degrees C surface isotherm) was applied (Kohfeld et al., 2013). In this presentation, we summarize current state of knowledge and obstacles of reconstruction of the PF through the glacial/interglacials. We also discuss appropriate methods to certainly track the past PF position.

Keywords: Antarctic Polar Front, Paleoceanography

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Integrated observations for marine earth science in the Indian sector of the Southern Ocean: Preliminary results of R/V Hakuho-maru KH-19-1 cruise

*Minoru Ikehara[1], Kay I. Ohshima[2], Takuya Itaki[3], Hiroshi Sato[4], Masakazu Fujii[5], Michiyo Yamamoto-Kawai[6], Hiroki Matsui[1], Takahito Ikenoue[7], . Scientific Party of R/V Hakuho-maru KH-19-1 cruise

1. Center for Advanced Marine Core Research, Kochi University, 2. ILTS, Hokkaido University, 3. GSJ, AIST, 4. Senshu University, 5. National Institute of Polar Research, 6. Tokyo University of Marine Science and Technology, 7. Marine Ecology Research Institute

Integrated observations for marin earth science have been done in the Indian sector of the Southern Ocean during the KH-19-1 cruise by R/V Hakuho-maru in early 2019. Multichannel seismic (MCS) reflection and bathymetric survey were conducted at three sites on the Del Cano Rise and the Conrad Rise, and these site survey for IODP proposal 918 was successfully completed. We also obtained sediment cores from the proposed sites DCR-03A and DCR-02A, and sedimentary archives of a piston core DCR-2PC (at DCR-02A) show obviously glacial-interglacial cycles based on magnetic susceptibility and color reflectance. Various rock samples were collected by dredge observation at the Conrad Rise and the obtained materials to be used for understanding of origin of rise and tectonics in the southwest Indian Ocean. Sediment trap samples were also recovered from a site ECR-1, where is located under the biogenic silica belt south of polar front. Flux of settling particles was increased in summer, suggesting that typical seasonal change was occurred in the Southern Ocean. In addition, multichannel seismic (MCS) reflection and bathymetric survey were also done on the across transect of the deep-sea valleys off Cape Darnley, East Antarctica. By analyzing these materials and data, it is expected to advance the research leading to changes in the sedimentation process accompanying expansion and retreat of the Antarctic ice sheets and elucidation of the history of the Cape Darnley bottom water.

Keywords: Southern Ocean, paleoceanography, sea ice, Antarctic, productivity, Antarctic Bottom Water

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[J] Oral | M (Multidisciplinary and Interdisciplinary) : M-IS Intersection

Mon. May 27, 2019 10:45 AM - 12:15 PM JST | Mon. May 27, 2019 1:45 AM - 3:15 AM UTC | Convention Hall B 2F

[M-IS14] Global climate change driven by the Southern Ocean and the Antarctic Ice Sheet

convener:Osamu Seki(Institute of Low Temperature Science, Hokkaido University), Akira Oka(Atmosphere and Ocean Research Institute, The University of Tokyo), Ryu Uemura(University of the Ryukyus), Ryosuke Makabe(National Institute of Polar Research), Chairperson:Sam Sherriff-Tadano(University of Tokyo)

The Southern Ocean and Antarctic ice sheet, which are the giant reservoirs of heat, water, and materials, have a potential to play central roles in long-term global climate change. This system is composed of the following sub-systems; ice shelf which is a place of the interaction of ice sheet and ocean, flowing iceberg, seasonal sea ice zone, Antarctic bottom water which drives the thermohaline circulation, active biological production and Antarctic Circumpolar Current. These sub-systems are interacted with each other and have significant impact on changes in the global environmental system. This session aim to summarize recent observational and simulation studies from various fields relating to the past and present changes in the Antarctic Ice sheet and Southern Ocean, which are essential elements for unraveling the changes in the global climate system. Further, future science plans for understanding of the environmental changes of the Antarctic Cryosphere is also discussed.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MIS14-06] High resolution ocean temperatures reconstructions over the last glacial-interglacial in the Kerguelen region, Southern Ocean.

*Matthieu Civel[1,2], Xavier Crosta[3], Giuseppe Cortese[4], Elisabeth Michel[5], Alain Mazaud[5], Samuel Jaccard[6], Lena Thöle[6], Minoru Ikehara[1], Takuya Itaki[2] (1.Center for Advanced Marine Core Research, Kochi University, Japan, 2.Geological Survey of Japan, AIST, Tsukuba, Japan, 3.UMR 5805 CNRS EPOC, Université de Bordeaux, France, 4.GNS Science, Lower Hutt, New Zealand, 5.LSCE-IPSL, CEA-CNRS-UVSQ, 91198 Gif-sur-Yvette, France, 6.Institute of Geological Sciences & Oeschger Centre for Climate Change Research, University of Bern, Switzerland)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MIS14-07] Present-day crustal motion and gravity change in East Antarctica: implications for the mantle viscosity and Holocene Antarctic Ice Sheet change inferred from GIA modeling

*Jun'ichi Okuno[1,2], Koichiro Doi[1,2], Yuichi Aoyama[1,2], Takeshige Ishiwa[1], Akihisa Hattori[2], Yoichi Fukuda[3] (1.National Institute of Polar Research, 2.SOKENDAI, 3.Kyoto University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MIS14-08] Reconstruction of the East Antarctic ice sheet variability during the last 3 myrs in the central & eastern Droning Maud Land, East Antarctica

*Yusuke Suganuma[1,2], Moto Kawamata[2], Kota Katsuki[3], Tatsuo Kanamaru[4], Heitaro Kaneda[5], Takushi Koyama[6], Tanabe Yukiko[1,2], Daisuke Shibata[7], Takeshige Ishiwa[1], Takuya Itaki[8], Jun'ichi Okuno[1,2], Osamu Seki[9], Itsuki Suto[10], Masakazu Fujii[1,2], Hideki Miura[1,2] (1.National institute of Polar Research, 2.SOKENDAI, 3.Shimane University, 4.Nihon University, 5.Chiba University, 6.Oita University, 7.Tsukuba University, 8.GSJ, AIST, 9.Hokkaido University, 10.Nagoya University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MIS14-09] Vertical ice flow motions obtained from year-round GNSS observations on Shirase Glacier, Antarctica

*Yuichi Aoyama[1,2], Koichiro Doi[1,2], Daisuke Hirano[3], Takeshi Tamura[1,2], Shigeru Aoki[3], Kazuo Shibuya[1] (1.National Institute of Polar Research, 2.SOKENDAI, 3.Institute of Low Temperature Science, Hokkaido University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MIS14-10] Operation plan and design of the Antarctic exploration AUV "MONACA"

*Hirokazu Yamagata[1], Toshihiro Maki[1], Hiroshi Yoshida[2], Yoshifumi Nogi[3] (1.Institute of Industrial Science, The University of Tokyo, 2.Japan Marine Science and Technology Center, 3.National Institute of Polar Research)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[MIS14-11] Geophysical insights into tectonic, volcanic, sedimentation, and glacial processes in Indian and Southern Oceans: Preliminary geophysical results of R/V *Hakuho-maru* KH-19-1 cruise

*Masakazu Fujii[1], Hiroshi Sato[2], Minoru Ikehara[3], Yoshifumi Nogi[1], Taichi Sato[4], Yasuyuki Nakamura[5], Eri Helen Amsler[6], Sam Sherriff-Tadano[7] (1.National Institute of Polar Research and SOKENDAI, 2.Senshu University, 3.Kochi University, 4.AIST, 5.JAMSTEC, 6.University of Bern, 7.AORI, UTokyo)

High resolution ocean temperatures reconstructions over the last glacial-interglacial in the Kerguelen region, Southern Ocean.

*Matthieu Civel[1,2], Xavier Crosta[3], Giuseppe Cortese[4], Elisabeth Michel[5], Alain Mazaud[5], Samuel Jaccard[6], Lena Thöle[6], Minoru Ikehara[1], Takuya Itaki[2]

1. Center for Advanced Marine Core Research, Kochi University, Japan, 2. Geological Survey of Japan, AIST, Tsukuba, Japan, 3. UMR 5805 CNRS EPOC, Université de Bordeaux, France, 4. GNS Science, Lower Hutt, New Zealand, 5. LSCE-IPSL, CEA-CNRS-UVSQ, 91198 Gif-sur-Yvette, France, 6. Institute of Geological Sciences & Oeschger Centre for Climate Change Research, University of Bern, Switzerland

The Southern Ocean (SO) is a place of primordial importance to the understanding of global ocean circulation as it connects the Atlantic, the Pacific and the Indian oceans and thus actively participates in global climate changes. Climate processes and variations in the Indian sector of the SO are not as well understood as processes in the Atlantic sector. This why this project documents climate variations and migrations of the Antarctic Circumpolar Current (ACC) hydrological fronts in the Kerguelen area over the last glacial-interglacial cycle. In this study sea surface temperatures (SST) are reconstructed in two sediment cores, the MD11-3353 (PFZ) and MD12-3396CQ (SAZ), with radiolarian and diatoms microfossil assemblages. By comparing the results given by these two proxies different signals were identified for surface and subsurface waters suggesting a decoupling of these two water masses in the SAZ East of the Kerguelen Plateau. But in the PFZ, both proxies showed similar results. The comparison between these results leads us to think of an influence of lower latitudes warm water in the SAZ whereas this influence is absent in the PFZ in this region.

Keywords: Southern Ocean, Radiolarian, Diatoms, Micropaleontology, Kerguelen

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Present-day crustal motion and gravity change in East Antarctica: implications for the mantle viscosity and Holocene Antarctic Ice Sheet change inferred from GIA modeling

*Jun'ichi Okuno[1,2], Koichiro Doi[1,2], Yuichi Aoyama[1,2], Takeshige Ishiwa[1], Akihisa Hattori[2], Yoichi Fukuda[3]

1. National Institute of Polar Research, 2. SOKENDAI, 3. Kyoto University

Geodetic and geomorphological observations in the coastal part of Antarctica indicate the uplift trend associated with the removal mass of the Antarctic Ice Sheet (AIS) in the last deglaciation. The numerical calculations of crustal motion derived from the glacial isostatic adjustment (GIA) modeling have played the role of inferring the ice mass change of AIS from observations related to solid Earth deformation. The deglaciation histories of the AIS inferred from the comparisons between the geomorphological sea-level records, and GIA modeling shows the monotonic Holocene retreat for the AIS (e.g., Whitehouse et al., 2012). However, GNSS observations in some regions in the coastal part of Antarctica cannot be explained the amplitudes of the uplift by only glacial rebound due to the last deglaciation of the AIS. Also, recent studies (e.g., Kingslake et al., 2018) concerning bedrock topography in the margin of AIS inferred that some portions of the ice sheet might have re-advanced after retreating behind the present-day margin in mid-to-late Holocene. Therefore, this re-advance of AIS in Holocene may be caused to arise the mismatch between GNSS observations and numerical predictions. On the other hand, GNSS observations include not only the components of the GIA due to the last deglaciation and also elastic deformation due to present-day surface mass balance (e.g., Hattori et al., 2018). Similarly, this effect could cause a difference between the GNSS observations and the GIA calculations. In this presentation, we will show the crustal deformation rates and gravity changes calculated by the GIA modeling using the previously published deglaciation histories and the comparisons with these observations obtained from East Antarctica. We intend to discuss the influences of AIS mass changes and choice of mantle viscosity profile on the geodetic measurements in East Antarctica.

Keywords: Glacial Isostatic Adjustment, East Antarctica, GNSS, gravity change

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Reconstruction of the East Antarctic ice sheet variability during the last 3 myrs in the central & eastern Droning Maud Land, East Antarctica

*Yusuke Suganuma[1,2], Moto Kawamata[2], Kota Katsuki[3], Tatsuo Kanamaru[4], Heitaro Kaneda[5], Takushi Koyama[6], Tanabe Yukiko[1,2], Daisuke Shibata[7], Takeshige Ishiwa[1], Takuya Itaki[8], Jun'ichi Okuno[1,2], Osamu Seki[9], Itsuki Suto[10], Masakazu Fujii[1,2], Hideki Miura[1,2]

1. National institute of Polar Research, 2. SOKENDAI, 3. Shimane University, 4. Nihon University, 5. Chiba University, 6. Oita University, 7. Tsukuba University, 8. GSJ, AIST, 9. Hokkaido University, 10. Nagoya University

Reconstructing past variability of the Antarctic ice sheets is essential to understand their stability and to anticipate their contribution to future sea level rise. However, magnitude and timing of ice sheet changes during the last several million years have not been well constrained, especially in central & eastern Droning Maud Land, East Antarctica. Recently, we have carried out several field campaigns in this area to reconstruct changes in thickness, geographical extent, and timing of retreat of the East Antarctic Ice Sheet based on the detailed geomorphological survey, cosmogenic exposure dating, and lake/shallow marine sediment records coupled with glacial isostatic adjustment modeling (GIA). In this presentation, we will introduce these recent achievements from the field campaigns and discuss scientific plans for the next few seasons.

Keywords: Giant Reservoirs - Antarctic, Solid Earth

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Vertical ice flow motions obtained from year-round GNSS observations on Shirase Glacier, Antarctica

*Yuichi Aoyama[1,2], Koichiro Doi[1,2], Daisuke Hirano[3], Takeshi Tamura[1,2], Shigeru Aoki[3], Kazuo Shibuya[1]

1. National Institute of Polar Research, 2. SOKENDAI, 3. Institute of Low Temperature Science, Hokkaido University

The Antarctic ice sheet is a huge heat sink acting as a feedback controller for adjusting global warming, so a loss of its mass would cause a great impact on the global climate change. It is valuable to evaluate an Antarctic ice mass balance, which is a consequence of competition between an ice discharge and a snow accumulation. With an objective of estimating the ice discharge around Lützow-Holmbukta, East Antarctica, we have measured three-dimensional (3D) ice flow motions around a grounding line of Shirase Glacier, which is fastest and largest ice stream in Lützow-Holmbukta.

We first performed one-month GPS measurement near the calving front of Shirase Glacier in 2011/2012 austral summer. The three-dimensional position of this site was determined by the kinematic precise point positioning (kPPP) method at every 30 seconds with a 4-5-cm precision for 25 days. From the 30-s interval position, we estimated the ice flow velocity vector, the basal melting rate of the iceberg, and ocean tidal variations (Aoyama et al. 2016). Subsequently, a year-round GNSS measurement system was installed six kilometers downstream from the grounding line of Shirase Glacier at the end of Jan. 2015. By maintaining this year-round system (changing SD card and battery) every austral summer season, we have already obtained a three-years continuous data from Jan. 30, 2015 to Dec. 30, 2017.
We analyzed the time series of the three-dimensional position of this system with kPPP method. The time series revealed the ice flow motion downstream from the grounding line of Shirase Glacier during 2015-2017. Focusing on the vertical motion, there is no remarkable ocean tidal variation. And the obtained vertical flow motion shows gradually descent, then rise, again descent slope. In order to clarify whether such vertical change is local or wide area, we compared with a TanDEM-X 90m DEM (Rizzoli et al., 2017). In the presentation, we will show properties of the ice flow motion downstream the grounding line of Shirase Glacier.

Keywords: year-round GNSS measurements on Shirase Glacier, Unmanned measurement in site where access is difficult

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Operation plan and design of the Antarctic exploration AUV "MONACA"

*Hirokazu Yamagata[1], Toshihiro Maki[1], Hiroshi Yoshida[2], Yoshifumi Nogi[3]

1. Institute of Industrial Science, The University of Tokyo, 2. Japan Marine Science and Technology Center, 3. National Institute of Polar Research

Autonomous Underwater Vehicles (AUVs) have been used for under-ice explorations of the Antarctic Ocean. Most of the current under ice AUVs are large and are used for the long-distance survey. Survey results of these AUVs are extremely precise, but there is a trade-off between precision and running cost and/or risk of losing AUVs.

In this presentation, the authors propose a variable and compact AUV MONACA (Mobility Oriented Nadir AntarctiC Adventurer) which can offer the necessary and sufficient compositions for various survey needs by the modular design. Development of MONACA is supported by JSPS Grant-in-Aid for Scientific Research on Innovative Areas No.4902, to measure the sea ice/shelf ice and ocean floor for research of ice sheet-ocean interaction.

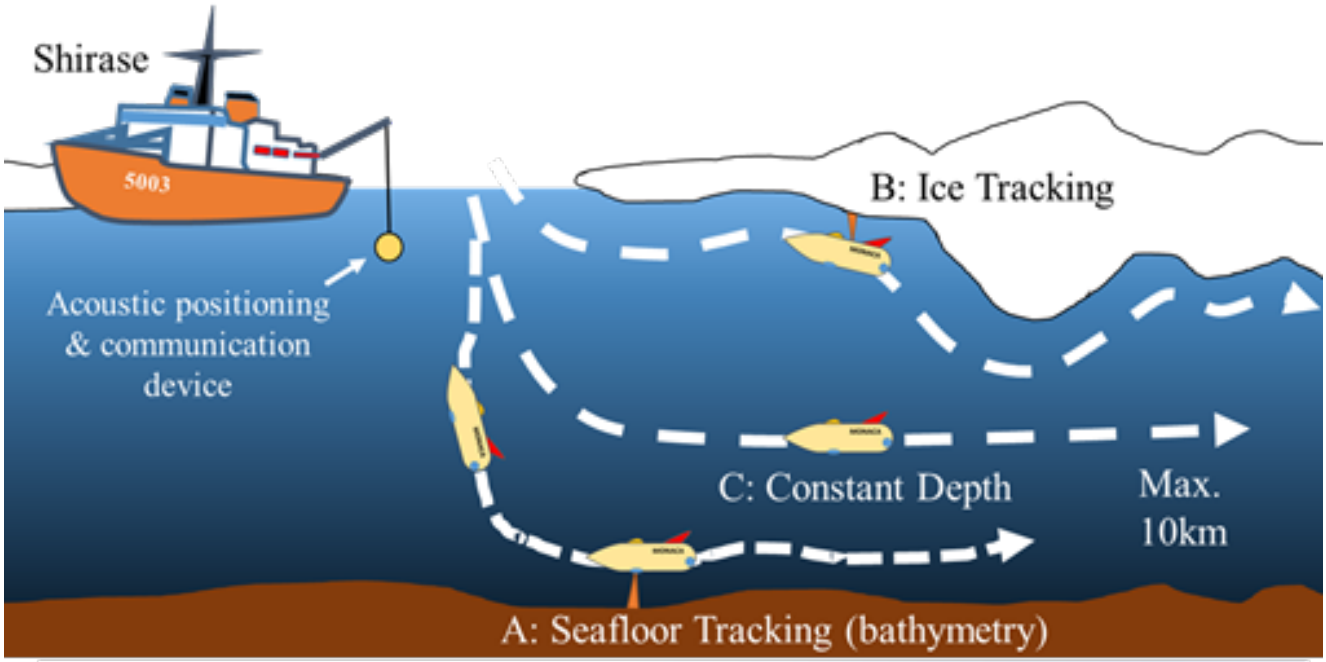
MONACA is 2 m long, 230 kg weight, and it can cruise for about 8 hours. Depth rating is 1500m. The vehicle is designed to go into ice-covered oceans as far as 10 km. The flat body is filled with buoyancy materials at the top so that the battery units and main unit can be accessed from the side. The vehicle has five degrees of freedom (surge, heave, roll, pitch, and yaw) by 4 vertical thrusters and 2 horizontal thrusters. Although the survey range is limited compared with large AUVs, it can conduct a highly precise survey with lower costs.

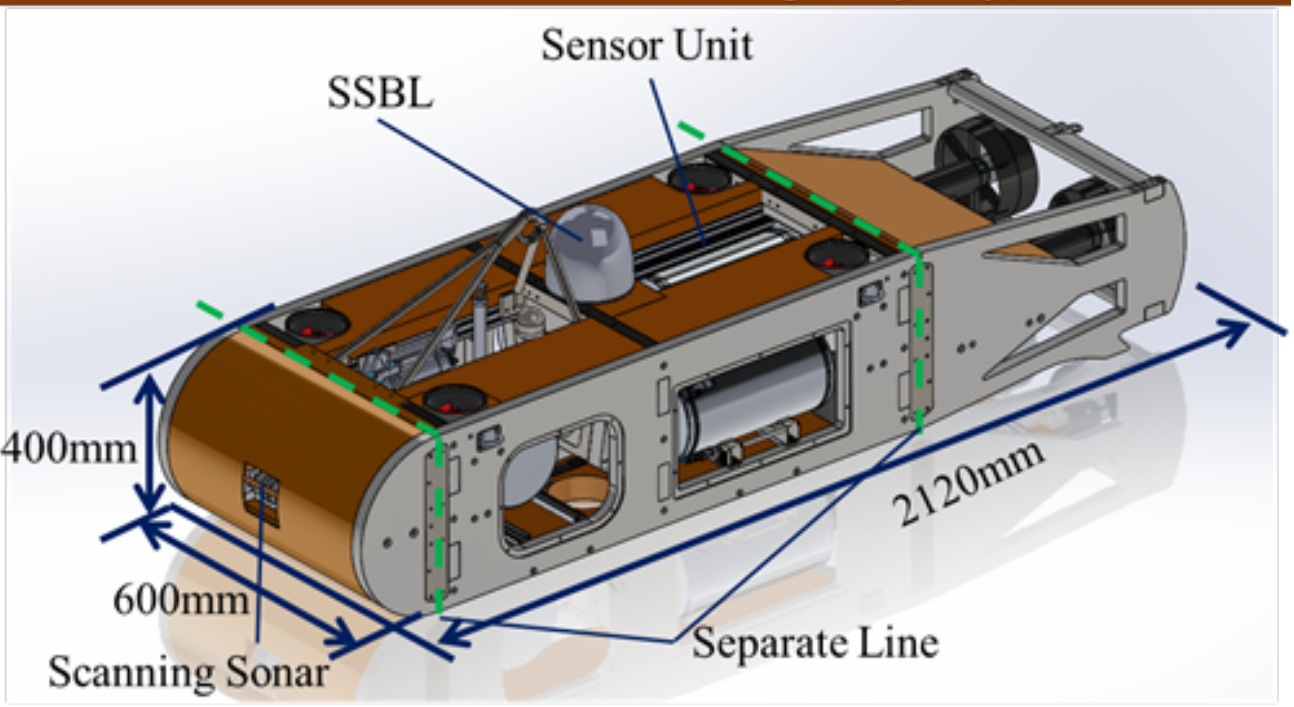
The three missions are considered as shown in the figure. (A: Seafloor tracking, B: Ice tracking, C: Water survey in constant depth). In the missions A and B, the shape of the seafloor or the ice is mapped by a multi-beam sonar while tracking it by a probabilistic approach using a scanning sonar. The multi-beam sonar measures 480 points in the swath width of 120˚. The vehicle has two set of releasable ballasts for diving and surfacing. The vehicle is designed to follow the seafloor or ice at the reference altitude of 50 m. In the mission C, the vehicle navigates at a constant depth, measuring water quality by a CTD sensor. Resolution of the CTD sensor is Temperature = +/- 0.0001 ˚C, Conductivity = +/- 0.0001 mS / cm, Depth = 0.03 m.

In order to realize these three missions under the size limitation, MONACA has the sensor unit that can be flipped upside down. The sensor unit includes the multi-beam sonar, an INS, and a DVL. Therefore, MONACA can navigate only by the sensor unit in case there are no obstacles in the seafloor.
MONACA is currently under construction, to be launched in 2019.

Keywords: Antarctic, AUV

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Geophysical insights into tectonic, volcanic, sedimentation, and glacial processes in Indian and Southern Oceans: Preliminary geophysical results of R/V *Hakuho-maru* KH-19-1 cruise

*Masakazu Fujii[1], Hiroshi Sato[2], Minoru Ikehara[3], Yoshifumi Nogi[1], Taichi Sato[4], Yasuyuki Nakamura[5], Eri Helen Amsler[6], Sam Sherriff-Tadano[7]

1. National Institute of Polar Research and SOKENDAI, 2. Senshu University, 3. Kochi University, 4. AIST, 5. JAMSTEC, 6. University of Bern, 7. AORI, UTokyo

The seafloor covers more than 70 percent of the solid-earth surface and has been progressively investigated since the 20th century, however most parts have not been explored because of observation difficulties in the ocean. Particularly, the seafloor of the Indian and Southern Oceans are expected to preserve significant records of paleo glacial processes and submarine volcanism as well as continental breakup and seafloor spreading. Here, we show new geophysical dataset just obtained during the R/V *Hakuho-maru*KH-19-1 cruise in early 2019. Underway geophysical mapping as well as multichannel reflection surveys and dredge rock samplings were conducted in this cruse. Specific scientific target area were set to 1) the Southwest Indian Ridge to reveal the seafloor spreading process in the Cenozoic era; 2) Conrad Rise to understand its origin and surrounding magmatism; 3) Del Cano Rise to reveal how it has been formed; 4) off Cape Darnley to reveal relationship between solid-earth processes and presently formed Antarctic bottom water; and 5) Southeast Indian Ridge to reveal the mid-ocean ridge oscillation. Multibeam bathymetry, total and vector magnetic fields, gravity, and sub-bottom profiler data were successfully acquired along the ship tracks which covers Fremantle to Mauritius in leg-1 (2 Jan to 11 Jan 2019) and Mauritius to Fremantle via mentioned target area in leg-2 (16 Jan to 12 Feb 2019). We overview preliminary geophysical results which were combined with previous *Hakuho-maru*cruises of KH-07-04, KH-09-05, KH-10-07, and KH-16-01 and data acquired during Japanese Antarctic Research Expedition by using Japanese icebreaker *Shirase*. Finally, we discuss geophysical insights into tectonic, volcanic, sedimentation, and glacial processes in Indian and Southern Oceans.

Keywords: Indian and Southern Oceans, Solid Earth processes, Marine geophysics, Hakuho-maru

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Mon. May 27, 2019 1:45 PM - 3:15 PM JST | Mon. May 27, 2019 4:45 AM - 6:15 AM UTC | Convention Hall B 2F

[M-IS14] Global climate change driven by the Southern Ocean and the Antarctic Ice Sheet

convener:Osamu Seki(Institute of Low Temperature Science, Hokkaido University), Akira Oka(Atmosphere and Ocean Research Institute, The University of Tokyo), Ryu Uemura(University of the Ryukyus), Ryosuke Makabe(National Institute of Polar Research), Chairperson:Takeshige Ishiwa(National institute of Polar Research)

The Southern Ocean and Antarctic ice sheet, which are the giant reservoirs of heat, water, and materials, have a potential to play central roles in long-term global climate change. This system is composed of the following sub-systems; ice shelf which is a place of the interaction of ice sheet and ocean, flowing iceberg, seasonal sea ice zone, Antarctic bottom water which drives the thermohaline circulation, active biological production and Antarctic Circumpolar Current. These sub-systems are interacted with each other and have significant impact on changes in the global environmental system. This session aim to summarize recent observational and simulation studies from various fields relating to the past and present changes in the Antarctic Ice sheet and Southern Ocean, which are essential elements for unraveling the changes in the global climate system. Further, future science plans for understanding of the environmental changes of the Antarctic Cryosphere is also discussed.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MIS14-12] Simulations of glacial ocean carbon cycle with a parameterization of stratification dependence of vertical diffusivity

*Hidetaka Kobayashi[1], Akira Oka[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MIS14-13] Impacts of precession on the periodicity of climate and AMOC variabilities

*Sam Sherriff-Tadano[1] (1.Atmosphere and Ocean Research Institute, the University of Tokyo)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MIS14-14] Warming and climate feedbacks in the southern high latitude driven by obliquity, precession-eccentricity, and atmospheric CO2

*Kanon Kino[1], Ayako Abe-Ouchi[1,2], Ryouta O'ishi[1], Fuyuki SAITO[2], Masakazu Yoshimori[1] (1.Atmosphere and Ocean Research Institute, the University of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MIS14-15] Origin of Circumpolar Deep Water intruding onto the Amundsen and Bellingshausen Sea continental shelves

*Yoshihiro Nakayama[1,2], Menemenlis Dimitris[2], Hong Zhang[2], Michael Schodlok[2], Eric Rignot[2,3] (1.Institute of Low Temperature Science, Hokkaido University, 2.NASA's Jet Propulsion Laboratory, 3.Uniersity of California, Irvine)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MIS14-16] Ocean and material circulation in the southern part of the Australian Antarctic Basin in 2018/2019 summer - preliminary results from Kaiyomaru KY18-04 cruise

*Katsuro Katsumata[1], Daisuke Hirano[2], Daiki Nomura[2], Kaihe Yamazaki[2], Yoichiro Koh[2], Masaaki Kiuchi[2], Shigeru Aoki[2], Hiroto Murase[3] (1.JAMSTEC, 2.Hokkaido Univ., 3.NRI-FSF)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MIS14-17] Mooring observation aiming direct current measurement and quantitative evaluation of Meridional Circulation of Southern Ocean

*Kitade Yujiro[1], Kohei Mizobata[1], Kazuho Watanabe[1], Linquiao Chen[3], Gaopin Guo[3], Shigeru Aoki[2], Shyuki Ushio[4], Keishi Shimada[1], Kay I. Ohshima[2] (1.Tokyo University of Marine Science and Technology, 2.Hokkaido University, 3.Shanghi Ocean University, 4.National Institute of Polar Research)

Simulations of glacial ocean carbon cycle with a parameterization of stratification dependence of vertical diffusivity

*Hidetaka Kobayashi[1], Akira Oka[1]

1. Atmosphere and Ocean Research Institute, The University of Tokyo

Paleo-ocean reconstructions supporting the Southern Ocean hypothesis, in which carbon storage in the deep Southern Ocean increases during the glacial ages, has not been sufficiently reproduced by previous paleoclimate modeling studies. In this study, we apply salinity restoring in the Southern Ocean and a parameterization of stratification dependence of vertical diffusivity to an ocean general circulation model and attempt to reproduce oceanic properties reconstructed from paleo-ocean proxy data at the Last Glacial Maximum (LGM). An LGM simulation including the salinity restoring expresses high bottom-water salinity associated with larger sea ice production at the LGM, and reproduces the reconstructed salinity distribution. Moreover, by considering the stratification dependence of vertical diffusivity in the global ocean, the reduced vertical mixing due to enhanced salinity stratification increases ventilation ages in the intermediate to the deep ocean. As a result, more carbon is stored in the deep ocean and the vertical gradient of dissolved inorganic carbon enlarges. This redistribution of carbon reduces atmospheric carbon dioxide concentration (pCO_2). In addition, the subsequent response of carbonate compensation may amplify the glacial reduction of atmospheric pCO_2. In our presentation, we plan to report the glacial variation of atmospheric pCO_2 explained by the response of the ocean carbon cycle including carbonate compensation in numerical simulations using an ocean general circulation model.

Keywords: ocean carbon cycle, glacial-interglacial cycle, global ocean meridional overturning circulation, carbonate compensation

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Impacts of precession on the periodicity of climate and AMOC variabilities

*Sam Sherriff-Tadano[1]

1. Atmosphere and Ocean Research Institute, the University of Tokyo

Over the glacial period, climate varied on centennial to millennial time scale between the warm instersadial and the cold staidial. Recent ice core and modelling studies have shown that changes in CO2 and the glacial ice sheet played a critical role in controlling the periodicity of the climate variability through affecting the Atlantic Meridional Overturning Circulation (AMOC). Here, by analysing simulation data from a climate model GFDL, it is shown that changes in insolation pattern due to changes in precession also exert a substantial impact on the periodicity of the climate and AMOC variability. Model results show that a change from a Northern Hemisphere summer solstice perihelion to winter solstice perihelion causes an increase in the periodicity of the AMOC variability from decadal to millennial. Analysis reveals that an increase of sea ice over the Northern Hemisphere and a decrease in sea ice over the Southern Ocean due to insolation changes play a role in increasing the periodicity through stabilising both the vigorous AMOC and weak AMOC. These results may have some implications in interpreting the ice core data.

Keywords: millennial time-scale climate variability, AMOC, sea ice

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Warming and climate feedbacks in the southern high latitude driven by obliquity, precession-eccentricity, and atmospheric CO2

*Kanon Kino[1], Ayako Abe-Ouchi[1,2], Ryouta O'ishi[1], Fuyuki SAITO[2], Masakazu Yoshimori[1]

1. Atmosphere and Ocean Research Institute, the University of Tokyo, 2. Japan Agency for Marine-Earth Science and Technology

Polar amplification is widely known as a major characteristic of observed and simulated global warming which induced by increasing atmospheric CO2. In the southern high latitude, a study using GCM investigated climate feedback system to reproduce the warming (Lu and Cai, 2009). A latest study of the Antarctic ice core precisely analyzed phase relationship between temperature changes in the past ages and the periodic changes in the Earth’ s orbital parameters (obliquity, precession and eccentricity (Uemura et al., 2018). In this study, we use MIROC-GCM to investigate the warming in the southern high latitude due to the orbital parameter changes, and climate feedback responses. Results are compared with the doubling CO2 experiment.
We use an AGCM with slab ocean of MIROC-GCM (Hasumi and Emori, 2004) and performed experiments with (1) large obliquity, (2) large precession and the winter solstice (austral summer) at the aphelion (Maximum values in the past ages are used). A seasonal surface feedback analysis method (Lu and Cai, 2009) is also applied.
Results show that warming on the Antarctica (covered by the ice-sheet) due to the orbital parameter change is dominated by short-wave radiation which is not interrupted by cloud, in contrast that the warming due to increasing atmospheric CO2 is dominated by downward long-wave radiation. Results also show that seasonal warming and climate feedback responses on the Southern Ocean are qualitatively common in the insolation and CO2 cases, as well as warming in the Arctic Ocean; little warming in the summer with absorption of energy and large warming in the autumn and winter with releasing of the energy. The strengths of the warming are qualitatively different whether the seasonality, especially spring and early summer, of radiative forcing is favorable for sea ice melt.
We will investigate the changes of the atmospheric circulation, precipitation, and the influence of the oceanic circulation.

Keywords: GCM, Antarctica, orbital parameter, feedback

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Origin of Circumpolar Deep Water intruding onto the Amundsen and Bellingshausen Sea continental shelves

*Yoshihiro Nakayama[1,2], Menemenlis Dimitris[2], Hong Zhang[2], Michael Schodlok[2], Eric Rignot[2,3]

1. Institute of Low Temperature Science, Hokkaido University, 2. NASA's Jet Propulsion Laboratory, 3. Uniersity of California, Irvine

Melting of West Antarctic ice shelves is enhanced by Circumpolar Deep Water (CDW) intruding onto the Amundsen and Bellingshausen Seas (ABS) continental shelves. Despite existing studies of cross-shelf and on-shelf CDW transports, CDW pathways onto the ABS originating from further offshore have never been investigated. Here, we investigate CDW pathways onto the ABS using a regional ocean model. Simulated CDW tracers from a zonal section across 67˚S (S04P) circulate along the Antarctic Circumpolar Current (ACC) and Ross Gyre (RG) and travel into ABS continental shelf after 3–5 years, but source locations are shifted westward by ~900 km along S04P in 2001–2006 compared to 2009–2014. We find that simulated on- and off-shelf CDW is ~0.1–0.2 ˚C warmer in the 2009–2014 case than in the 2001–2006 case together with changes in simulated ocean circulation. These differences are primarily caused by lateral, rather than surface, boundary conditions, implying that large-scale atmospheric and ocean circulations are able to control CDW pathways and thus off- and on-shelf CDW properties.

Keywords: Ice shelf-ocean interaction, Amundsen-Bellingshausen Sea, Circumpolar Deep Water (CDW)

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Ocean and material circulation in the southern part of the Australian Antarctic Basin in 2018/2019 summer - preliminary results from Kaiyomaru KY18-04 cruise

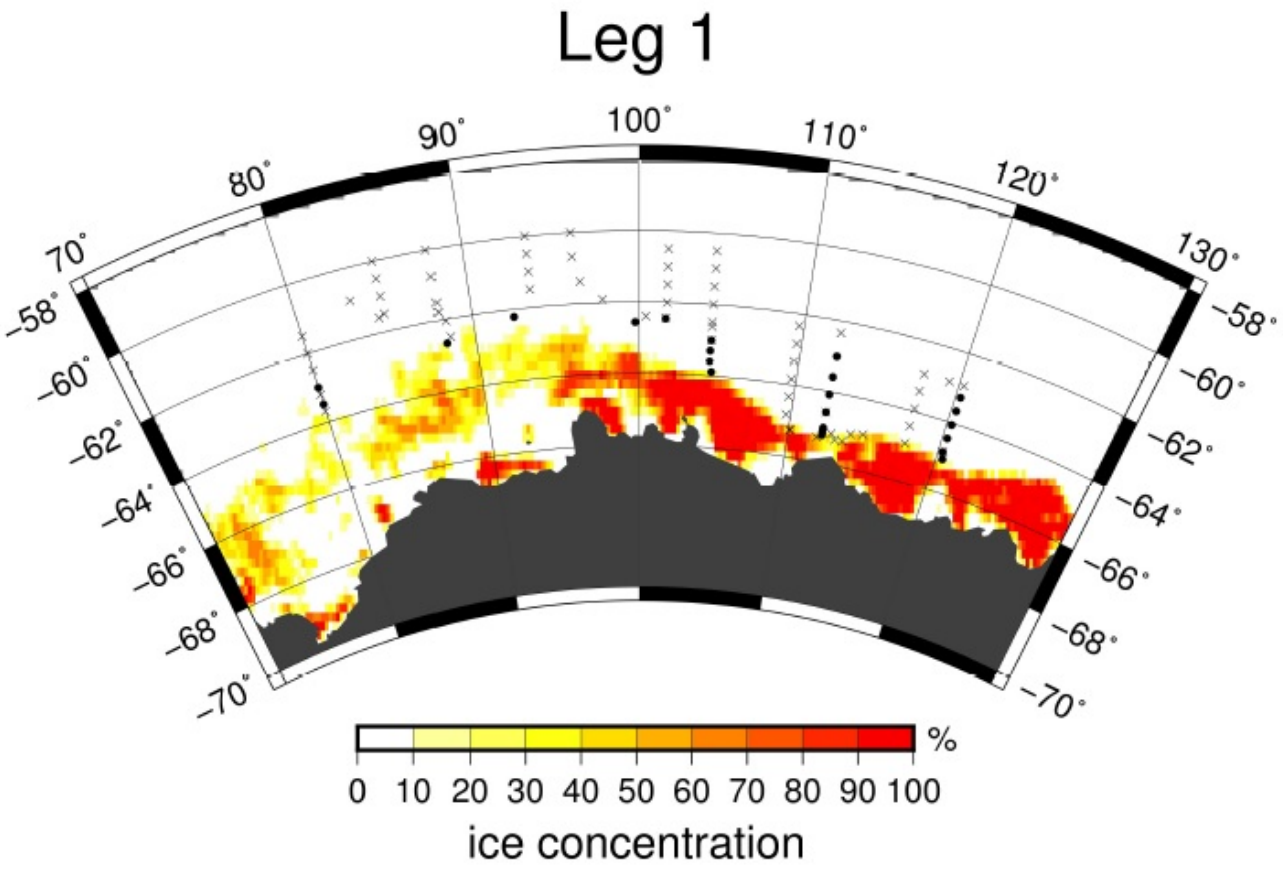
*Katsuro Katsumata[1], Daisuke Hirano[2], Daiki Nomura[2], Kaihe Yamazaki[2], Yoichiro Koh[2], Masaaki Kiuchi[2], Shigeru Aoki[2], Hiroto Murase[3]

1. JAMSTEC, 2. Hokkaido Univ., 3. NRI-FSF

The Australian Antarctic Basin collects dense shelf water from the Ross Sea and off Adelie Coast along the westward-flowing Antarctic Slope Current and modifies its property through mixing before initiating the bottom branch of the meridional overturning circulations in the Indian and Pacific oceans. It is necessary to monitor the current status of the near-bottom circulation in the basin in order to understand how the recently-reported volume decrease of the Antarctic Bottom Water and changes in the atmosphere-ocean and cryosphere-ocean interactions are related. It is established that the Southern Ocean, particularly at the north of the Antarctic Circumpolar Current (ACC), acts as a sink of anthropogenic carbon through its low surface pCO2 and mode and intermediate watermass production. Then, is the south of the ACC source or sink of anthropogenic carbon with its dense shelf water production in the face of upwelling of carbon-rich deep water masses? How do these changes in the environment affect the biosphere and ecosystem in the Southern Ocean?
With these questions in mind, R/V Kaiyomaru, Japan Fishery Agency, conducted a research cruise in the basin, in proximity of its seasonal ice edge, from December 2018 to March 2019. This part of the basin has been observed by an Australian team in 1996. At the time of writing, more than 40 stations have been occupied for CTD and LADCP observations and bottle sampling, more than 80 XCTD probes have been deployed. Preliminary analysis shows the changes in the bottom water masses. The Figure below shows the CTD/LADCP/sampling stations (black dots) and XCTD deployments (crosses) for Leg1 (5 Dec 2018 to 16 Jan 2019) with AMSR2 derived ice concentration, which is a combination of west of 90E (observed on 17 Dec 2018), between 90E and 107E (24 Dec 2018) and east of 107E (31 Dec 2018). In the talk, the latest results and its outlook will be discussed.

Keywords: Shelf circulation, Bottom water formation, carbon circulation

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Mooring observation aiming direct current measurement and quantitative evaluation of Meridional Circulation of Southern Ocean

*Kitade Yujiro[1], Kohei Mizobata[1], Kazuho Watanabe[1], Linquiao Chen[3], Gaopin Guo[3], Shigeru Aoki[2], Shyuki Ushio[4], Keishi Shimada[1], Kay I. Ohshima[2]

1. Tokyo University of Marine Science and Technology, 2. Hokkaido University, 3. Shanghi Ocean University, 4. National Institute of Polar Research

The deep Global circulation is a large-scale thermohaline circulation over the Earth and plays an important role in maintaining a stable climate.

In recent years, as rising temperature and freshening of Antarctic bottom water is being observed in various places, in order to quantitatively understand its freshening mechanism and the flow rate and change of Southern Ocean meridional circulation, We are planning to construct a large mooring observation network.

Therefore, as the first attempt, we deployed two moorings (January 2017 - January 2018) by TR/V Umitaka-maru in order to carry out direct current measurement of Meridional circulation. At the time of deployment and recovery of mooring system, we carried out CTD observation up to the sea floor along 110 ˚E line and off Vincennes Bay. At the northern edge of the seasonal sea ice zone, station KMN (60-56 S, 110-07 E, depth of water: 4180 m), we deployed five current meters, one ADP current meter, four MicroCat-CTDs and six RBR soloTs. At KMS (63 - 32 S, 108 - 02 E, depth: 3201 m) in the vicinity of the summer divergence zone, we deployed 10 MicroCats, 3 CTs sensors, 30 soloTs. Because the top buoy of the mooring system at KMN had come up to the sea surface, the two buoys were damaged due to the overhang of the sea ice in winter, but all the sensors were successfully recovered.

Mooring revealed that a flow field suggesting the structure of circulation and periodic fluctuations due to medium-scale eddies and seasonal fluctuations. In this report, we introduce the whole of the observation, the digestive result of the moored observation. The annual averages of current velocitiy [u, v (cm / s)] obtained with 5 current meters are [2.15, -1.26] at 429 db, [1.46, - 0.88] at 859 db, 0.26, -1.26 at 1918 db, [-1.32, -0.78] at 3366 db, and [-1.65, -1.77] at 4080 db. The east-west current structure shows eastward in the upper three layers and westward in the lower two layers, indicating a reasonable zonal current velocity structure. In north - south component, it is slightly larger at the lowest layer, but in other depths it shows southward flow of about 1 cm/s. The 1 cm/s agree well with the current velocity estimated form Sverdrup transport by the wind stress field in this area.

In addition, at around 400 m depth, water masses around 2 degree considered to be the Circumpolar Deep Water were distributed, and it appeared that the temperature rose synchronously with the periodic southward current. We believe that these flow velocity structures and variations are the first approximate features of the circulation of the sea area. In addition, we investigated the fluctuation of Curl of wind stress using WindSat's wind data and found periodic period fluctuations corresponding to some of current fluctuations. In this summary, only the qualitative features which are known from the preliminary report value are described, but at the time of the presentation, other mooring data will be also added and the contents which we entered into more quantitative discussion are introduced.

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Keywords: Southern Ocean, Meridional Circulation, mooring observation, wind stress

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Mon. May 27, 2019 3:30 PM - 5:00 PM JST | Mon. May 27, 2019 6:30 AM - 8:00 AM UTC | 302 3F

[M-IS15] Evolution of Pelagic Realm

convener:Atsushi Matsuoka(Department of Geology, Faculty of Science, Niigata University), Katsunori Kimoto(Japan Agency for Marine-Earth Science and Technology), Toshiyuki Kurihara(Graduate School of Science and Technology, Niigata University), Tetsuji Onoue(Earth and Environmental Sciences, Graduate School of Science and Technology, Kumamoto University), Chairperson:Atsushi Matsuoka, Toshiyuki Kurihara

This session focuses on the evolution of ecosystem in the pelagic realms,
including discussions on all aspects of pelagic biota covering biostratigraphy,
biochronology, evolution, and biogeography, which are important to the
reconstruction of the spatio-temporal framework in the pelagic realm.
Reconstructions of plate configuration through time are included in the scope of
 this session. Biological, geochemical, sedimentological approaches to the
pelagic environments are welcomed.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MIS15-01] Environmental changes of the North Pacific Ocean through the Cenozoic era recorded in DSDP/ODP pelagic clay cores

*Kazuhide Mimura[1], Katsushi Yamamoto[1], Kentaro Nakamura[1], Kazutaka Yasukawa[1,2], Junichiro Ohta[2], Koichiro Fujinaga[2,1], Shiki Machida[2], Yoichi Usui[3], Yasuhiro Kato[1,2] (1.Department of Systems Innovation, School of Engineering, the University of Tokyo, 2.ORCeNG, Chiba Institute of Technology, 3.JAMSTEC)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MIS15-02] Reconstruction of oceanic redox conditions in the Lower Jurassic (Pliensbachian–Toarcian) pelagic deep-sea bedded chert sequence of the Mino Belt, central Japan

*Katsuhito Soda[1] (1.Department of Earth and Environmental Sciences, Faculty of Science, Kumamoto University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MIS15-03] Conodont biostratigraphy of Anisian pelagic deep-sea sedimentary rocks deposited in the pelagic Panthalassa—Integration with radiolarian biozones—

*Shun Muto[1], Satoshi Takahashi[1], Satoshi Yamakita[2], Katsuhito Soda[3], Tetsuji Onoue[3] (1.Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo, 2.Faculty of Education, University of Miyazaki, 3.Faculty of Advanced Science and Technology)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MIS15-04] Triassic marine Os isotope record reconstructed from a pelagic chert succession, Sakahogi section, Mino Belt, southwest Japan

★Invited Papers

*Tatsuo Nozaki[1,2,3,4], Takashi Nikaido[5], Tetsuji Onoue[6], Yutaro Takaya[7,1,2,4], Keiko Sato[1], Jun-Ichi Kimura[8], Qing Chang[8], Daisuke Yamashita[6], Honami Sato[4,1], Katsuhiko Suzuki[1], Yasuhiro Kato[2,4], Atsushi Matsuoka[5] (1.JAMSTEC/R&D CSR, 2.Univ. of Tokyo, 3.Kobe Univ., 4.ChibaTech, 5.Niigata Univ., 6.Kumamoto Univ., 7.Waseda Univ., 8.JAMSTEC/D-SEG)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MIS15-05] The preservation of radiolarians across the Jurassic-Cretaceous (J/K) boundary in the Bosso Valley section, Central Italy

*XIN LI[1], Atsushi Matsuoka[2], Angela Bertinelli[3], Marco Chiari[4] (1.State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, 2.Niigata University, 3.Università degli Studi di Perugia, 4. Istituto di Geoscienze e Georisorse)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MIS15-06] Radiolarian faunas around the Jurassic-Cretaceous boundary in the Bosso Valley section, central Italy

*Atsushi Matsuoka[1], XIN LI[2], Marco Chiari[3], Angela Bertinelli[4] (1.Department of Geology, Faculty of Science, Niigata University, 2.Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciense, 3.C.N.R., Istituto di Geoscienze e Georisorse, sede secondaria di Firenze, 4. Dipartimento di Fisica e Geologia, Università degli Studi di Perugia)

Environmental changes of the North Pacific Ocean through the Cenozoic era recorded in DSDP/ODP pelagic clay cores

*Kazuhide Mimura[1], Katsushi Yamamoto[1], Kentaro Nakamura[1], Kazutaka Yasukawa[1,2], Junichiro Ohta[2], Koichiro Fujinaga[2,1], Shiki Machida[2], Yoichi Usui[3], Yasuhiro Kato[1,2]

1. Department of Systems Innovation, School of Engineering, the University of Tokyo, 2. ORCeNG, Chiba Institute of Technology, 3. JAMSTEC

Deep-sea sediment records paleo-environmental changes thorough geologic time. Pelagic clay, one of the most common types of deep-sea sediment, is an important medium recording changes of atmospheric/oceanic circulations and surface ocean productivity that occurred in pelagic realm [1]. Despite its importance, however, less attention has been paid to the pelagic clay than to other sediments, mainly due to the two following reasons: (1) pelagic clay lacks visible features, which hampers clarifying the stratigraphic variations within pelagic clay units, (2) determining the depositional age is very difficult due to lacks of siliceous/calcareous microfossils and difficulties in identifying paleomagnetic reversals.

Our recent studies [2,3] have shown that bulk chemical composition is a very useful tool to characterize apparently homogenous pelagic clay. We previously determined bulk geochemistry of pelagic clay samples obtained from ODP sites 1149 and 1179 in the western North Pacific Ocean [2], and compared with that from LL44-GPC3 in the central North Pacific Ocean [1]. The results indicate that pelagic clay in the North Pacific is composed of common three layers, each having characteristic major- and trace-element composition [2,3]. This suggests that the problem (1) (i.e., difficulty in stratigraphic characterization) can be solved on the basis of geochemistry. Moreover, regarding the problem (2) (i.e., difficulty in age determination), we have applied biostratigraphy of ichthyolith (microfossils of fish teeth) to constraining the depositional ages of pelagic clay at sites 1149 and 1179 [3]. These achievements suggest that the problems in using pelagic clay as a recorder of paleo-environment can be overcome.

Here, we newly determined bulk chemical compositions of pelagic clay cores at DSDP sites 576, 578 and ODP Site 886, whose depositional ages were constrained [4,5]. By combining the results with our previous data, we constructed a dataset of bulk geochemistry and depositional age of pelagic clay covering a broad area in the North Pacific Ocean. The data show that the common chemostratigraphy we have reported [2,3] is truly a general feature of pelagic clay in the North Pacific Ocean. Moreover, the integration of the geochemical features and paleogeographic reconstruction suggests that the common chemostratigraphy in the North Pacific Ocean reflects the global environmental changes through the Cenozoic era.

References: [1] Kyte et al. (1993) *Geochim. Cosmochim. Acta* **57**, 1719-1740. [2] Mimura, K et al. (2017) *JpGU Meeting 2017*. [3] Mimura, K et al. (2018) *JpGU Meeting 2018*. [4] Doyle and Riedel (1985) *Init. Repts. DSDP* **86**, 349-366. [5] Ingram (1995) *Proc. ODP* **145** 399-412.

Keywords: pelagic clay, North Pacific Ocean, chemostratigraphy, paleoenvironment, Cenozoic era

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Reconstruction of oceanic redox conditions in the Lower Jurassic (Pliensbachian–Toarcian) pelagic deep-sea bedded chert sequence of the Mino Belt, central Japan

*Katsuhito Soda[1]

1. Department of Earth and Environmental Sciences, Faculty of Science, Kumamoto University

The Pliensbachian-Toarcian interval in the Early Jurassic is characterized by a second-order marine mass extinction and remarkable worldwide palaeoenvironmental perturbations associated with the early Toarcian oceanic anoxic event (T-OAE). However, oceanic redox conditions and palaeoceanographic processes for redox sensitive elemental accumulation are unclear in the pelagic deep-sea realms of the Panthalassic Ocean. Here we show geochemical and multivariate statistical analyses in the pelagic deep-sea sedimentary rocks of the Panthalassic Ocean during the Pliensbachian-Toarcian. Three principal components (PC1, PC2, and PC3) in the redox sensitive elements explained 88.64% of the total variance. The PC1 represents the comprehensive redox variations, whose stratigraphic variations show euxinic-anoxic conditions across the Pliensbachian/Toarcian (Pl/To) boundary layer and the classical T-OAE. The PC2 depicts the sorption processes of Fe-Mn oxide minerals with transition elements, whose stratigraphic variations suggest few drawdowns of the transition elemental inventory after the Pl/To boundary layer. The PC3 delineates the active particulate shuttles by Fe (-Mn) oxide minerals, whose stratigraphic variations indicate the strong activation between the Pl/To boundary layer and the classical T-OAE. The statistical extraction of both the PC1 and the PC3 support the characteristic phenomena in the pelagic deep-sea realms of the Panthalassic Ocean under the relatively strong reductive conditions.

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Conodont biostratigraphy of Anisian pelagic deep-sea sedimentary rocks deposited in the pelagic Panthalassa—Integration with radiolarian biozones—

*Shun Muto[1], Satoshi Takahashi[1], Satoshi Yamakita[2], Katsuhito Soda[3], Tetsuji Onoue[3]

1. Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo, 2. Faculty of Education, University of Miyazaki, 3. Faculty of Advanced Science and Technology

The age of pelagic Panthalassic deep-sea sedimentary rocks such as bedded chert and claystone has been assigned based on radiolarian biozones. However, Middle Triassic radiolarian biozones of pelagic Panthalassic deep-sea strata are not precisely correlated to the standard geological timescale. In order to establish a direct correlation between the pelagic Panthalassic radiolarian biozones and the standard geological timescale, we investigated conodont biostratigraphy in two radiolarian-controlled bedded chert sections of Anisian age: the Ajiro Island section in Oita Prefecture and the Kurusu section in Aichi Prefecture. We recognised six conodont biozones in the studied sections: the upper Olenekian *Novispathodus brevissimus-Icriospathodus collinsoni* and *Triassospathodus homeri* Zones, the lower Anisian *Chiosella timorensis* Zone, the middle Anisian *Paragondolella bulgarica* Zone, the upper Anisian *Paragondolella excelsa* Zone and the uppermost Anisian to lowermost Ladinian *Paragondolella trammeri* Zone. Based on the recognition on these conodont zones, we reassessed the age of the Triassic radiolarian biozones defined by Sugiyama (1997, *Bull. Mizunami Foss. Mus.*, vol. 24, p. 79–193). Sugiyama’ s radiolarian TR 1 Zone, previously considered to be of Olenekian age, extends to the middle Anisian. The TR 2A Zone, the TR 2B Zone and the lower part of the TR 2C Zone are correlated to the middle Anisian, while the upper part of the TR 2C Zone and the lower part of the TR 3A Zone are correlated to the upper Anisian. The upper part of the TR 3A Zone and the lower part of the TR 3B Zone are probably correlative to the uppermost Anisian, but the possibility that they are correlative to the lowermost Ladinian cannot be ruled out.

Keywords: bedded chert, microbiostratigraphy, Jurassic accretionary complex

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Triassic marine Os isotope record reconstructed from a pelagic chert succession, Sakahogi section, Mino Belt, southwest Japan

*Tatsuo Nozaki[1,2,3,4], Takashi Nikaido[5], Tetsuji Onoue[6], Yutaro Takaya[7,1,2,4], Keiko Sato[1], Jun-Ichi Kimura[8], Qing Chang[8], Daisuke Yamashita[6], Honami Sato[4,1], Katsuhiko Suzuki[1], Yasuhiro Kato[2,4], Atsushi Matsuoka[5]

1. JAMSTEC/R&D CSR, 2. Univ. of Tokyo, 3. Kobe Univ., 4. ChibaTech, 5. Niigata Univ., 6. Kumamoto Univ., 7. Waseda Univ., 8. JAMSTEC/D-SEG

Pelagic cherts preserved in accretionary complexes represent former seafloor sediment that can retain geochemical evidence of paleoceanographic conditions that predate the oldest extant oceanic crust. The ratio of Os isotopes in seawater, in particular, is of wide interest as a source of insight into notable geologic events such as oceanic anoxic events, rapid global warming episodes, and eruption of large igneous provinces, but marine Os isotope records from before 80 Ma are scarce. We present a record of secular variations of marine Os isotope ratios from a thick, continuous succession of Middle and Upper Triassic pelagic chert in the Sakahogi section of the Mino Belt accretionary complex.

Keywords: Chert, Re-Os isotope, Triassic, Accretionary complex, Mino Belt, Southwest Japan

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The preservation of radiolarians across the Jurassic-Cretaceous (J/K) boundary in the Bosso Valley section, Central Italy

*XIN LI[1], Atsushi Matsuoka[2], Angela Bertinelli[3], Marco Chiari[4]

1. State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, 2. Niigata University, 3. Università degli Studi di Perugia, 4. Istituto di Geoscienze e Georisorse

The Bosso Valley section is located near the Pianello-Cagli road and follows the Bosso River in the Umbria-Marche area of the Central Italy. The pronounced increase in abundance of *Calpionella alpina* documented at the base of *Calpionella* zone was accepted as the Jurassic–Cretaceous boundary (JKB) indicator in the Bosso Valley section. The magnetostratigraphical record of the JKB has been correlated with the *Calpionella* zone. The JKB is placed between Beds 77 and 78 (Housa et al. 2004). The Maiolica Formation, which crosses the JKB, is characterized by whitish, beige to gray colored, well-bedded limestones with abundant black to gray chert layers and chert nodules and marly intervals. Certain horizons in the Bosso Valley section yield well-preserved radiolarians, significant for the correlation of deep marine sediments. In order to establish radiolarian biostratigraphy across the JKB, detailed study was conducted to elucidate relationship between lithology and preservation of radiolarians in the Bosso Valley section.

Thin sections of 19 samples were observed to elucidate the relationship between lithology and preservation of radiolarians. Three samples of micritic limestone below the JKB (Beds 73, 75, and 77) and two samples above the JKB were collected for analyzing. The limestone samples were immersed in 10% hydrochloric acid for 30 to 60 minutes, then washed, dried and examined under a binocular microscope and a scanning electron microscope.

Radiolarians are abundant both in the chert bands or nodules and in the limestone. Preservation of radiolarians varies in different parts because of the diagenesis. Surfaces of etched limestone are observed and divided into different parts, based on the preservation of radiolarians. Radiolarians are generally calcified in the pure lime beds. Radiolarians are generally bad preserved in the chert bands or nodules. Well-preserved radiolarians are located inside the lime part near the chert bands or nodules. Primary results of radiolarian assemblages near the JKB are proposed. Limestones near chert layers or nodules in the Bosso Valley section enable radiolarian biostratigraphic study across the JKB.

Keywords: preservation, radiolarians, Jurassic-Cretaceous (J/K) boundary

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Radiolarian faunas around the Jurassic-Cretaceous boundary in the Bosso Valley section, central Italy

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The Global Boundary Stratotype Section and Point (GSSP) of the Jurassic–Cretaceous boundary (JKB) is the last among the GSSPs in the Phanerozoic. It is defined as the base of the Berriasian Stage. The formal definition was decided in 2016 to use the base of the *Calpionella alpina* Subzone as the primary marker by the Berriasian Working Group in the International Subcommission on Cretaceous Stratigraphy. The definition is satisfactorily applicable for shallow marine deposits within the western Tethys, north Atlantic and central-south America. Unfortunately, the primary marker taxon cannot be found in the Pacific and circum-Pacific regions because of the limited distribution of *Calpionella*. To determine the base of the Berriasian outside of the *Calpionella* territory, alternative markers are needed.

Radiolarians are good candidates for defining the JKB because they are wide spread and can be found both shallow and deep sedimentary facies. Pelagic sequences across the JKB have been reported in ODP/IODP sites in the western Pacific and land sections in Japan, the Philippines, southern Tibet, Iran and others. Evolutionary lineages of several radiolarian taxa across the JKB are reviewed and suitable bioevents, which are approximate to the JKB, are presented. The *Loopus–Pseudodictyomitra* lineage can be the most important phylogeny for defining the JKB.

The Bosso Valley section in Umbria–Marche, central Italy, is one of potential candidates for GSSP of the JKB. The Maiolica Formation, which crosses the JKB, is characterized by whitish, beige to gray colored, well-bedded micritic limestones with abundant black to gray chert layers and nodules. Calpionellid stratigraphy and magnetostratigraphy have been studied sufficiently in the section. The base of the *Calpionella alpina* Subzone, i.e. the JKB, is placed between Beds 77 and 78. We carried out detailed field observations and careful sample collections in a 4-m interval across the JKB. Acid-etched examination of rock samples revealed that well-preserved radiolarians are recognized inside the lime part near the chert layers or nodules. Several samples of micritic limestone below and above the JKB yield well-preserved radiolarians. The result of radiolarian faunal analysis in the Bosso Valley section is presented.

Keywords: Jurassic–Cretaceous boundary , GSSP, Radiolaria

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Mon. May 27, 2019 9:00 AM - 10:30 AM JST | Mon. May 27, 2019 12:00 AM - 1:30 AM UTC | 201B 2F

[M-IS17] History X Earth and Planetary Science

convener:Yasuyuki Kano(Earthquake Research Institute, The University of Tokyo), Kei Yoshimura(Institute of Industrial Science, The University of Tokyo), Hiroaki Isobe(Faculty of Fine Arts, Kyoto City University of Arts), kiyomi iwahashi(National Institute of Japanese Literature), Chairperson:Yasuyuki Kano(東京大学 地震研究所), Kiyomi Iwahashi, Hiroaki Isobe, Kei Yoshimura, Harufumi Tamazawa

The history of modern observation in earth and planetary sciences is often far shorter compared with the timescales of their interests. Investigation of the long-term variations and occurrences of extremely rare events requires effective use of information before modern observations. Historical documents recorded by diverse kinds of authors in various situations are the important sources of such information.

Thus, historical documents have been referred in various fields of earth and planetary sciences such as seismology, climatology, meteorology and astronomy. Sharing their records, methods and experiences will be beneficial for each field and bring new insights. It is also essential to involve experienced scholars in history because one needs to carefully investigate the reliability and the context of each document in order to use it as scientific data. On the other hand, analyzing the record in the historical documents with the eyes of modern science may also bring new insights to the history scholars.

In this session we overview the studies using the historical documents in various fields of the earth and planetary sciences as well as the recent advances in related topics such as digital humanities and historical-data assimilation. The aim is to promote the communication and dialogues among the researchers in various background, and thus foster the new ideas and collaborations in the study of "History X EPS."

9:00 AM - 9:05 AM JST | 12:00 AM - 12:05 AM UTC

Introduction

9:05 AM - 9:30 AM JST | 12:05 AM - 12:30 AM UTC

[MIS17-01] Document based reconstruction of environment of forests in the Edo period

★Invited Papers

*SATOSHI SHIROUZU[1] (1.Chuogakuin University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[MIS17-02] Studies of Babylonian Astronomical Diaries: Today and the Future

*Yasuyuki Mitsuma[1] (1.The University of Tokyo)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[MIS17-03] Characteristics of the Sunspots that Produce Large Solar Flares and the Possibility to Investigate these Events Utilizing Historical Observational Records

*Shin Toriumi[1] (1.National Astronomical Observatory of Japan)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[MIS17-04] An Approach of Environmental History to the "14th Century Crisis"

*Isahaya Yoichi[1] (1.Slavic-Eurasian Research Center, Hokkaido University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[MIS17-05] Recovery of the Asian monsoon variations since the late 19th century by the data rescue activities in ACRE-Japan

*Jun Matsumoto[1,2], Tomoshige Inoue[1], Fumiaki Fujibe[1], Jun-Ichi Hamada[1], Taiichi Hayashi[3], Toru Terao[4], Fumie Murata[5], Hisayuki Kubota[6], Ikumi Akasaka[7], Hirotaka Kamahori[8], Nobuhiko Endo[9], Haruhiko

Yamamoto[10], Shigeru Kobayashi[11], Yoshitaka Muraji[12] (1.Deaprtment of Geography, Tokyo Metropolitan University, 2.Department of Coupled Ocean-Atmosphere-Land Processes Research, 3.Kyoto University, 4.Kagawa University, 5.Kochi University, 6.Hokkaido University, 7.Senshu University, 8.Meteorological Research Institute, 9.NARO/NIAES, 10.Yamaguchi University, 11.Osaka University, 12.EScoT)

Document based reconstruction of environment of forests in the Edo period

*SATOSHI SHIROUZU[1]

1. Chuogakuin University

Edo period is sometimes praised as the people had lived sustainably in harmony with nature. However, the people not necessarily lived sustainably. For example, excess usage of natural resources leaded to exhaustion of the resources.

There is a category of historical document called “O-Hayahi-Kakiage-Cho” or register of official forests. The “O-Hayashi” or the official forest is a forest controlled by Tokugawa shogunate or local feudal government, which could not be used by ordinary people. Maintenance of the forest was assigned to local people, “O-Hayashi-Mori” who made the register. The register contains the data such as kind or name, thickness, highlight, and number of woods. While the register itself is boring document for historians, it is a mine of data for dendrologists. The register describes a condition of the forest over a few hundred years ago, which helps dendrologists to reconstruct the environment of the forests. Dr. Yasuhiro Koyama showed that most of the official forest in northern part of Shinano province, or Nagano Prefecture, were sparse woods with Japanese red pine of 20-30 cm diameter. The official forests in the region were not green nor rich. By contrast, “Sendou-O-Hayashi” in the same region corresponds to Sakae village showed totally different environment. The forest had a spread of 13.5 ha. 70% of the woods were Japanese oak and beech. There were over 56 woods with diameter of 2 m. 1615 of woods had circumference over 3 m which corresponds the definition of “giant tree” by Ministry of the Environment. The forest was the one with a grade of Natural monuments today. It is surprising that there was such a rich forest in Japan only 200 years ago. Natural environment of Japan seemed to foster the rich forests. The rich forests have been lost because of deforestation by human. This is a good example to show the importance of human activities on condition of natural environment.

Rapid deforestation at nonofficial forests leads to exhaustion of useful woods. All the useful woods such as Japanese cedar and arborvitae had been cut down around Akiyama district until late 19 century. A historical document reported that only useless woods such as Japanese beech, oak, or chestnut remained. The people of Akiyama district demanded conifers to make wooden products such as bucket. After difficulty to obtain material, people changed their mind to use broadleaf trees and started to make bowl and plow etc. The useless woods turned to main material for production. Although they overcame the difficulty, they continued deforestation as they wrote on a document that the desire of human was limitless.

Incorrect or false descriptions are found from the close examination of the registers. There are same numbers of woods on registers recorded at different time. The person in charge seemed to alter the number for fear of meeting criticism for insufficient management. This example shows that historical records are product of “human.” The true value of historical science is to reveal the activity and society of human. The examination of historical documents on the assumption of the human nature or the procedure of information evaluation increase the value of the historical documents as data.

Keywords: history, forests, environment

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Studies of Babylonian Astronomical Diaries: Today and the Future

*Yasuyuki Mitsuma[1]

1. The University of Tokyo

The presenter uses a large group of Akkadian cuneiform texts on clay tablets, the Astronomical Diaries from ancient Babylonia (mainly from Babylon) as the main source of his presentation. The text group is called ADB in this presentation. ADB is a large series of clay tablets recording astronomical and meteorological phenomena, commodity prices, level of the Euphrates, and historical events from the seventh to the first centuries BC. The clay tablets of ADB count up to over 1500, but only about 400 tablets have been published for the use of researchers. The presenter stayed in London for two years and consulted and photographed most of the unpublished tablets of ADB, which are now preserved in the British Museum. He also took photos of a considerable amount of published ADB tablets. Basesd on the photos and additional data of ADB tablets, the presenter will publish the (new and more exact) texts of published and unpublished ADB tablets. The presenter will also colloborate with some researchers and provide them with the astronomical and meteorological data of ADB, which are useful for the restoration of the ancient astronomical phenomena and climate.

Keywords: Babylonian Astronomical Diaries, Babylon, Cuneiform Scripts

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Characteristics of the Sunspots that Produce Large Solar Flares and the Possibility to Investigate these Events Utilizing Historical Observational Records

*Shin Toriumi[1]

1. National Astronomical Observatory of Japan

Solar flares are the sudden releasing of magnetic energy and, among them, the energetic ones that occur around the sunspot regions may directly and indirectly affect the Earth through the enhancement of electromagnetic waves, releasing of high energy particles, and coronal mass ejection. While it is accepted that the strongest flare activity ever observed is the "Carrington event" in September 1859, in order to understand the mechanisms and trends of such extreme space-weather events, it is crucial to increase the sample number of the events with enough observational data and conduct statistical investigations. Although often these events do not have observations of sufficient data quality for modern scientific analysis, there are several ways to elucidate how and why the strong events occurred. In this presentation, we first show the morphological and magnetic characteristics of flare-productive sunspots that are revealed by observational data analysis of sunspots in Solar Cycle 24 (especially for six years from 2010) and by magnetohydrodynamic simulations to model these sunspots. Then, we introduce several research attempts to reconstruct magnetic activities by using historical documents such as sunspot drawings. Finally, we discuss the the possibility to investigate extreme space-weather events by applying our modern knowledge of flare-productive sunspots to extreme events in history.

Keywords: Solar flares, Sunspots, Historical documents

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An Approach of Environmental History to the "14th Century Crisis"

*Isahaya Yoichi[1]

1. Slavic-Eurasian Research Center, Hokkaido University

This paper is an introduction to an approach of environmental history to the “14th Century Crisis.” The “14th Century Crisis” is the term for collective peril in the 14th century which is considered to be the time of transition from the Medieval Warm Period (ca. 1000–1300) to the Little Ice Age. The peril consists of cooling, natural disasters, epidemics and political upheaval such as the fall of the Mongol Empire (1206–1368). Our project embarks upon interdisciplinary collaboration between sciences (astronomy, meteorology, and seismology) and humanities (history and archival science) to elucidate an actual phase of the crisis. In the context of world history, the “14th Century Crisis” has attracted scholarly attention as the pivot that closed the multi-centered “13th Century System” across Afro-Eurasia, and paved the way for the European-centered “Modern World-System.” The grand shift, however, could not be calibrated properly without taking account of the environmental transition to the Little Ice Age. This is an introductory remark of our project aiming to shed some new light upon entangled relationships between human development and environment.

Keywords: 14th Century Crisis, Environmental History, Little Ice Age, Medieval Warm Period, History of Eurasia, Mongol Empire

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Recovery of the Asian monsoon variations since the late 19th century by the data rescue activities in ACRE-Japan

*Jun Matsumoto[1,2], Tomoshige Inoue[1], Fumiaki Fujibe[1], Jun-Ichi Hamada[1], Taiichi Hayashi[3], Toru Terao[4], Fumie Murata[5], Hisayuki Kubota[6], Ikumi Akasaka[7], Hirotaka Kamahori[8], Nobuhiko Endo[9], Haruhiko Yamamoto[10], Shigeru Kobayashi[11], Yoshitaka Muraji[12]

1. Deaprtment of Geography, Tokyo Metropolitan University, 2. Department of Coupled Ocean-Atmosphere-Land Processes Research, 3. Kyoto University, 4. Kagawa University, 5. Kochi University, 6. Hokkaido University, 7. Senshu University, 8. Meteorological Research Institute, 9. NARO/NIAES, 10. Yamaguchi University, 11. Osaka University, 12. EScoT

In most of the countries in monsoon Asia, the meteorological observations by modern instruments started during their colonial period before the World War II. However, most of these old meteorological data have not been digitized yet, and have not been utilized in the past climatic change researches. Here, we will briefly introduce our recent data rescue activities mainly for the daily precipitation data in the Former British India, China, Philippines, Vietnam, and Japan for the recovery of the past Asian monsoon variations since the late 19th century as one of the activities in the ACRE (Atmospheric Circulation Reconstruction over the Earth) project. Although with the aid of the World Meteorological Organization, the National Oceanic and Atmospheric Administration archived the scanned images of huge data books all over the world, it was sometimes very difficult to read the numerals in the scanned data. The original data books/sheets are needed for the accurate digitization of the old data. Acknowledgments: Part of this study was supported by The JSPS KAKENHI (25282085,26220202,15K16283,18K19951, 18H01681), The GRENE program of the MEXT. Digitization activities of the former British India were supported by Drs. Shoichi Shige (Kyoto Univ.), Masashi Kiguchi (Univ. Tokyo), Hironari Kanamori (Nagoya Univ.), and Nozomi Kamizawa(Tokyo Metrop Univ.). They were also supported from the India Meteorological Department, the Indian Institute of Tropical Meteorology and Indian students in Pune.

Keywords: Data rescue, Precipitation, Climatic variations, Asian monsoon

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Mon. May 27, 2019 10:45 AM - 12:15 PM JST | Mon. May 27, 2019 1:45 AM - 3:15 AM UTC | 201B 2F

[M-IS17] History X Earth and Planetary Science

convener:Yasuyuki Kano(Earthquake Research Institute, The University of Tokyo), Kei Yoshimura(Institute of Industrial Science, The University of Tokyo), Hiroaki Isobe(Faculty of Fine Arts, Kyoto City University of Arts), kiyomi iwahashi(National Institute of Japanese Literature), Chairperson:Hiroaki Isobe, Kei Yoshimura, Kiyomi Iwahashi, Yasuyuki Kano(東京大学 地震研究所), Harufumi Tamazawa

The history of modern observation in earth and planetary sciences is often far shorter compared with the timescales of their interests. Investigation of the long-term variations and occurrences of extremely rare events requires effective use of information before modern observations. Historical documents recorded by diverse kinds of authors in various situations are the important sources of such information.
Thus, historical documents have been referred in various fields of earth and planetary sciences such as seismology, climatology, meteorology and astronomy. Sharing their records, methods and experiences will be beneficial for each field and bring new insights. It is also essential to involve experienced scholars in history because one needs to carefully investigate the reliability and the context of each document in order to use it as scientific data. On the other hand, analyzing the record in the historical documents with the eyes of modern science may also bring new insights to the history scholars.
In this session we overview the studies using the historical documents in various fields of the earth and planetary sciences as well as the recent advances in related topics such as digital humanities and historical-data assimilation. The aim is to promote the communication and dialogues among the researchers in various background, and thus foster the new ideas and collaborations in the study of "History X EPS."

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MIS17-06] Historical big data: integrated analysis of the past world by the workflow that bridges data structuring gaps

*Asanobu Kitamoto[1,2,3], Mika Ichino[1,2] (1.National Institute of Informatics, 2.ROIS-DS Center for Open Data in the Humanities, 3.SOKENDAI)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MIS17-07] Felt earthquakes in Tokyo (Edo) based on historical daily records and seismic intensity data

*Kenji Satake[1] (1.Earthquake Research Institute, University of Tokyo)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MIS17-08] Climate and social changes in ancient Japan construed by use of high resolution reconstruction of the Climate in Historical Time

*Katsunori IMAZU[1], Takeshi Nakatsuka[2] (1.OKAYAMA University Graduate School of Humanities and Social Sciences, 2.Research Institute for Humanity and Nature)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MIS17-09] Absolute ages for huge eruptions of Towada Caldera and Baitoushan volcano in the 10th century as seen from dendrochronological studies and historical documents

*Masataka Hakozaki[1], Fusa Miyake[2], Masaki Sano[3], Katsuhiko Kimura[4], Toshio Nakamura[2], Mitsuru Okuno[5], Minoru Sakamoto[1], Takeshi Nakatsuka[6,2] (1.National Museum of Japanese History, 2.Nagoya University, 3.Waseda University, 4.Fukushima University, 5.Fukuoka University, 6.Research Institute for Humanity and Nature)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MIS17-10] How can we activate collaborations with history and archaeology? – Lesson from Historical Climate Adaptation project

★Invited Papers

*Takeshi Nakatsuka[1,2] (1.Research Institute for Humanity and Nature, 2.Graduate School of Environmental Studies, Nagoya University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

Discussion

Historical big data: integrated analysis of the past world by the workflow that bridges data structuring gaps

*Asanobu Kitamoto[1,2,3], Mika Ichino[1,2]

1. National Institute of Informatics, 2. ROIS-DS Center for Open Data in the Humanities, 3. SOKENDAI

1. Introduction

Reconstruct and analyze the past world through the extraction and integration of information from the past books and documents –we call this type of historical research as “historical big data.” This is because this approach has the same structure and purpose with “modern big data” on the current world, and it is meaningful to extend this approach into the past world. A big obstacle, however, is in data structuring. We start from data written in Kuzushiji (cursive scripts) on historical documents to high quality data usable for computaitonal analysis of the past world. For this purpose, we need information infrastructure to support this long data structuring workflow from digitzation to quality control. Because this is difficult to automate, we need efficient data structuring workflow based on human-machine collaboration. We therefore design a workflow to convert non-structured data (e.g. image and text) to structured data (analysis-ready data) and develop information platform for humanities dataset that is reusable and verifiable.

A similar but bigger project has started in EU called “Time Machine Flagship” involving more than 200 organizations. The project is building “time machine” to move freely within spatio-temporal space, especially within the big data of cities such as Venice in Italy and Amsterdam in the Netherlands. This trend has not been incorporated in Japan and Asia, so our platform may also be an entry point for this global initiative.

2. Issues

Many research projects for reconstructing the past have been carried out, but historical big data is a different approach in terms of the following.

First, the type of data is different. For example, paleoclimate research uses any data related to climate; not only books and documents, but also traces in the nature (proxy data such as ice core and growth ring). On the other hand, historical big data limits its scope on records written by human, and focuses on developing new data structuring workflow including the interpretation of textual records.

Second, the target of discipline is different. Research in one discipline had a tendency of focusing only on a limited type of phenomena, and did not pay attention to other phenomena. Even when researchers are studying the same diary, bibliographic data or extracted data were not shared across research groups, and many researchers repeated similar tasks again and again. To solve this problem, historical big data offers data structuring workflow that is effective across disciplines, and enables research that takes advantage of data sharing.

3. Data crossing and re-interpretation

To extend the modern big data into the past, relevant issues are not only the extension of technologies

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but also concepts and methodologies.

First, data crossing is a methodology to overlay different data to find unexpected relationship. A typical example is a map. By registering and overlaying data from different sources, we can take actions based on insights obtained from data. Here important challenges include the interoperability of API and sharing of terminology. To solve this challenge, we share future challenges within our research group, take advantage of the strength of each member without overlapping tasks, and develop information infrastructure maximizing the outcome within limited resources.

Second, data re-interpretation is a methodology to find effective reuse of data collected for one purpose into another purpose. A famous example in the modern big data is the case of reusing car probe data for the map showing passed routes after earthquake disasters. A same approach should be effective for historical big data. For example, is it possible to use the change of bureaucrat's directories for evaluating societal impact by climate change? Flexible imagination may lead to the creative usage of data.

4. Beyond “One Bed Multiple Dreams”

Historical big data is a multidisciplinary research. Of course, a big gap exists between humanities and science/technology, but difference within science and technology disciplines are not negligible. How to go beyond these gaps? Our basic idea is to recognize that we are in “one bed multiple dreams” situation in the sense that each member in the research group has a different dream. But at the same time, we recognize the advantages of being in one bed. For example, data and tools can be shared even if we have different dreams. After maximizing the advantages of sharing, an individual researcher tackles the reconstruction of a different part of the past world –this is the concept of historical big data research.

Keywords: Historical big data, Paleoclimate, Data structuring, Information infrastructure, Multi-disciplinary research , Historical documents

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Felt earthquakes in Tokyo (Edo) based on historical daily records and seismic intensity data

*Kenji Satake[1]

1. Earthquake Research Institute, University of Tokyo

There have been three generations of collection and publication of historical materials on earthquakes. They are “Dai-Nihon Jishin Shiryo (Collection of Historical Documents on Earthquakes in Great Japan)” in 1904, “Zotei Dai-Nihon Jishin Shiryo” and “Nihon Jishin Shiryo” in 1941-1951, and “Shinshu Nihon Jishin Shiryo” in 1981-1991. On the basis of these collected materials, annual number of felt earthquakes in Tokyo (formerly Edo) was examined by Usami (1979, CCERP report) and Usami and Watanabe (2005, 2006, Historical Earthquakes). Number of felt earthquakes strongly depends on the available materials. The above collections contains some daily records of clans which documented daily weather and earthquakes, and the recorded earthquakes include small shocks or aftershocks of large damaging earthquakes. In order to discuss temporal changes of seismicity, such homogeneous records should be used. In this study, number of yearly earthquakes in several daily records are counted, and compared with seismic intensity data of Japan Meteorological Agency since 1885.

Among the daily records during the Edo period (1603-1867), “Tsugaru-han On-nikki” recorded the largest number of felt earthquakes; approximately 1550 events during 200 year period between 1668 and 1866. However, there are several years during which no earthquake was documented. The next one is “Sakaki-bara Nikki”, which documented approximately 700 events during 200 year period between 1651 and 1859. This record also contains years without any earthquake, but such years are different from those of the previous record. By merging these two daily records, there are only few years without felt earthquakes. For the earlier Edo period, “Edo-bakufu Nikki” (two different sources) cover more or less continuously from 1631 to 1707 with 680 earthquakes. In addition, several other records such as “Tsushima-han Mainichiki”, “Inaba-shi Eidai Nikki” or “Sakai-ke Shiryo” each documented more than 100 earthquakes. Yearly number of earthquakes were counted for each record, and the largest number for each year was selected. The dataset thus made contain nearly 2500 earthquakes for 241 year period (1628-1868) with annual average of about 10 events. The yearly record has several peaks in 1704 (about 60 events), in 1855 (about 50 events) and in 1649 (about 50 events). These represent aftershocks of the 1703 (31 December) Kanto earthquake, 1855 Edo earthquake and two M7 earthquakes in 1649.

Seismic intensity data since 1885 has been complied by JMA (Ishigaki and Takagi, 2000, Quarterly J. Seismology; Ishigaki, 2007, ibid), which shows that the annual number of earthquakes with intensity 1 or larger, 2 or larger, 3 or larger are 52, 16 and 5, respectively. If we assume that the seismic intensity rate is constant in the last 400 years, then the above merged historical daily data recorded felt earthquakes with intensity 2 or larger. The JMA data show that the largest number of felt earthquakes was recorded in 2011, with 148 events with intensity 2 or larger, representing aftershocks and triggered seismicity by the Tohoku earthquake. Numbers of earthquakes with intensity 2 or larger were 36 and 35 in 1923 and 1924, following the Taisho Kanto earthquake. Combining the historical data from daily records, it is concluded that the number of felt earthquakes was largest in 2011 in the last 400 years.

Keywords: Historical earthquakes, Daily records, Tokyo

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Climate and social changes in ancient Japan construed by use of high resolution reconstruction of the Climate in Historical Time

*Katsunori IMAZU[1], Takeshi Nakatsuka[2]

1. OKAYAMA University Graduate School of Humanities and Social Sciences, 2. Research Institute for Humanity and Nature

This study focuses on ancient times of Japan, specifically the 8th and 9th Century in an attempt to clarify how the weather impacted societies then. Takeshi Nakatsuka developed per-annum reconstruction of climate for that period of time, which revealed that the 8th Century was, in general, relatively dry but stable, whereas the second half of the 9th Century turned to be unstable and wet, then in the 10th Century the weather changed to dry. Historical literature including Shoku Nihongi (second of the six classical Japanese history texts)、Nihon Kouki (third of the six classical Japanese history texts), Shoku Nihon Kouki (fourth of the six classical Japanese history texts), Nihon Montoku Tenno Jitsuroku (fifth of the six classical Japanese history texts), and Nihon Sandai Jitsuroku (sixth of the six classical Japanese history texts) described history of said period and included the description of the weather then. However, they are very brief and do not provide precise details as to the severity of drought, spells of rain or torrential rain. At long last, high-resolution weather reconstruction helps to bring clarity to the level of extreme dryness and humidity of summer and the damage they brought about, when we review historical documents. Additionally, the deeper understanding of the mid- to long-term weather pattern changes helps to visualize the interrelationship between the climate change and changes in the state and societies.

In this research, our interest, in particular, lies on demographic change and social system transformation in ancient times. In the early 8th Century Taiho Code was enacted and a centralized government established a political system based on the Ritsuryo Codes, which demonstrated their intent to emulate the system in China. The systems set forth by the Ritsuryo-Code-based-nation laid the foundation for the framework of Japan and played an essential role in defining the subsequent development of its history. The population that the state of the Ritsuryo Codes ruled is estimated to be around 4.5 million at the beginning of the 8th Century and approximately 5.5 million at the beginning of the 9th Century, with the average population growth rate from the 8th to 9th Century being 0.2% per annum. The population in the 17th Century, the beginning of the Edo era, is estimated as 12-18 million. The population slightly increased from the ancient times to early modern times. The yearly population increase over a course of 800 years from the mediaeval to early modern times was only 0.1-0.15% at best. Ancient Japan was frequently visited with plague and famine, which kept the nation highly fluid and vulnerable. Despite this situation, yet the population growth was at a higher rate comparing to the middle ages. This is considered due in part to a high functioning reproductive system set forth by the Ritsuryo system in which the central government exercised control over the people's lives and rice paddies and also by a relatively stable weather in the 8th Century.

Changes in Tang dynasty and Shilla, the neighboring countries of Japan, affected the Ritsuryo system in Japan, which collapsed little by little. The Ritsuryo-based-nation considerably changed from the late 9th Century to late 10th Century. These social changes were triggered by the changes in the overseas political landscape in its vicinity as well as the climate change. In the second half of the 9th Century they faced problems of the rise of non-arable rice paddies and flooding of rice fields. We are convinced that the climate change resulting in the humidity level increase of the land was at the root of these problems at that time. The Ritsuryo system started to give up on its exercise of control over its people and rice fields, thereby the reproductive system of the Ritsuryo state broke down. It was exacerbated by frequent

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earthquakes, a volcano eruption, famine and pandemic, all of which occurred during the same time frame. It was a time of crisis for ancient Japan as a whole. The nation under the Ritsuryo codes established a centralized government at the beginning of the 8th Century, but in the late 9th Century and onwards it started to collapse and the central government was contracted into a dynastic state in the capital of Heiankyo.

Keywords: tree-ring oxygen isotope ratio, Ritsuryo system, population, Climate change

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Absolute ages for huge eruptions of Towada Caldera and Baitoushan volcano in the 10th century as seen from dendrochronological studies and historical documents

*Masataka Hakozaki[1], Fusa Miyake[2], Masaki Sano[3], Katsuhiko Kimura[4], Toshio Nakamura[2], Mitsuru Okuno[5], Minoru Sakamoto[1], Takeshi Nakatsuka[6,2]

1. National Museum of Japanese History, 2. Nagoya University, 3. Waseda University, 4. Fukushima University, 5. Fukuoka University, 6. Research Institute for Humanity and Nature

The Towada Caldera (Aomori Prefecture / Akita Prefecture) and Baitoushan volcano (China / North Korea) each caused a huge eruption in the 10th century, respectively. These traces are clearly left behind in the stratum of the northern Japan as To-a tephra and B-Tm tephra. These two eruptions are estimated to be one of the largest in Japan and the world in the past 2000 years, respectively (Hayakawa & Koyama 1998). However, direct document records of these eruptions have not been found from any countries around the volcano. For that reason, these absolute ages had long been unknown. Also, due to uncertain age, the impact on human society and the global environment of these eruptions has not been evaluated.

Recently, the absolute age of the 10th century eruption of Baitoushan volcano was decided in AD946(Oppenheimer et al. 2017, Hakozaki et al. 2018). It was achieved by "^{14}C-spike matching" which is applied a rapidly carbon-14 increase event in AD775 discovered from tree-rings of Japanese trees (Miyake et al. 2012). And this age was also verified by the result of the oxygen isotopic dendrochronology (Kimura et al. 2017). Hayakawa and Koyama (1998) picked up this age (AD946) from descriptions suggesting distant eruptions written in a few old documents of Japan and Korea (ex. "Kofukuji-nendaiki", "Goryeosa") .

On the other hand, due to fixed in AD946 the absolute age of B-Tm, doubts occurred in the age of 10th century eruption of the Towada caldera. The 10th century eruption of Towada caldera had been estimated to be AD915 according to the description on the "Fuso Ryakuki" suggesting the eruption, and the dates of archaeological timbers buried in the lahar at Akita prefecture. Based on this age, the varves at lakes in Akita prefecture counted between To-a and B-Tm to be 14 layers, Kamite et al(2010) estimated the eruption age of Baitoushan volcano to be AD929. However, since the absolute age of B-Tm was AD946, as described above, it became clear that there was a gap of 17 years from Kamite et al's estimates. In other words, there is a possibility that the 10th century eruption of Towada caldera may be AD932. If this is correct, there is a possibility that the description of AD 915 in the "Fuso Ryakuki" indicates the eruption that occurred in volcanoes other than Towada caldera.

Recently, the oxygen isotopic dendrochronology was applied to the timbers of the fence of Tagajo site of Miyagi prefecture, and the absolute age was decided to be AD917 (Saito et al. 2018). In the archaeological survey, this fence has been thought to be built before the ash fall of To-a tephra (AD915) (Miyagi prefectural research institute of the Tagajo site 2018). The fact that the tree-ring of the AD917 was recognized in the timbers of the fence largely contradicts the estimated age (AD915) of To-a tephra. Furthermore, neither bark nor sapwood remained in these timbers, and it is clear that the logging year is later than AD917.

In this presentation, we show how the ages of timbers of Baitoushan volcano and Tagajo site determined

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by two new dendrochronological methods, and what is necessary to determine the absolute age of the 10th century eruption of Towada Caldera.

Keywords: dendrochronology, 14C-spike, Baitoushan volcano, oxygen isotope, Towada Caldera, huge eruption

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How can we activate collaborations with history and archaeology? –Lesson from Historical Climate Adaptation project

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Introduction

Earth and planetary sciences belong to historical sciences dealing with past natural and human phenomena as well as history and archaeology. Although many inter-disciplinary researches have been conducted between them, there are a lot of problems originating from differences of their essential philosophy. Here, I will discuss how to activate collaborations with history and archaeology based on my experiences as the leader of “Historical Climate Adaptation Project” in Research Institute for Humanity and Nature (RIHN) from 2014 to 2018.

Fundamental Strategy of the Project

RIHN is an inter-university research institute, accepting many research proposals aiming to solve a global environmental problem by inter-disciplinary approaches between natural and human sciences. In the framework of RIHN, we created three steps of research strategies. 1) To reconstruct variations in past climate at annual resolution for last several millennia in Japan. 2) To compare paleoclimate data with numerous historical and archaeological archives. 3) To elucidate characteristics of societies resilient or vulnerable to climate changes by comparing many historical cases. Although I initially imaged the unidirectional data provision from paleoclimatology to history and archaeology except for the study of historical climatology, the inter-disciplinary communications actually made unexpected progress in the paleoclimatology, especially in the establishment of super-long chronology of tree-ring cellulose oxygen isotope ratio.

Results of Inter-Disciplinary Collaboration

Tree-ring cellulose oxygen isotope ratio is a novel proxy to reconstruct past summer precipitation precisely even in humid and temperate areas like Japan where traditional dendroclimatology was not very successful. We planned to establish the long-term datasets over Japan. At the beginning, historians and archaeologists were regarded as users of the data, but they actually contributed to the creation and refinement of data by various ways. After receiving the data, they answered to paleoclimatologists as follows. (1) Active provisions of excavated woods and old architectural woods for isotopic analyses. (2) Critical evaluation of the paleoclimate data from the viewpoint of history and archaeology. (3) Request to improve the resolution and extension of paleoclimate data. Paleoclimatologists welcome (1), but it was not easy to answer to (2) and (3) because such criticisms and requests are not usually originating from themselves. However, the request (3) finally made us enable the tree-ring based millennial scales climate reconstruction, by combing the tree-ring oxygen and hydrogen isotope ratios, which were validated by critical evaluations of historians and archaeologists (2). It promoted many studies in paleoclimatology, history and archaeology. However, it was not easy to elucidate “societal systems resilient to climate change” because we had not shared the research purposes between natural and human sciences.

Conclusion

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The unprecedented length and precision of paleoclimate data are the results of active inter-disciplinary communications. Although the unidirectional data provision was not successful, the critical interactions improved both the data quantity and quality. On the other hand, the sharing of research philosophy between natural and human sciences was necessary to promote “real inter-disciplinary” research. In the project, I found the fact that historians and archaeologists do not usually study history to solve contemporary problems. Rather, they focus on the difference in people’s sense of values between past and present. Because the future must be different from the present as well as the past, it is very important to promote collaborations between natural scientists who seek the universality in history and human researchers who understand the diversity of history in order to make sustainable society. That was my most important finding in the project.

Keywords: Inter-disciplinary between natural and human sciences, Climate variation, Paleoclimatology, History, Archaeology, Dendrochronology

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Mon. May 27, 2019 1:45 PM - 3:15 PM JST | Mon. May 27, 2019 4:45 AM - 6:15 AM UTC | 301A 3F

[M-IS18] Geophysical fluid dynamics-Transfield approach to geoscience

convener:Keita Iga(Atmosphere and Ocean Research Institute, The University of Tokyo), Shigeo Yoshida(Department of Earth and Planetary Sciences, Faculty of Sciences, Kyushu University), Takatoshi Yanagisawa(Department of Deep Earth Structure and Dynamics Research, Japan Agency for Marine-Earth Science and Technology), Hidenori AIKI(Nagoya University), Chairperson:Kensuke Nakajima

This session on geophysical fluid dynamics is open to discussions and researches on fluid phenomena in whatever fields of earth and planetary sciences, e.g., motions in the earth and planetary interior, oceans, atmospheres, volcanoes, and the ionosphere, conducted with whatever methods. Talks intending to stimulate exchange of ideas among multiple fields of researches or those identifying concepts that are commonly applicable to wide range of geophysical fluids are especially welcome.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MIS18-01] Axisymmetric disturbance on an axisymmetric shallow water vortex

*Toshihisa Itano[1] (1.National Defense Academy)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MIS18-02] Numerical studies on the classification of flow regimes of the 3-D thermal convection of rotating fluids

*Masanori Kameyama[1,2] (1.Geodynamics Research Center, Ehime University, 2.Japan Agency for Marine-Earth Science and Technology)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MIS18-03] Diffusive behavior of columnar vortices in rotating thermal convection

*Daisuke Noto[1], Yuji Tasaka[2], Takatoshi Yanagisawa[3], Yuichi Murai[2] (1.Graduate School of Engineering, Hokkaido University, 2.Faculty of Engineering, Hokkaido University, 3.Japan Agency for Marine-Earth Science and Technology)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MIS18-04] Liquid metal flows driven by a rotating magnetic field

*Koki Sawada[1], Vladimir Galindo[2], Tobias Vogt[2], Sven Eckert[2], Yuji Tasaka[3], Yuichi Murai[3] (1.Graduate School of Engineering, Hokkaido University , 2.Helmholtz-Zentrum Dresden-Rossendorf, 3.Faculty of Engineering, Hokkaido University,)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MIS18-05] A symmetry-breaking self-regulating dynamo generating Mercury’s anomalous magnetic field

*Futoshi Takahashi[1], Hisayoshi Shimizu[2], Hideo Tsunakawa[3] (1.Faculty of Sciences, Kyushu University, 2.Earthquake Research Institute, University of Tokyo , 3.Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

Discussion

Axisymmetric disturbance on an axisymmetric shallow water vortex

*Toshihisa Itano[1]

1. National Defense Academy

The air in an eye of a typhoon is often considered to be stratospheric origin. Indeed, the region of high equivalent potential temperature invading eyes from stratosphere can be seen in most of tropical cyclones. Therefore, we can recognize tropical cyclones are vortices where the air with low potential temperature revolves around the warm air sucked from stratosphere. Also, elliptical or polygonal deformation of an eye of a tropical cyclone can be attributed to the oscillation of the interface between such two kinds of fluids. Thus, in this study, a tropical cyclone is modeled with two layer fluids where the upper fluid touches the ground surface at the core region of the vortex, and the motion on the interface is investigated with the shallow water equations described in polar coordinate by assuming the upper fluid at rest.
An axisymmetric swirling fluid whose center is completely dried up is adopted as the basic state, where the tangential speed is assumed to be inversely proportional to the α-th power of radius. Perturbations are again set to be axisymmetric. Under these settings, the governing equations are linearized, and an eigenvalue problem is formulated after hypothesizing sinusoidal time variation with the angular frequency ω. The eigenvalues are, at first, obtained numerically by discretizing the variables with a standard staggered grid. Then, in the case of no ambient rotation, the problem is solved analytically, by applying a series expansion to the governing equations.
Results reveal the existence of modes like gravity waves. Since the amplitudes of the modes are non-zero at the inner boundary corresponding to the outer edge of the dry core, they would be responsible for the periodic expansion and contraction of an eye in an actual tropical cyclone. Moreover, quasi-steady modes with no nodes in the radial direction emerge in the case of no ambient rotation. Although numerical and analytic solutions roughly coincide with each other, a definite discrepancy is found near the dry core of the basic vortex: radial cross sections reveal that the numerical solutions tend to swing once more against the analytic solutions around there.

Keywords: eye, vortex, axisymmetric disturbance, shallow water equation

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Numerical studies on the classification of flow regimes of the 3-D thermal convection of rotating fluids

*Masanori Kameyama[1,2]

1. Geodynamics Research Center, Ehime University, 2. Japan Agency for Marine-Earth Science and Technology

In this study we made a series of statistical analysis for a thermal convection in a three-dimensional Cartesian box rotating about a vertical axis, aiming at obtaining clues to readily understand the flow regimes of rotating convection. First we conducted numerical calculations of 20 cases where the values of Rayleigh number (Ra), Ekman number (Ek) and Prandtl number are systematically varied in the range of earlier studies. We confirmed that, based on the efficiency of convecting heat transfer, the flow patterns of these cases are classified into three regimes mainly depending on Ra and Ek: (i) no-rotating convection, (ii) the regime with strong effect of rotation, and (iii) that with moderate effect of rotation. In particular, we found that the change between the regimes with strong and moderate effect of rotation is associated with the change in the pattern and occurrence of Ekman pumping near the top and bottom boundaries, which can be clearly seen from the correlation between the vertical components of velocity and vorticity there. In the regime with strong effect of rotation, a strong correlation is observed in the vertical flows both away from and toward the horizontal boundaries. In the regime with moderate effect of rotation, in contrast, it is observed only in the flows departing from the boundaries. Our findings suggest that, from the viewpoint of rotating convection, the flow regime the Earth's outer core can be well identified from the observation of the correlation between the radial components of velocity and vorticity.

Keywords: thermal convection of rotating fluids, 3-D numerical experiments, Ekman pumping

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Diffusive behavior of columnar vortices in rotating thermal convection

*Daisuke Noto[1], Yuji Tasaka[2], Takatoshi Yanagisawa[3], Yuichi Murai[2]

1. Graduate School of Engineering, Hokkaido University, 2. Faculty of Engineering, Hokkaido University, 3. Japan Agency for Marine-Earth Science and Technology

Rotation effect on thermal convections in a fluid layer driven between two parallel plates with temperature difference, i.e., Rayleigh-Bénard convection (RBC) is a ubiquitous to explain large scale fluid motions observed on the Earth, such as typhoon, tornadoes, and liquid metal convection inside outer core. Various approaches so far have revealed its interesting features, e.g. heat transfer enhancement at moderate rotation rate, rotation dependent flow morphologies, and so on. Especially in them, formation of vertically aligned columnar vortices is one of the most curious phenomenon. Early experimental works mentioned those chaotic behavior like vortex-vortex interactions, however, little is known about this complicated vortex dynamics.

The present study is paying attention to such vortex dynamics observable in rotating RBC. With using encapsulated thermochromic liquid crystals, long-time $O(10^3$ s) experimental visualizations of the vortices on time variations of a temperature field were conducted, and we reached two novel insights. One is horizontal diffusive motion like Brownian motion of the columnar vortices. Statistical analyses on motions of the columnar vortices elucidated various kinds of diffusive motion. Such diffusive motions strongly depend on observation timescale (vortex lifetime) and columnar vortices present anomalous diffusive motion. Another is the effect of centrifugal force even under conditions for empirically negligible small effects of centrifugal force. This is the first found thanks to our long-time observations and might give a new caution to rotating RBC studies.

Keywords: Natural convection, Rotating field, Diffusive motion, Vortex dynamics

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Liquid metal flows driven by a rotating magnetic field

*Koki Sawada[1], Vladimir Galindo[2], Tobias Vogt[2], Sven Eckert[2], Yuji Tasaka[3], Yuichi Murai[3]

1. Graduate School of Engineering, Hokkaido University , 2. Helmholtz-Zentrum Dresden-Rossendorf, 3. Faculty of Engineering, Hokkaido University,

Doing experimental studies on liquid metal flows under interactions with magnetic fields is of great importance for understanding fluid dynamical phenomena including flows in planetary cores. In this research, liquid metal flows driven by a rotating magnetic field (RMF) were examined experimentally. The RMF generates eddy currents in liquid metal layers, and thus Lorentz force as the results of the interaction between the magnetic field and the current achieves the rotating flows. The fluid motions are dominated by angular velocity and magnetic strength of the RMF. In cases at which the skin effect is negligible small because of moderate angular velocity, modal transitions of the flow occur with increase of magnetic Taylor number (Ta_m), which is a dimensionless number including the angular velocity and the magnetic strength. For sufficiently small Ta_m, a quasi-two-dimensional, axisymmetric steady flow is formed. With increase of Ta_m, then, unsteady flows emerge by collapsing the symmetry. For this transition problem, theory and numerical calculation have been preceded. On the other hand, experimental approaches have essential unknows, even though there are quired to uncover the phenomena especially at higher Ta_m with stronger nonlinearity; namely, how to realize the RMF by experiment, and whether the experiment system can reproduce the flows expected by numerical simulations.

In the present experiment, we tried to produce the RMF by switching electric current in six-pair coils. A square container with aspect ratio 2 filled with eutectic of GaInSn, a liquid metal having low melting point, was arranged at the center of the coil. The GaInSn is an opaque fluid and it is impossible to be optically visualized. Ultrasonic Doppler velocimetry was used to obtain information of the flow fields. The switching frequency of the RMF was set at 50 Hz at which the skin effect did not appear, and Ta_m was modified by changing the magnetic strength. A long these methods, the flow transition depending on Ta_m was observed. As the measurement results, a stationary axial symmetric flow, that is in good agreement with the numerical simulation results, was observed under relatively small Ta_m. The increase in Reynolds number with respect to Ta_m also show reasonable agreement with the numerical simulations. Furthermore, the process of unsteady and turbulent transition in the increase of Ta_m was discussed and was compared with the numerical simulations.

Keywords: Rotating magnetic field, Liquid metal flow, Flow transition

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A symmetry-breaking self-regulating dynamo generating Mercury’s anomalous magnetic field

*Futoshi Takahashi[1], Hisayoshi Shimizu[2], Hideo Tsunakawa[3]

1. Faculty of Sciences, Kyushu University, 2. Earthquake Research Institute, University of Tokyo , 3. Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology

The discovery of Mercury’s unusually axisymmetric, anomalously axially offset dipolar magnetic field shows a new regime of planetary magnetic fields. The cause of the offset dipole remains to be resolved, although some exotic models have been proposed. Since the magnetic fields of the terrestrial planets are generated by fluid motions in the liquid iron core through dynamo action, which is inevitably linked to the structure and evolution of planetary interiors, untangling why Mercury has such an anomalous field is not only crucial for understanding the internal dynamics, evolution history and origin of the planet, but also essential for establishing the general theory of planetary magnetic fields by extending our knowledge to small bodies in our solar system such as Ganymede, Moon and asteroids. In this study, we use numerical dynamo models. Convection is driven as thermo-compositional convection. A thermally stably stratified layer is imposed in the outer part of the core. It is found that the magnetic fields similar in morphology as well as strength to that of Mercury are reproduced. Also, the dynamo-generated magnetic fields act on the flow to induce interaction between equatorially symmetric and antisymmetric components, and resultantly to yield north-south asymmetric helicity. Additional runs demonstrate that the offset dipolar field cannot be maintained without the magnetic self-regulating effect. Thus, it is concluded that the symmetry breaking self-regulating effect causes the flow to generate and maintain the Mercury-like offset dipolar field.

Keywords: Mercury, Offset dipole, Dynamo, Self-regulation, Symmetry-breaking

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Mon. May 27, 2019 9:00 AM - 10:30 AM JST | Mon. May 27, 2019 12:00 AM - 1:30 AM UTC | 103 1F

[M-IS20] Mountain Science

convener:Keisuke Suzuki(Department of Environmental Sciences, Faculty of Science, Shinshu University), Yoshihiko Kariya(Department of Environmental Geography, Senshu University), Akihiko SASAKI(Department of Geography and Environmental Studies, Kokushikan University), Chiyuki Narama(Niigata University, Department of Science), Chairperson:Yoshihiko Kariya(専修大学)

Mountainous areas provide water resources to the populated downstream areas, protecting the
 diversity of ecosystem and providing tourism attraction. To access the mountain environment
 changes and mitigate the impacts of global warming influences, a cross-cutting session is
 proposed to share the scientific knowledge among various fields; such as climatology, hydrology, geography, glaciology, water/carbon/material cycle, eco-diversity, etc.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[MIS20-01] Early Holocene landslide deposits found from Mount Honita, the upper Tama River basin, west of Tokyo

*Yoshihiko Kariya[1], Koichiro Sawabe[2] (1.Department of Environmental Geography, Senshu University, 2.Japan Conservation Engineers)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[MIS20-02] The effect of understanding of mountainous terrain using 3D maps and solid model

*Jiro Komori[1] (1.Teikyo Heisei University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[MIS20-03] Development process of Lake Naganuma in a large-scale landslide on Hachimantai Volcano

*Natsuki Sasaki[1], Toshihiko Sugai[1] (1.Graduate School of Frontier Science, the University of Tokyo)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[MIS20-04] Air and ground temperature conditions on alpine and sub-apline zone of Norikura Volcano, Northern Japanese Alps

*Akihiko SASAKI[1], Motoshi NISHIMURA[2], Keisuke Suzuki[3] (1.Department of Geography and Environmental Studies, Kokushikan University, 2.Interdisciplinary Graduate school of Science and Technology, Shinshu University, 3.Faculty of Science, Shinshu University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[MIS20-05] Initiation and flow characteristics of debris flows on a sediment deposition zone in a mountain area

★Invited Papers

*Fumitoshi Imaizumi[1], Yuichi S. Hayakawa[2], Haruka Tsunetaka[3], Norifumi Hotta[4] (1.Faculty of Agriculture, Shizuoka University, 2.Faculty of Environmental Earth Sciences, 3.Forestry and Forest Products Research Institute, 4.Graduate School of Agricultural and Life Sciences)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[MIS20-06] Relationships between annual landform changes of the riverbed and vegetation dynamics during recent 10 years in the upper Asusa River in Kamikochi valley in the Japan Alps

★Invited Papers

*Hiroshi Shimazu[1] (1.Department of Geography, Faculty of Geo-Environmental Science, Rissho University)

Early Holocene landslide deposits found from Mount Honita, the upper Tama River basin, west of Tokyo

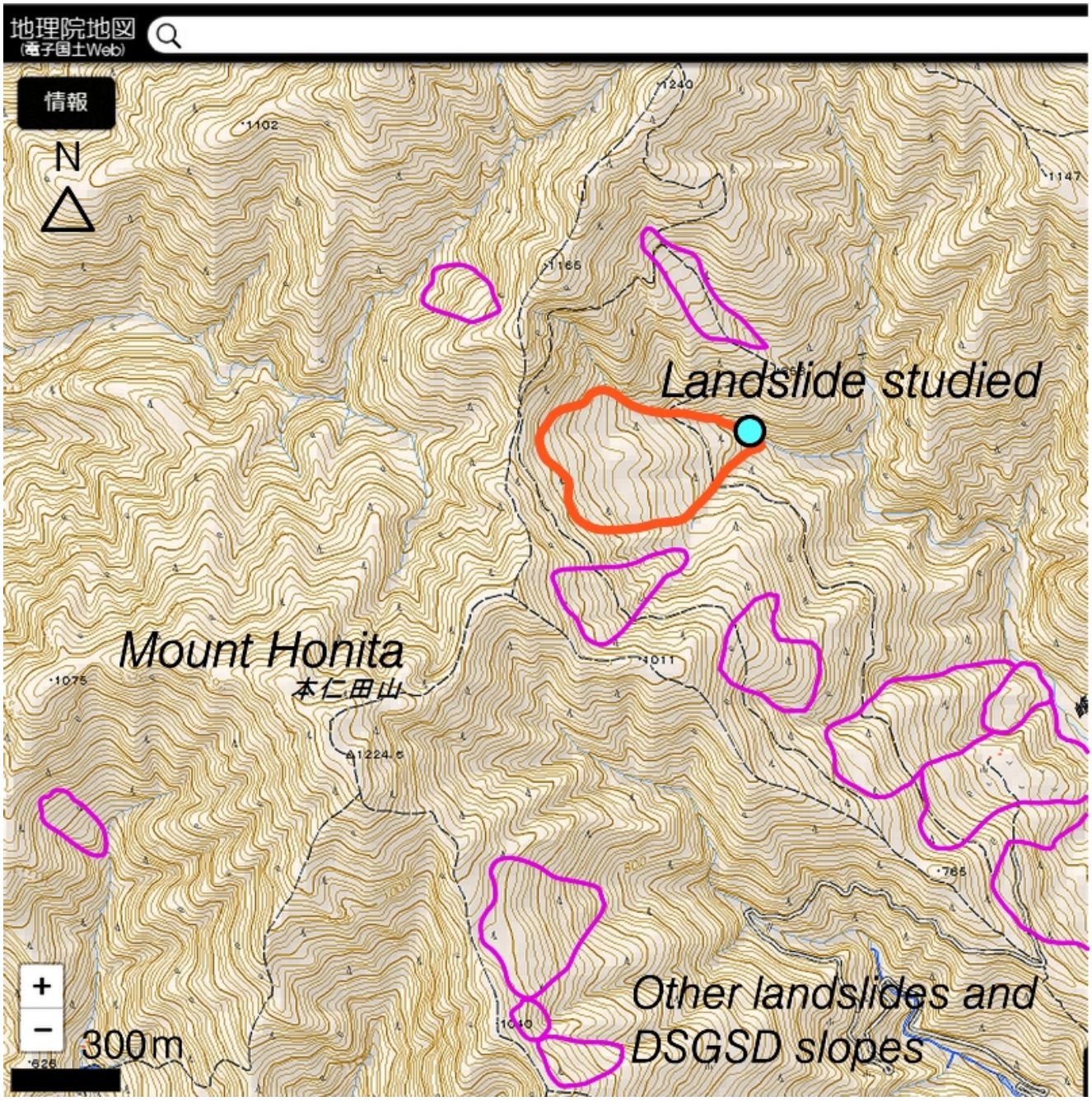
*Yoshihiko Kariya[1], Koichiro Sawabe[2]

1. Department of Environmental Geography, Senshu University, 2. Japan Conservation Engineers

Landslide features are common in the upper Tama River basin west of Tokyo Metropolis where sedimentary rocks derived from Mesozoic accretionary prisms are widespread. We obtained two wood fragments from landslide deposits on the northeast side of Mount Honita (710 m ASL). Radiocarbon ages of those fossils showed 10250-10189 cal BP and 10150-10057/10042-9987/9959-9704 cal BP (2sigma; OxCal4.3 with IntCal13). This result indicates that landslide occurred in the early Holocene when precipitation had increased and the elevation of riverbed had decreased in central Japan due to global changes. This situation would create morphogenetic environments prone to landslide occurrence. Although the Tachikawa Fault zone is close to Mount Honita, the age of latest paleoseismic event revealed by a trenching survey does not coincide with ages of the landslide event shown here.

Keywords: Upper Tama River basin, 14C ages, Mass movement, Landslide

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The effect of understanding of mountainous terrain using 3D maps and solid model

*Jiro Komori[1]

1. Teikyo Heisei University

The topography shows various forms by a background of the formation of the place, i.e history of geology and structural development, weathering, erosion and deposition. However, for a person without an interest and opportunity for geoscience study, it is difficult to understand the relation between the topography and background. On the other hand, it became easy to see a stereoimage of the topography without difficulty using a special relief map, 3D view on the screen and hands-on model by 3D printer. This presentation will introduce practical example and reaction of the students for understanding mountain topography.

Keywords: Red Relief Image Map, online map, 3D printer, glacial topography, landslide topography, educational effect

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Development process of Lake Naganuma in a large-scale landslide on Hachimantai Volcano

*Natsuki Sasaki[1], Toshihiko Sugai[1]

1. Graduate School of Frontier Science, the University of Tokyo

In the Hachimantai volcanic group, landslide is one of the most important origins of wetland, and various types of wetlands, including lakes and peatlands, tend to coexist in a large-scale landslide (Sasaki and Sugai, 2015). Landslide wetlands commonly develop from lakes to peatlands, so the wetland types are considered to reflect their developmental stage. This study analyzed sediment cores to reconstruct the development history of Lake Naganuma formed in a large landslide of the Hachimantai volcanic group, and discussed the difference in the developmental history with Oyachi, a large peatland in the same landslide.

Lake Naganuma, which is formed in the upper part of the Komonomori landslide in the northwest of Hachimantai volcano, has an elliptical shape with a long axis in the north-south direction parallel to the scarp of the landslide, and its southern part is peatland. Drilling surveys were conducted at two sites on the long axis, and each sediment core was designated as NN1 and NN 2 from near to the water area. In NN1 core, we identified two lithostratigraphic units: NN1-Unit 1 (3.40–2.64 m depth) was organic silt; NN1-Unit 2 (2.64–0.00 m depth) was peat. In NN2 core, we recognized three lithostratigraphic units: NN2-Unit 1 (4.50–4.20 m depth) was silt with low organic content showing parallel lamination; NN2-Unit 2 (4.20–1.57 m depth) was organic silt; NN2-Unit 3 (1.57–0.00 m depth) was peat. The boundary between each unit was unclear, and their organic content gradually changed. We visually identified 5 tephra layers in NN1 core and 4 layers in NN2 core. From the result of chemical composition analysis of volcanic glasses, pumice layers at 1.05 m depth in NN1 core and at 1.10 m depth in NN2 core 2 were correlated with the To-a tephra, which is widely distributed over the northern Tohoku region as a result of the 915 AD eruption of Towada volcano. And the chemical composition of volcanic glasses at 2.22 m depth in NN1 core and at 2.87 m depth in NN2 were similar to that of the To-Cu tephra, erupted by Towada volcano at 6.2 ka.

The southern part of Lake Naganuma had developed from lake to peatland, because the organic silt layer changed to the peat layer upward in both sediment cores, and because the lower part of the organic silt layer in NN1 and the silt layer in NN2 showed parallel lamination. The lake changed to peatland before 6.2 ka, since the peat layer of NN1 contained To-Cu tephra. However, in NN2 far from the water area, To-Cu was contained in the organic silt layer below the peat layer. Moreover, the organic silt layer of NN2 was thicker, and the deposition rate between To-a and To-Cu layer was estimated about 0.35 mm/yr for NN2, while that of NN1 was about 0.27 mm/year. These suggest that fine grained soil continuously and slightly flowed into peatland around NN2 from the surrounding slopes even after terrestrialization. From the above, we concluded that Lake Naganuma had gradually filled from the upstream part and then been stable in the present state at least for over a thousand years, while peat layer formed.

Many wetlands are formed in the Komonomori landslide, and the development process of Oyachi peatland in the landslide, located about 800 m southwest of Lake Naganuma, is different from that of Lake Naganuma. Oyachi wetland was in the depression formed by a landslide activity before 8600 cal BP, and its transition from peatland to forest was interrupted at about 5500 cal BP by slope movement leading to the development of a lake that was drained by streams at about 3300 cal BP, after which a peatland environment has persisted until the present (Sasaki and Sugai, 2018). On the other hand, Lake Naganuma is more stable for a long period. These suggested that development processes and rates of wetlands are various even in a same landslide, probably depending on local slope stability rather than regional climatic

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changes.

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Keywords: wetland, development process, landslide, Hachimantai Volcano

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Air and ground temperature conditions on alpine and sub-apline zone of Norikura Volcano, Northern Japanese Alps

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In Japanese mountains, the alpine zone above the forest limit coincides with the periglacial zone, therefore the position of the forest limit and its genesis are important. The forest limit is thought to control by factors such as thermal conditions, prevailing wind, snow cover, and form and deposit of slope surfaces. We observe the air temperatures on the two sites of forest zone, where are forest limit and under limit of subalpine zone of Norikura volcano. In addition, we also observe the air temperature on an alpine zone of Fujimi-dake in Norikura volcano.
The annual mean air temperatures on the forest limit were 0.1 ℃ in 2014 and -0.3 ℃ in 2017. The warmth index (WI) on the forest limit were 19.7 ℃・months in 2014, 21.8 ℃・months in 2015, and 19.8 ℃・months in 2017, respectively. This WI value exceeds 15℃・months of Kira's WI for the forest line in Japan. This result supports the proposal that the forest line of Norikura volcano is controlled not by thermal conditions but by other factors such as the prevailing wind or snow cover.

Keywords: air temperature observation, ground temperature observation, forest limit, alpine zone, norikura volcano, Northern Japanese Alps

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Initiation and flow characteristics of debris flows on a sediment deposition zone in a mountain area

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Debris flows is a geomorphic process, which is extremely hazardous as a result of their high velocity, long travel distance, and destructive power. However, debris flow characteristics in the initiation zones, which could possibly be affected by accumulation conditions of the storage (i.e., channel gradient and volume of storage) associated with sediment supply from hillslopes and the evacuation of sediment by debris flows, are poorly understood because of the difficulty in access. Thus, we studied the influence of accumulation condition of the storage on initiation and flow characteristics of debris flow at the Ohya landslide body in Japan by periodical terrestrial laser scanning (TLS) and UAV surveys, and field monitoring. In the Ohya landslide, debris flow occurs frequently (about three or four events per year) due to the mobilization of storage Our study clarified that initiation location of the debris flow is highly affected by depth of the storage and water supply from tributaries. Partly saturated debris flow is an important hydrogeomorphic processes in the initiation zones of debris flow because of the steep terrain. The flow characteristics were affected by the volume of storage and rainfall patterns. Partly saturated flow dominated when total of the storage > 15,000 m^3, while fully saturated flow dominated when total volume of the storage < 10,000 m^3. Transition of the flow type from partly saturated flow to fully saturated flow as the surges flow down was monitored by the time lapse cameras. Therefore, debris flow characteristics in the initiation zone, which is highly affected by accumulation conditions of the storage, are sometimes different from that in the transportation and deposition zones.

Keywords: debris flow, mountainous area, sediment disasters

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Relationships between annual landform changes of the riverbed and vegetation dynamics during recent 10 years in the upper Asusa River in Kamikochi valley in the Japan Alps

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The Azusa river is originated from Mt. Yarigatake and runs through the Kamikochi valley, whichi has the wide valley bottom instead of the mountain region. The Azusa river forms multi bar with gravelbed braided channel in the Kamikochi valley. There are patchy willow communities of *Salix arbutifolia* and *Salix rorida* in the riverbed. Kamikochi Natural History Research Group has made geomorphological maps more than 25 years, recorded annual landform changes and dynamics of vegetation. This paper discusses the relationships between landform changes and germination and destruction of willow communities.

After 2008 major channel pattern changes occurred in 2009, 2010, 2011, 2013, 2017 and 2018. Except 2009 there were heavy rain event whose daily rain fall was over 110mm in the Baiu rainy season (from June to July). In July 2009 rain observed 29 days and maximum 3 days rainfall was excess 170mm. Based on the overview images taken by interval shooting cameras placed in the study area between July 2011 and October 2016, one or two hours after beginning of rain water level rises and in heave rainfall events occurred not in the Baiu maximum water level was not high as in the event in the Baiu.

Observation of surveyed cross sections of the riverbed and distribution of vegetated area on the gravel bars shows that the channels do not move laterally. Former channels were buried by transported sediments and new channels were excavated. Although the most bars were covered with water and sediments, their surfaces were not eroded. Thus, most vegetation on the bars survived the food event. By slight lateral erosion patchy communities of willow were gradually destructed and reduction of the area. During recent ten years a new willow community germinated in a shallow ditch continues growing. The Height of the community reaches 3 meters. Another willow community germinated in 1998 and more than 20m in height continues growing, reducing its area by lateral erosion in several flood events. Isolated willow trees on the bar in the center of the riverbed survived more than 20 years impact of yearly flood flows. But some of them were washed away in the 2017 and 2018 flood events.

The landform of the riverbed of the Azusa River in Kamikochi region considerably changed by burying former channels and excavating new channels, which occurred in once in several years during heavy rainfall events in the Baiu season. After these flood events *Salix arbutifolia* germinated and form new patchy communities. Although these communities were destructed partly, they have continued growing and some of them form communities of isolated large trees. These processes form the peculiar alpine river landscape in Kamikochi area.

Keywords: riverbed, landform change, vegetation dynamics, braided channel, Azusa river, Japan Alps

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Mon. May 27, 2019 10:45 AM - 12:15 PM JST | Mon. May 27, 2019 1:45 AM - 3:15 AM UTC | 103 1F

[M-IS20] Mountain Science

convener:Keisuke Suzuki(Department of Environmental Sciences, Faculty of Science, Shinshu University), Yoshihiko Kariya(Department of Environmental Geography, Senshu University), Akihiko SASAKI(Department of Geography and Environmental Studies, Kokushikan University), Chiyuki Narama(Niigata University, Department of Science), Chairperson:Akihiko SASAKI

Mountainous areas provide water resources to the populated downstream areas, protecting the
 diversity of ecosystem and providing tourism attraction. To access the mountain environment
 changes and mitigate the impacts of global warming influences, a cross-cutting session is
 proposed to share the scientific knowledge among various fields; such as climatology, hydrology, geography, glaciology, water/carbon/material cycle, eco-diversity, etc.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MIS20-07] Age dating of groundwater using tritium and CFCs in headwater catchments, Fukushima after the Fukushima Dai-ichi Nuclear Power Plant accident

*Koichi Sakakibara[1], Sho Iwagami[2], Maki Tsujimura[3], Yutaka Abe[4], Manami Hada[5], Ishwar Pun[6], Yuichi Onda[3,7] (1.Faculty of Science, Shinshu University, 2.Department of Disaster Prevention, Meteorology and Hydrology, Forestry and Forest Products Research Institute, 3.Faculty of Life and Environmental Sciences, University of Tsukuba, 4.Natural Environment Conservation Center, Kanagawa, 5.Graduate School of Life and Environmental Sciences, University of Tsukuba, 6.Organization for the Strategic Coordination of Research and Intellectual Property, Meiji University, 7.Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MIS20-08] Hydraulic adaptation for tree height growth in tall tree species

★Invited Papers

*Wakana Azuma[1] (1.Kyoto University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MIS20-09] The molecular phylogenetic structure and biogeographic history of a alpine gravel environment specific plant *Dicentra peregrina* (Papaveraceae) in Japan

*Takahisa Ozaki[1], Hirokazu Matsuda, Koji Tojo[2] (1.Graduate School of Science and Technology, Shinshu University, 2.Biology Department, Faculty of Science, Shinshu University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MIS20-10] Formation process of small stands of *Abies mariesii* forest in pseudo-alpine zone on Mt. Akita-komagatake, northern Japan

*Asaka Konno[1] (1.International Research Institute of Disaster Science, Tohoku University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MIS20-11] Distribution of the pinas forests including a Cryptomeria japonica and its environmental factors in Echigo mountain range.

*Masatsugu YASUDA[1] (1.Asia Air Survey Co., Ltd.)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[MIS20-12] Roles of glacier microbes in alpine ecosystems of Asian high mountains: effect of cryoconite outflow on soil development in glacier forefields

★Invited Papers

*Nozomu Takeuchi[1], Masato Shiomuki[1] (1.Chiba University)

Age dating of groundwater using tritium and CFCs in headwater catchments, Fukushima after the Fukushima Dai-ichi Nuclear Power Plant accident

*Koichi Sakakibara[1], Sho Iwagami[2], Maki Tsujimura[3], Yutaka Abe[4], Manami Hada[5], Ishwar Pun[6], Yuichi Onda[3,7]

1. Faculty of Science, Shinshu University, 2. Department of Disaster Prevention, Meteorology and Hydrology, Forestry and Forest Products Research Institute, 3. Faculty of Life and Environmental Sciences, University of Tsukuba, 4. Natural Environment Conservation Center, Kanagawa, 5. Graduate School of Life and Environmental Sciences, University of Tsukuba, 6. Organization for the Strategic Coordination of Research and Intellectual Property, Meiji University, 7. Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba

Groundwater age is crucial information for understanding the continuum groundwater flow system from mountain to ocean. Headwaters are origins of the terrestrial hydrological cycle and therefore important areas to understand the water resources management, material cycle, and disaster prevention. After the Fukushima Dai-ichi Nuclear Power Plant accident, concerns of radionuclide contamination of water resources have been elevated. However, the groundwater flow system including age information in radionuclide-contaminated headwaters in Japan has not been well clarified. Therefore, the objective of this study is to investigate the groundwater age and related radionuclide effect on the water resources by using multi-tracer approach in headwater catchments approximately 30 km north-west apart from the Fukushima Dai-ichi Nuclear Power Plant. Periodical field surveys were conducted from May 2011 (2 months after the disaster) to November 2012. Tritium, chlorofluorocarbon (CFCs), and stable isotopes (oxygen and hydrogen) were used as environmental tracers.
Mean groundwater age in the study areas was estimated to be ranging from 10 to 26 years by combined use of multiple CFCs concentrations. The tritium concentration in groundwater was between 1.3 TU and 6.0 TU, which supported the estimated CFCs-based groundwater age. In addition, the governing groundwater flow system was approximated by a piston flow model; however, a modern water fraction was also suggested based on the relationship between CFC-11 and CFC-12. The estimated water age and isotopic signals among the stream water, spring water, and groundwater suggested an indication of the radionuclide intrusion into the groundwater. This is consistent with the monitored ^{137}Cs concentration in the groundwater (Iwagami et al., 2017). Modern water fractions with relatively high radionuclide concentrations into groundwater possibly cause the prolonged contamination of water resources.

Keywords: tritium, CFCs, groundwater age, headwater catchment

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Hydraulic adaptation for tree height growth in tall tree species

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Forest ecosystems, one of the major elements of the mountainous area, are characterized by its complicated three-dimensional structure which is 95% occupied by canopy where cannot be reached from the ground, compared to grasslands, deserts and rocky areas (Lowman and Rinker 2004). Various life activities such as photosynthesis, transpiration, breeding, and interaction with various organisms are performed on the canopy. Canopy researches have been progressed rapidly by the development of methods for accessing treetop in recent years (Nakanishi et al. 2018).

The question of why trees can grow up so tall is simple but its discussion has continued for a long time among ecophysiological studies. Among some factors related to tree height growth being pointed out, a main factor is considered that the limitation of water transport from root to leaves at the far end (e.g. Ryan et al. 2006). While this is the beginning of theoretical research, it has not been directly measured how much actual leaves are affected by the water transport limitation in tall trees. Therefore, we accessed to crown for 100 m tall of *Sequoia sempervirens* and 50 m tall *Cryptomeria japonica* by tree climbing, and directly evaluated water relations characteristics of leaves at various heights. As a result, although the supposed influence by water limitation was not observed, the high water capacitance of treetop leaf was revealed. This results suggested that the high water capacitance of treetop leaf would compensate for the physical water transport limit at treetop (Ishii et al. 2014).

How can treetop leaves perform high water capacity? To investigate a relationship between leaf anatomy and water relations, leaves of 50 m tall C. japonica were freeze by liquid nitrogen in situ of crown before dawn and at midday, then took it back to the laboratory and sectioned with cryo-SEM for observations. As a result, it was revealed that the transfusion tissue specific to the gymnosperm, which is located between the vascular bundle and the mesophyll, reversibly stored water and shrink like a sponge. At the treetop, large number of transfusion cells contributed to maintain the physiological function by the tissue structure giving priority to the water limit compensation, and as a result, maximum tree height could be regulated by tradeoff of the resource allocation with photosynthetic structure (Azuma et al. 2016).

To elucidate the mechanism of water retention within leaves focusing on the physicochemical properties, infrared spectroscopy is conducted. By applying it to leaf cross-sections in combination with a microscope, it is possible to quantify and visualize the distribution of water and sugars which were difficult to evaluate by an anatomical method alone. Although water is treated as one kind in the present plant physiology, in actual, physicochemical studies are known that various water components exists due to a difference in hydrogen bonding. In this study, working hypothesis that water with short hydrogen bonding component could be retained to polysaccharides within leaves was discussed. (Azuma et al. 2017).

These results suggest the one of a mechanism for tree height growth in tall conifer species with a new insight that “adaptation” to the water transport limit at treetop. To elucidate the actual ecophysiological characteristics in such huge trees, more comprehensive understanding from multiple perspectives would be necessary.

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Keywords: water relations, hydraulic architecture, canopy

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The molecular phylogenetic structure and biogeographic history of a alpine gravel environment specific plant *Dicentra peregrina* (Papaveraceae) in Japan

*Takahisa Ozaki[1], Hirokazu Matsuda, Koji Tojo[2]

1. Graduate School of Science and Technology, Shinshu University, 2. Biology Department, Faculty of Science, Shinshu University

In determining the distribution area of an organism, meteorology, climate, geography, topography and geology are important factors. In particular plants are more susceptible to climate change by limitations on dispersion compared with animals, thus the relationship between climate change and geographical distributional history in the glacial-interglacial cycles have been discussed a lot. For example, a hypotheses and a pattern have been proposed about the distribution history of alpine plants in the Japanese Archipelago. During the glacial periods, their distribution area was expanded (to the more southern region), on the other hand, the distribution area shrank (to the more northern region) during the interglacial periods and survived only in the alpine areas. Regarding the geological conditions, soil nutrition, size and stability of gravels influence species composition and population dynamics. Not only environmental factors but also biological interactions play an important role. If the weather, geography and geological conditions are severe, it will be a major barrier to plants' lives. However, few cases have established the effects of habitats' environments on their distributional histories. *Dicentra peregrina* inhabiting the alpine gravel lands and represent the alpine desert plants' community. In Japan, *D. peregrina* is also called "queen of alpine plants". Such alpine gravel lands distribute scattered around the volcanoes, and also around the ridgeline areas of high altitude mountains with strong disturbances: harsh weathering and/or unstable lands' surface. Therefore, migration is strongly restricted and highly influenced by weather, geography, topography and geology, compared with other alpine plants. Thus, *D. peregrina* is a suitable targeted alpine plant to investigate the relationship between the habitat environments and the distributional history. In order to estimate their distributional history, we have conducted phylogenetic analyses of *D. peregrina* in the Japanese Archipelago. Additionally, we have also conducted the "Ecological niche modeling" to estimate distributional changes by climate changes. As a result of our phylogenetic analyses, we observed two major genetic lineages within *D. peregrina*: one is endemic to Hokkaido (Group 1), and the other was observed from wide-areas in the Japanese Archipelago (Group 2). The boundary between the two lineages was recognized within the Daisetsu Mountain Range at Central Hokkaido. In Hokkaido, Group 2 was only observed in Mt. Kaundake and Mt. Furanodake. According to some geological studies, both Mt. Kaundake and Mt. Furanodake having comparatively old origin, it is considered that they were formed before 700,000 years ago. In contrast, regarding mountains where observed the Group 1, it is considered that they were formed around 150,000 years ago. Such differences of the mountain formation ages might be affected the population dynamics of *D. peregrina* in the glacial-interglacial climate changes. The Group 2 of *D. peregrina* is highly likely migrated to the Japanese Archipelago during the last glacial period. On the other hand, the Group 1 was dispersed to the Japanese Archipelago in older period and it is considered that their distribution spread more widely in the last glacial period. Thus, these old originated mountains served as refugia during inter-glacial periods. In addition, the genetic structure of *D. peregrina* was largely different from other alpine plants, and such difference suggests the distributional history of *D. peregrina* is strongly related to geological history rather than other alpine plants.

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Keywords: phylogeography, alpine Plant, alpine desert, glacial-interglacial cycles

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Formation process of small stands of *Abies mariesii* forest in pseudo-alpine zone on Mt. Akita-komagatake, northern Japan

*Asaka Konno[1]

1. International Research Institute of Disaster Science, Tohoku University

The coniferous forest (largely composed of *Abies mariesii*) is presently the typical vegetation of the subalpine zone in Japan. However, around Mt. Akita-komagatake, in northern Japan, the expected predominance of *A. mariesii* is not extensively observed, and the predominant vegetation is instead the dwarf bamboo (Sasa kurilensis) grasslands and broad leaf forests. It' s called Pseudo-Alpine zone. According to pollen analysis, this vegetation is assumed to be attributed to unsatisfactory expansion of *A. mariesii* forest.

Here we clarify the formation process of small stand of the *A. mariesii* forest by its size structure and process of regeneration.

The surveyed area is located in the northern Mt. Akita-komagatake. We classified the vegetation and measured DBH (diameter at breast height) and created frequency histograms of size structure on each vegetation.

The both histograms of *A. mariesii* thick and thin forest display gradual decreasing on the small classes on the *X* axis (DBH). The maximum classes of DBH are the class of 20-30 cm on the both histograms. The decreasing is considered to be brought about by two reasons: the second generation of *A. mariesii* on 20-30 cm DBH class is not enough equipped to propagate, and there is less numbers of first generation. These results are indicated that the small stands of *A. mariesii* forest rapidly formed by second generations.

Keywords: Abies mariesii forest, formation process, Mt. Akita-komagatake, pseudo-alpine zone

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Distribution of the pinas forests including a Cryptomeria japonica and its environmental factors in Echigo mountain range.

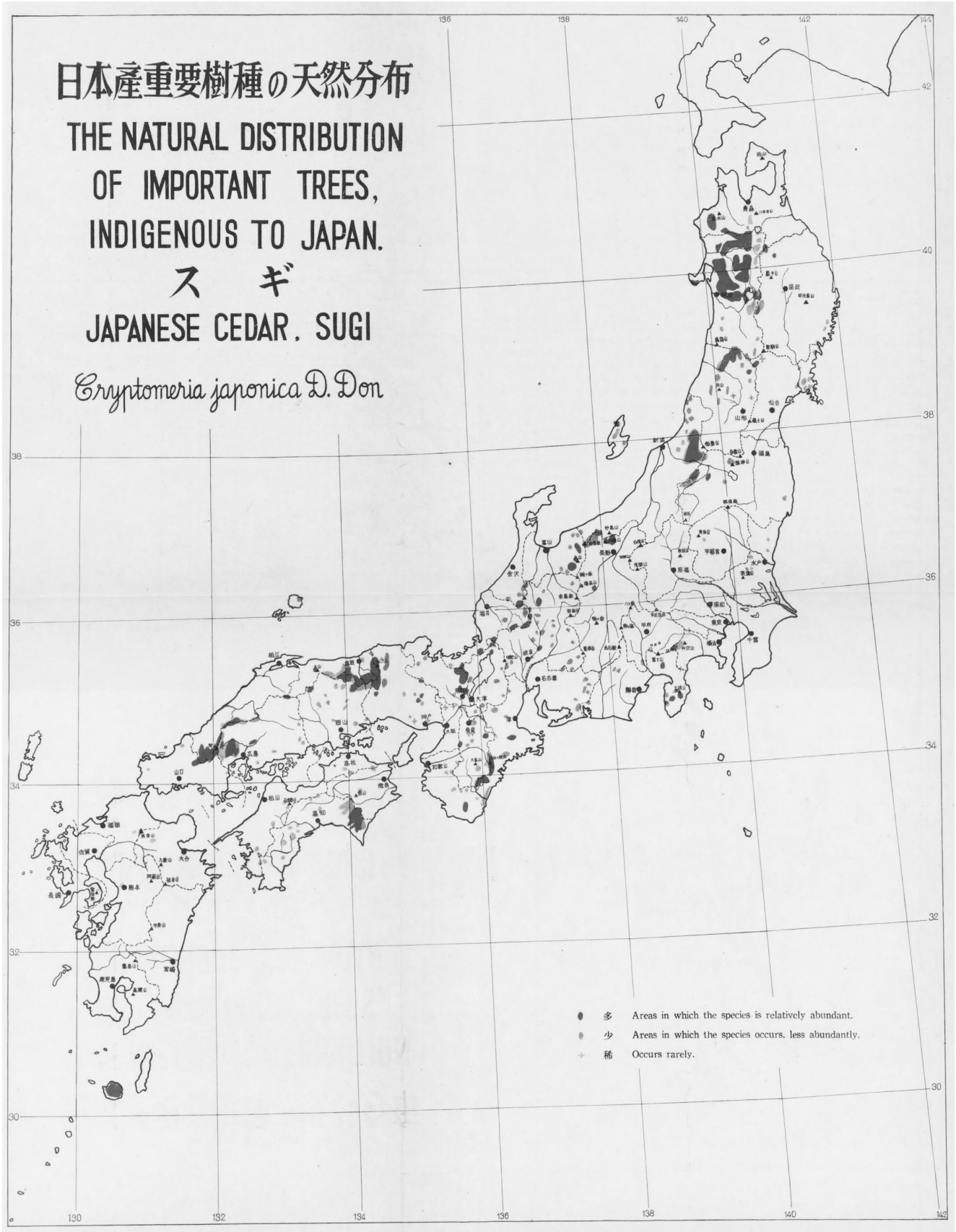
*Masatsugu YASUDA[1]

1. Asia Air Survey Co., Ltd.

Natural cedar grows in the area of southeastern part of Aizu area to Higashi Kanbara gun.
This cedar is known as the real name Cryptomeria japonica or Sanjo Sugi, a famous cultivar called Sugi or Sanjo Sugi. On a gentle slope it forms a forest that intermixes with beech and on the ridge it forms a mixed forest with the Chitose or Pinus densiflora.
Forests mixed with sugi and beech are recognized on the Sea of Japan side mainly in Akita prefecture (2018 Echigo valley), whereas forests mixed with sugi and Kitakagoyo or Pinus densiflora are not well recognized in other areas, .
Regarding vegetation in this area Matsuura (2010) says, "The most characteristic of vegetation in this area is avalanche vegetation consisting of shrub forests and grasslands formed by frequent avalanche due to heavy snow.The upper slope of the ridge An avalanche vegetation in a shrub forest from both sides, formed as a result of snow accumulation as a pine forest (Mainly for Kita gobo and Mixed Pinus densiflora in a low altitude) on a Yase ridge remains linear (Mohegan cut) It shows that it is vegetation.
By the way, the author made a survey in this area around the autumn of last year, and found that the pine forest including this cedar has relevance to snow accumulation gradient. In addition, from the viewpoint of the combination of plants, that is, from the viewpoint of plant sociology, it was also found to be strongly related to "Crobe - Kita - gobay Forest" distributed in the sub - alpine region of Japan.
We analyze these relationships, that is, the plant sociological features and the geographical relevance of the environment such as snow cover by using existing vegetation survey database and mesh climate value and report the results.

Keywords: Natural Cryptomeria japonica, Echigo mountain range, Mt. Mikagura, Snow coverage, Phytosociology, Vegetation survey database

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Roles of glacier microbes in alpine ecosystems of Asian high mountains: effect of cryoconite outflow on soil development in glacier forefields

*Nozomu Takeuchi[1], Masato Shiomuki[1]

1. Chiba University

The Tien Shan Mountains are one of the major mountain systems in Central Asia, extending over 2000 km, from east Uzbekistan to northeast of the Taklamakan Desert in China. The major Tien Shan peaks rise from over 4000 to 7000 m above sea level (a.s.l.). Glaciers presently exist in mountains mainly above 3500 m a.s.l. and most rivers originating from the Tien Shan glaciers flow down through the steppes and deserts surrounding the mountains. Water from the mountains has sustained the local inhabitants and ecosystems of this arid area. Recent studies revealed that there are diverse microbes living on the Tien Shan glaciers and they produce significant amounts of cryoconite, which is a small granular aggregation of microbial organic matter on the glacier ice. We found abundant cryoconite deposit along a river from glaciers, which is likely to contribute development of organic soil in the glacier forefields. Thus, biological communities living on the glaciers also play a role to maintain the alpine ecosystems and regional environments in the Tien Shan Mountains.

Keywords: cryooconite, glacier forcefields, Tienshan Mountains

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Mon. May 27, 2019 1:45 PM - 3:15 PM JST | Mon. May 27, 2019 4:45 AM - 6:15 AM UTC | 103 1F

[M-IS20] Mountain Science

convener:Keisuke Suzuki(Department of Environmental Sciences, Faculty of Science, Shinshu University), Yoshihiko Kariya(Department of Environmental Geography, Senshu University), Akihiko SASAKI(Department of Geography and Environmental Studies, Kokushikan University), Chiyuki Narama(Niigata University, Department of Science), Chairperson:Chiyuki Narama(新潟大学)

Mountainous areas provide water resources to the populated downstream areas, protecting the
 diversity of ecosystem and providing tourism attraction. To access the mountain environment
 changes and mitigate the impacts of global warming influences, a cross-cutting session is
 proposed to share the scientific knowledge among various fields; such as climatology, hydrology, geography, glaciology, water/carbon/material cycle, eco-diversity, etc.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MIS20-13] Comparison of surface energy balance of seasonal snowcover for three sites in Japanese alpine region

*Motoshi NISHIMURA[1], Akihiko SASAKI[2], Keisuke Suzuki[3] (1.Interdisciplinary Graduate school of Science and Technology, Shinshu University, 2.Department of Geography and environmental Studies, Kokushikan University, 3.Faculty of Science, Shinshu University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MIS20-14] The influence of snow for the local wind system on the east slope of Mt.Norikura

*Genki Uehara[1], Keisuke Suzuki[2] (1.Graduate School of Science and Technology, Shinshu University, 2.Department of Environmental Science, Faculty of Science, Shinshu University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MIS20-15] Mass balance of "Avalanche-accumulation type"glaciers and perennial snow patches in Hida mountain range.

*Kenshiro Arie[1], Chiyuki Narama[2], Kotaro FUKUI[3], Hajime IIDA[3] (1.Graduate School of Science and Technology, Niigata University, 2.Faculty of Science, Niigata University, 3.Tateyama Caldera Sabo Museum)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MIS20-16] Pattern of occurrence of sea of clouds and waterfall cloud near Mt.Nishihotakadake

★Invited Papers

*Toru Awazawa[1] (1.Faculty of Science, Shinshu University National University, Shinshu University Faculty of Science)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MIS20-17] Review and prospect of strong local wind “Matsubori-kaze” blowing at the western foot of Mt. Aso.

★Invited Papers

*Hiroshi Matsuyama[1] (1.Graduate School of Urban Environmental Sciences, Tokyo Metropolitan University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MIS20-18] Two decades of mountain climate monitoring and research: lessons learned and future challenges.

*Luis Duran[1,2,3], Irene Rodríguez-Muñoz[1] (1.interMET Sistemas y Redes S.L.U. Madrid. Spain, 2.Centro de Investigación, Seguimiento y Evaluación del Parque Nacional Sierra de Guadarrama. Madrid. Spain, 3.Departamento de Física de la Tierra y Astrofísica. Facultad de Ciencias Físicas. Universidad Complutense de Madrid. Spain)

Comparison of surface energy balance of seasonal snowcover for three sites in Japanese alpine region

*Motoshi NISHIMURA[1], Akihiko SASAKI[2], Keisuke Suzuki[3]

1. Interdisciplinary Graduate school of Science and Technology, Shinshu University, 2. Department of Geography and environmental Studies, Kokushikan University, 3. Faculty of Science, Shinshu University

Process of snow and glacier ablation is one of the indicator of global climate change, so is of interest as understanding earth system. In the discussion of snow ablation process, calculating surface energy balance (SEB) is one effective method, and it is generally analysed with local meteorological observation data. SEB is sensitive to regional atmospheric conditions, therefore it often reflects in situ regional climate and surrounding environment. This presentation offers the result of regional SEB analysis in central Japanese alpine region, Kamikochi (1490 m a.s.l.), Norikura highland (1590 m a.s.l.) and Nishi-Hodaka (2355 m a.s.l.) to reveal the characteristic of SEB of seasonal snowcover in Japanese sub-alpine region. Three automatic weather stations, operated by Shinshu University, were located each targeted region in snow covered period of 2016/17 (Hydrological year). SEB analysis was conducted using surface energy balance method, and an analysis of turbulent heat flux was done using the bulk aerodynamic method. SEB analysis were conducted only snow covered period from October, 2016 to June, 2017.
The most major energy source was net shortwave radiation and negative energy flux was offered by net longwave radiation and latent heat flux in every site. Those characteristics were often reported in continental regions and high elevation areas, such as alpine region, because atmospheric condition in those regions are often cold and dry so that incoming turbulent enegy flux were restrained. The most atrractive characteristic resulted in SEB comparison is that the behavior of snowmelt energy flux in later ablation period is different in three sites. Snowpack in Nishi-Hodaka is persisted longer (untill June) than other two sites due to a lot of snowfall offered in winter, so that atmospheric condition (e.g. air temperature, specific humidity) and radiation components in later ablation period have been different from other two sites. Threrfore the different SEB properties in each site were also discovered.
Similar and diference SEB properties, which are resulted from regional climate condition and local topographic environment, among the three target sites were revealed. It is interesting that the target sites, relatively near but diferent (or same) elevation band, have each different SEB properties, so more detailed analysis of regional SEB properties are required.Comparison of surface energy balance of seasonal snowcover for three sites in Japanese alpine regionComparison of surface energy balance of seasonal snowcover for three sites in Japanese alpine region

Keywords: snow melt, alpine region, snow surface energy balance

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The influence of snow for the local wind system on the east slope of Mt.Norikura

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On the east slope of Mt.Norikura (3026 m), there is a unique local wind system, which is thought to be influenced by the snow on the slope. In general, on the mountain regions, the nocturnal flows are down-slope and down-valley wind, while the daytime flow are up-slope and up-valley wind. However, in the Mt.Norikura on the winter-spring, the down-slope wind develop afternoon even though daytime. It is a unique local wind system. The snow on the slope of mountain is possible to play a role in the development of the unique wind system. Because a temperature of a snow surface is always near or below 0 ˚C, a downward sensible heat be formed whenever the air temperature is above 0 ˚C. The air over snow that has been cooled by a downward flux of sensible heat produce the down-slope wind in especially the late afternoon of warm, sunny days (Whiteman, 1999). We consider that the unique wind system is formed with the result of the interaction between “down-slope wind on the snow” and “up-slope wind on the no-snow surface“.

Japanese Alps including the Mt.Norikura is known as a heavy snow region, a lot of snow falls on the mountain region in winter (Suzuki, 2013). The snow surface forms a characteristic thermodynamically structure and plays important roles in the atmospheric environmental of mountain regions. However the atmospheric environment of mountain regions have not been understood sufficiently due to insufficiency of meteorological observation. In this research, We will report the relevance between a local wind system and snow on the mountain region with using the data of meteorological observation.

Keywords: mountains meteorological, thermally driven wind, snow

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Mass balance of "Avalanche-accumulation type"glaciers and perennial snow patches in Hida mountain range.

*Kenshiro Arie[1], Chiyuki Narama[2], Kotaro FUKUI[3], Hajime IIDA[3]

1. Graduate School of Science and Technology, Niigata University, 2. Faculty of Science, Niigata University, 3. Tateyama Caldera Sabo Museum

In the Hida mountain range, we clarified mass balance of glaciers and perennial snow patches of ” avalanche-accumulation type" by aerial photos and SfM analysis. Comparing mass balance of the "snowdrift-acumulation type" and "avalanche-accumulation type", "avalanche-accumulation type" was more positive.

Keywords: glacier, perennial snow patch, mass balance, SfM, aerial photography

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Pattern of occurrence of sea of clouds and waterfall cloud near Mt.Nishihotakadake

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The mountain ranges of 3000 m class are connected to the spear ·Mt.Yarigatake-Mt.Hotakadake mountain range, and the mountain ranging from Mt.Nishihotakadake located at the southwest end to Mt.Yakedake, Mt.Norikuradake ridgeline is also over 2000 m. Although it is said that the atmospheric boundary layer is within 1000 meters in the temperate region, situations where the atmosphere boundary layer between Gifu prefecture and Nagano prefecture is divided by continuous mountains often occurs in this area. Under such circumstances, when moist air flows into the lower layer from the Sea of Japan side, it becomes a form that can be stopped at Gifu prefecture side. Furthermore, when an event such as subsidence inversion layer due to high pressure occurs, stratocumulus cover the sky with the reversal layer as the boundary, and a sea of clouds occurs. Analysis of the weather conditions at the time of occurrence revealed that there are some patterns in the inflow of moist air in the lower layer. We also verified the supply of lower layer wetness to maintain the generated cloud sea and the influence of solar radiation at the time of disappearance of the sea of clouds.

In addition, waterfall cloud often occurs near Nishiho Sanso, but this is due to the lowest between Nishiho Maruyama and Mt.Yakedake in the ridgeline leading from Mt.Yarigatake-Mt.Hotakadake mountain range to Mt.Yakedake. It was found that there are two patterns in the waterfall cloud seen in this mountain region. Dynamic things, such as weakening of high pressure and strengthening inflow of moist air in the lower layer, are added at the time of the occurrence of the sea of clouds, the altitude of the sea of clouds rise, and from Nishiho Maruyama - Mt.Yakedake to Nagano Prefecture side It occurs by the cloud overflowing. On a small scale, it is caused by the air rising along the slope like the cap cloud and disappearing when it goes down, but in any case, it will be between Nishiho Maruyama and Mt.Yakutake The low altitude is a major factor in the occurrence.

Keywords: Mt.Yarigatake-Mt.Hotakadake mountain range, sea of clouds, waterfall cloud, inversion layer



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Review and prospect of strong local wind “Matsubori-kaze” blowing at the western foot of Mt. Aso.

*Hiroshi Matsuyama[1]

1. Graduate School of Urban Environmental Sciences, Tokyo Metropolitan University

“Matsubori-kaze” (hereafter referred to as MK) is strong local wind blowing at the western foot of Mt. Aso. It is likely to blow when a depression with warm front is located off the southwestern part of Kyushu. In this presentation, we reviewed the studies on MK and their future.

The first study that investigated MK is Hayamizu and Yamashika (1950). They observed wind speed and temperature at Tateno and Ozu from 10th to 21st November, 1949. Strong local wind blew at night when Kyushu was prevailed by an anticyclone. Because Aso-caldera is located at east, they considered cold air pooled at the caldera flew through Tateno Valley. This study was introduced in the textbook of Yoshino (1961). Yoshino (1968) investigated the distribution of wind breaks around Tateno Valley. They were densely distributed around Tateno Valley, and he estimated MK was the strongest there.

Onodera (1975) opposed to the proposed blowing mechanism of MK . He investigated the diaries of Ozu-higashi elementary school, located at the strongest area of MK. He found MK blew more frequently in spring than in autumn-winter. He also found that a depression with warm front was located at 300 km south of Kyushu when strong MK blew. Onodera (1975) concluded that the inversion layer around the top of Mt. Aso, along with the existence of warm front, was important for the occurrence and intensification of MK.

Ozu-higashi elementary school stopped keeping diaries after October 1971. Because meteorological stations were not located there, we could not know when and how MK blew after October 1971. Yoshino (1986) cited Onodera (1975), however, he still explained MK originated from cold air pooled at Aso-caldera as in Yoshino (1961).

Based on long-term meteorological and mobile observations, Kurose et al. (2002a, b) clearly distinguished two types of winds, i.e., “Aso-oroshi” (hereafter referred to as AO) and MK. Kurose et al. (2002a) found AO was outflow of cold air pooled at Aso-caldera that mainly occurred at calm night in autumn-winter. On the other hand, Kurose et al. (2002b) found MK was airflow over Mt. Aso that occurred in the specific weather condition, i.e., stable stratification was formed at lower part of the troposphere, and southeasterly wind over 10 m/s prevailed at 850 hPa level. Under this condition, the airflow over mountains converged at Tateno Valley, and its wind speed exceeded 10 m/s which usually caused damages in agriculture.

It was speculated that unique topography of Mt. Aso certainly affected MK. By using virtual topographies, Inamura et al. (2009) conducted numerical simulation using meso-scale model (RAMS). They clarified MK was composite wind of downslope wind at the southern slope of Tateno Valley as well as the gap wind through it. They also revealed that a critical layer around 850hPa was important for producing well-mixed stagnant layer and generating the strong wind beneath it.

Matsuyama et al. (2014) conducted questionnaire survey to families of the students at Ozu-higashi elementary school. Keywords in the answer sheets were summarized as “strength and mode of MK,

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“agricultural damage in areas with strong winds”, and “surrendering to MK". Matsuyama (2014) also analyzed written descriptions of the students’ impressions to MK. As for children, keywords were summarized as “fear”, “outdoor experiences”, and “intellectual interest”.

Sakamoto et al. (2014) caught MK blowing on 5th to 6th April, 2013. They conducted mobile observations and investigated the spatial extent to which MK reached. They also reproduced the phenomena by RAMS. The wind speed around Ozu town was on average 1.5 times as large as that at Nishihara village, closely located south of Ozu town. RAMS revealed that fluctuation of wind speeds depended on the relation between the position of Nishihara village and hydraulic jump caused by airflow over Mt. Aso.

Based on meteorological observations, Sagawa (2017) investigated the spatial extent to which AO reached. He also compared wind speeds at Tateno and Fuketa/Uchimaki where MK is the strongest. Sagawa (2017) clarified that AO blew from Fuketa to the Kikuchi-minami fire station. Wind speeds were significantly lower at Tateno both for AO and MK. It was clearly evident during the blowing of MK.

So far, characteristics of MK have been clarified fairly well. For the occurrence of MK, wind direction and wind speed at 850 hPa (about 1500 m a.s.l.) are important information. At central cone of Mt. Aso, Aso-san Meteorological Observatory (1142.3 m a.s.l.) had been operated whose data were frequently used. However, it stopped observations on 11th December, 2017, i.e., it is impossible to use these data in the future. This is a serious damage in the study of MK.

Keywords: Mt. Aso, local wind, Matsubori-kaze, Aso-oroshi, Meteorological observations in mountains

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Two decades of mountain climate monitoring and research: lessons learned and future challenges.

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During the last two decades several efforts have been made in order to have an accurate assessment of climatic conditions in a mountain area in Central Spain (Peñalara Massif). A combination of in-situ measurements, statistical analysis of historical data, use of re-analyses and high resolution modeling has been done in order to overcome the difficulties inherent in such a complex terrain. The first decade has been focused on the design and operation of a mountain observational network. After some efforts, the performance achieved was satisfactory. As a result, long and homogeneous records are now available for the first time. Also, valuable technical and operational information has been gained which helped in the re-design of the network which is now in operation. In the meantime, connections between mountain meteorological phenomena and synoptic forcing has been found using weather typing methods using total column water vapor flux fields from re-analyses. The interaction between regional scale advection of humidity and orography has been identified as the leading phenomena in terms of precipitation. This finally led to the application of an orographic precipitation model giving a high resolution assessment of precipitation at this mountain area which is coherent with in-situ observations. This database opens new horizons of research since it converts point measurements into spatial fields. This comprehensive approach for researching the climate of a mountain area has proven to be effective but also brings future challenges which will be discussed here.

Keywords: Mountain climate, Mountain meteorology, Mountain weather monitoring

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Mon. May 27, 2019 9:00 AM - 10:30 AM JST | Mon. May 27, 2019 12:00 AM - 1:30 AM UTC | 106 1F

[M-IS23] Planetary Volcanology

convener:Rina Noguchi(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Tomokatsu Morota(Graduate School of Environmental Studies, Nagoya University), Kyoko S. Kataoka(Research Institute for Natural Hazards and Disaster Recovery, Niigata University), Shizuka Otsuki(Research Institute of Earthquake and Volcano Geology, Geological Survey of Japan, Advanced Industrial Science and Technology), Chairperson:Rina Noguchi(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Nobuo Geshi(GSJ/AIST)

Volcanoes exist on solid planetary surface across the solar system. They tell insight into the interior, and the surface environment when they were formed and subsequent evolution. Recent high-resolution remote sensing data on extraterrestrial body allows us to analyze on outcrop scales. Now we are on the stage to share the research targets beyond fields of general volcanology and planetary science. Because some geomorphological and geological environments
in other planets are similar to those on Earth, research on volcanic geomorphology and geology on Earth will provide good terrestrial analogues to understand planetary volcanology. The aim of this session is to discuss formation history and mechanism of volcanoes across the solar system.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[MIS23-01] Growth and evolution of isolated volcanic island, Nishinoshima, Ogasawara

★Invited Papers

*Fukashi Maeno[1] (1.Earthquake Research Institute, University of Tokyo)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[MIS23-02] The style of magmatism on terrestrial planets of various sizes predicted from numerical models of mantle dynamics

*Masaki Ogawa[1] (1.Division of General Systems Studies, Graduate School of Arts and Sciences, University of Tokyo)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[MIS23-03] Lunar and Matian lava tubes and explorations to them through their skylight holes

*Junichi Haruyama[1], Takahiro Iwata[1], Yukio Yamamoto[1], Tetsuya Kaku[2,1], Wataru Miyake[2], Atsushi Kumamoto[3], Ken Ishiyama[1], yokota yasuhiro[4], Takumi Ono[2,1] (1.Japan Aerospace Exploration Agency, 2.Tokai University, 3.Tohoku University, 4.Kochi University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[MIS23-04] Volcanic activity on Io, formation of the atmosphere, and escape of atmosphere to the magnetosphere

*Fuminori Tsuchiya[1], Ryoichi Koga[1], Mizuki Yoneda[2], Masato Kagitani[1], Kazuo Yoshioka[4], Reina Hikida[4], Go Murakami[3], Tomoki Kimura[1], Atsushi Yamazaki[3], Hajime Kita[3], Ichiro Yoshikawa[4] (1.Tohoku University, 2.Tadano, 3.ISAS/JAXA, 4.The University of Tokyo)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[MIS23-05] Cryovolcanism, a critical review

*Kei Kurita[1] (1.Earthquake Research Inst.,The University of Tokyo)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[MIS23-06] Cryovolcanisms on Solar System bodies: Observations, importance, and future perspectives

★Invited Papers

*Yasuhito Sekine[1] (1.Earth-Life Science Insitute, Tokyo Institute of Technology)

Growth and evolution of isolated volcanic island, Nishinoshima, Ogasawara

*Fukashi Maeno[1]

1. Earthquake Research Institute, University of Tokyo

The process of birth and growth of ocean islands is an interesting phenomenon in the field of geoscience in terms of the creation of new land and the creation of a place for new terrestrial life activities. Nishinoshima is a rare place on the earth that can trace the process of birth, formation and evolution of such ocean islands from various viewpoints of research fields. Meanwhile, since the eruption in the shallow sea can be a factor of maritime hazards, the establishment of investigation/observation method and risk assessment method is also an important subject. Nishinoshima is located in a place deserving to call as an isolated island, 130 km west of Chichijima, Ogasawara Islands. In November 2013, a new island was born by submarine eruption. It gradually covered the preexisted island and increased the land. A series of eruptive activities in Nishinoshima from 2013 to 2018 provided various valuable data on the birth of a new volcanic island and its growth process, and was also important as a place for practical investigation and observation of remote island volcanoes. The eruptive activity of Nishinoshima is divided into November 2013 - December 2015 (first stage), April to August 2017 (second stage), and July 2018 (third stage). Meanwhile, various surveys and observations were conducted to understand the activities of Nishinoshima. Immediately after the beginning of the eruption, the observation data from remote was the only information source, and based on analysis of high-resolution satellite images and direct observation from the airborne, the growth process of Nishinoshima was monitored, focusing on the changes in surface topography and morphology, area, volume, and discharge rate. After that, following the decline in activity at the end of 2015, comprehensive investigation of volcanic activity and biota was carried out in October 2016. In this survey, earth science and ecological scientists collaborated with each other to conduct a landing survey, in order to minimize the risk of bringing invasive species to new Nishinoshima, and lava samples were collected directly for the first time, and the seismometer and the microphone were also installed. In 2017 and 2018, Nishioshima became active again and grew larger, finally its activity ended at the end of July 2018. After 2016, surveys were conducted remotely utilizing drone and unmanned helicopter, taking images and movies of new lavas and craters, sampling eruptive products, installing and collecting loggers for ecological monitoring, magnetic survey and others were carried out, and the result enhancing our understanding of activities and evolution of Nishinoshima is being obtained. Such surveys and observations in Nishinoshima, where it is difficult to access and the perspective of conservation of primitive ecosystem is also necessary, may have common terms with surveys of extraterrestrial body surface. In this presentation, I will introduce the growth and evolution of Nishinoshima, the volcanic activity, and the methods and results of surveys carried out so far, while being conscious of the connection with planetary volcanology.

Keywords: volcanic island, Nishinoshima, remote observation, landing survey

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The style of magmatism on terrestrial planets of various sizes predicted from numerical models of mantle dynamics

*Masaki Ogawa[1]

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A series of numerical models of magmatism in the convecting mantle suggest that the vigor and style of mantle magmatism critically depend on the planetary size because of its effects on the elementary processes that exert control over mantle dynamics. On a small planet like the Moon, a mild magmatism continuously occurs for several hundred million years in upwelling limbs of mantle convection and then wanes, because the magmatism extracts heat-producing elements (HPEs) from the mantle. Magmatism, however, often becomes more vigorous and episodic, as observed for the Large Igneous Provinces on Mars and larger planets, because the buoyancy of the generated magma boosts the upwelling flow in the mantle that causes the magmatism itself. The convective stirring enhanced by the MMU feedback keeps the mantle rather homogeneous, despite that the vigorous magmatism due to the feedback differentiates the mantle. The effect of the MMU feedback is particularly important in Venus and the Earth where the lower mantle develops: The solid-solid phase transitions that occur at the top of the lower mantle make mantle upwelling flow pulsating, when the mantle is strongly heated by HPEs and magmatism is vigorous. This pulse or burst of hot materials from the lower mantle causes a vigorous magmatism, especially in the early mantle. Due to this vigorous magmatism, the crust enriched in HPEs recycles back to the mantle to serve as the energy source for the magmatism that continues throughout the history of the mantle. On the Earth, plate tectonics also causes magmatism and recycling of the generated crust. In contrast to Venus, this magmatism differentiates the mantle, because tectonic plates and subducting slabs stir the mantle only mildly.

Keywords: magmatism, mantle convection, planetary size, numerical simulation

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Lunar and Matian lava tubes and explorations to them through their skylight holes

*Junichi Haruyama[1], Takahiro Iwata[1], Yukio Yamamoto[1], Tetsuya Kaku[2,1], Wataru Miyake[2], Atsushi Kumamoto[3], Ken Ishiyama[1], yokota yasuhiro[4], Takumi Ono[2,1]

1. Japan Aerospace Exploration Agency, 2. Tokai University, 3. Tohoku University, 4. Kochi University

Large and deep hole structures of a few tens to hundreds meter diameter and depth were discovered on Mars in the thermal emission data acquired by Mars Odyssey THEMIS and on the Moon in the SELENE (Kaguya) Terrain Camera visible image data, about 10 years ago. These are probably skylights of underlying caves produced by volcanic activities such as lava tube formation. Later, many hole structures and depression features as "pits" possibly associated to lava tubes have been identified on these celestial bodies in image data of orbiting explores. Intact lava tube existence on the Moon are also suggested by gravity measurements by GRAIL and radar sounding experiments by SELENE (Kaguya).
The role of lava tube on the formation of vast terrains expanding on the Moon and Mars are scientifically interesting, though the study has not been sufficiently done. In addition, lava tubes and their skylight holes offers prominent environments to conduct scientific examination of the history of volcanic activities on the Mars and Moon. Lava tubes on Mars and the Moon are expected to be secure shelters for humans and instruments potentially protecting from micrometeorites bombardments and cosmic ray radiations, In the next decades, therefore, Martian and lunar lava tube exploration will be executed by space agencies of countires and even private companies.
In this presentation, we would introduce recent studies of lava tubes of Mars and the Moon and their explorations.

Keywords: moon, Mars, hole, lava tube, cave

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Volcanic activity on Io, formation of the atmosphere, and escape of atmosphere to the magnetosphere

*Fuminori Tsuchiya[1], Ryoichi Koga[1], Mizuki Yoneda[2], Masato Kagitani[1], Kazuo Yoshioka[4], Reina Hikida[4], Go Murakami[3], Tomoki Kimura[1], Atsushi Yamazaki[3], Hajime Kita[3], Ichiro Yoshikawa[4]

1. Tohoku University, 2. Tadano, 3. ISAS/JAXA, 4. The University of Tokyo

Jupiter's satellite Io is known as the most active volcanically active body in the solar system. The atmosphere of the satellite consists mainly of volcanic gas composed of sulfur dioxide. The molecular escaped becomes primary source of plasma in the magnetosphere of Jupiter. Here, observations of the volcanic gas escaped from satellite with the extreme ultraviolet telescope satellite, Hisaki, and a groundbased visible telescope, and observations of hot spot of Io's volcano with infrared telescopes are presented. We will discuss the formation of the satellite atmosphere, escape process of the atmospheric gas to the magnetosphere, and their relation to volcano types.

Keywords: volcano, Io, Hisaki

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Cryovolcanism, a critical review

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Volcanoes are surface manifestation of internal activity of planets and satellites. In planetary explorations the primarily available data source would be the surface images so that the volcanoes identified on the surface are unique window into the interior. This argument is particularly significant in icy bodies of the outer solar system because exploration data are so limited except for the surface images. Up to now several types of surface morphology have been considered as a product of cryovolcanism. In this presentation I will focus on the general aspects of the cryovolcanism in comparison to the silicate volcanism and would like to emphasize the significant role of hydrate phase in cryovolcanism.

Similarities and dissimilarities between cryovolcanism and silicate volcanism: There exist a lot of similarities between ice and silicate minerals such as the rheological properties and the melting relationship. The depression of the melting point in the existence of accessary components in both systems should play an important role in promoting differentiation. The critical difference is the pressure dependence of the melting temperature and the density contrast between liquid and solid phase. Since water magma is not buoyant in the icy lithosphere this density reversal requires special mechanism for driving water magma to the surface. This situation is, however similar to the continental basalt volcanism. In the icy satellites the stress field in the outer lithosphere plays an important role. Both exogenetic origin such as tidal forcing and endogenous origin such as thermal stress and volume change driven by phase change would be

Significant role of hydrate phase in cryovolcanism: Hydrate is a common phase in the multicomponent system including H2O. It is stable at higher pressure so that it should be an important constituent phase while it decomposes near surface. This may result in explosive behavior because the decomposition is associated with generation of gas phase. Although a lot of combination of the components form various hydrate phases, there exist two planetologically significant end-members, CO2 hydrate and CH4 hydrate. These two have contrasting nature in terms of the density, which would cause different evolution path in the material differentiation.

Keywords: cryovolcanism, hydrate

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Cryovolcanisms on Solar System bodies: Observations, importance, and future perspectives

*Yasuhito Sekine[1]

1. Earth-Life Science Insitute, Tokyo Institute of Technology

Cyrovolcanos are volcanos on icy planetary bodies, erupting liquids and vapors of volatiles (e.g., water, ammonia, methane, and carbon dioxide) from subsurface water reservoirs or oceans. In the Solar System, geologically-active icy moons (e.g., Enceladus, Titan, and potentially Europa) and icy dwarf planets (e.g., Ceres and Pluto) are known to possess cryovolcanisms in the past or even today.

Cryovolcanos are unique windows to reveal the physico-chemical states of the subsurface oceans of the icy bodies, which is essential to understand the thermal evolution and habitability. Morphology of cryovolcanos would be a key to constrain the physical properties (e.g., viscosity and density) of liquids in the subsurface water reservoirs. Chemical compositions of erupting materials would provide information on volatile and salt compositions of the liquids. Eruption of volatiles (e.g., methane and nitrogen) could be also a major source of atmospheric gas species and thus could have affected the surface environments.

Despite such importance, the nature of cryovolcanisms, such as formation mechanisms and eruption styles, is largely unknown. Since pure liquid water is denser than that of ice, dissolved gas species in cryolava would play a key role for its eruption through bubbling and a consequent decline in the bulk density. Dissolved gas/salt in the liquids also controls the viscosity of cryolava. Such importance of dissolved species in cryovolcanisms implies a potential similarity in the role of volatiles in silicate volcanisms on rocky planets, such as Earth. Here we review recent observations of cryovolcanos on the Solar System icy bodies by spacecrafts. We then discuss the possibility of and future perspectives for development of comparative researches between cryo- and silicate-volcanisms in the Solar System.

Keywords: icy bodies, Solar System exploration, cryovolcano

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Mon. May 27, 2019 1:45 PM - 3:15 PM JST | Mon. May 27, 2019 4:45 AM - 6:15 AM UTC | 201B 2F

[M-IS28] Fluid-sediment migration and geo-bio interaction

convener:Robert Jenkins(School of Geosciences and Civil Engineering, College of Science and Engineering, Kanazawa University), Tomohiro Toki(Faculty of Science, University of the Ryukyus), Akira Ijiri(Japan Agency for Marine-Earth Science and Technology), Takami Nobuhara(Science Education (Geology), Faculty of Education, Shizuoka University), Hiromi Kayama WATANABE(Japan Agency for Marine-Earth Science and Technology), Miho Asada(Japan Agency for Marine-Earth Science and Technology), Chairperson:Tomohiro Toki, Robert Jenkins(Kanazawa University)

Chemosynthetic communities are distributed at hydrothermal system and/or cold seep in bathal zone. They gain their energy from chemosynthetic bacteria, a symbiotic life. The chemosynthetic communities have changed in their taxonomic composition and spatial distribution through the Earth history, but the causes and background remain to be unclear.
Mud volcano is one of geological features which derives fluid nd sediment from depth to the Earth's surface and make topographic feature. It plays a role of carbon cycling connecting depth and surface, pipe of life in depth, disaster and civil engineering. Mechanism and activity of mud volcanoes, however, are not enough understood yet. Mud volcano in Japan is mostly active in offshore fields and are frequently accompanying cold seeps at around it.
Here we propose a joint session with Chemosynthetic communities and Mud volcanoes to have cross-cutting discussion between us. Topics relates to mud volcano will help discussion of evolution of communities and chemosynthetic communities will help to understand mud volcano activity along time and space. Study results for usual two sessions, for cross-cutting discussions, and from related settings are absolutely welcome.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MIS28-01] Upper Pliocene large lucinid communities with cold-seep carbonates from the Shimajiri Group in the Miyagi-jima Island off the central part of Okinawa-jima Island, Japan

*Takami Nobuhara[1], Robert Jenkins[2], Shin-ichi Nomura[3] (1.Science Education (Geology), Faculty of Education, Shizuoka University, 2.School of Natural System, College of Science and Engineering, Kanazawa University, 3.Chiba Prefectural Kisarazu High School)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MIS28-02] Chemosynthetic fossil community in Early Cretaceous methane seep from Yubari City, Hokkaido

*Nanami Shimazu[1], Robert Jenkins[1] (1.Kanazawa University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MIS28-03] Marine Snow Hypothesis: What is controling faunal composition of the methane-seep since Mesozoic?

*Robert Jenkins[1] (1.School of Geosciences and Civil Engineering, College of Science and Engineering, Kanazawa University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MIS28-04] *In situ* Sr isotope analysis of methane-seep carbonates: insight into ancient subseafloor fluid circulation

★Invited Papers

*Yusuke Miyajima[1], Michał Jakubowicz[2,3], Takafumi Hirata[1] (1.Geochemical Research Center, Graduate School of Science, The University of Tokyo, 2.Institute of Geoecology and Geoinformation, Adam Mickiewicz University, Poland, 3.Isotope Laboratory, Adam Mickiewicz University, Poland)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MIS28-05] Monitoring CH_4 amounts deep inside deep-water mud volcanoes

★Invited Papers

*A. Kioka[1], T. Tsuji[2], H. Otsuka[3], J. Ashi[3] (1.Universität Innsbruck, Austria, 2.Kyushu University, Japan, 3.The University of Tokyo, Japan)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MIS28-06] Discussion

*Robert Jenkins[1] (1.School of Natural System, College of Science and Engineering, Kanazawa University)

Upper Pliocene large lucinid communities with cold-seep carbonates from the Shimajiri Group in the Miyagi-jima Island off the central part of Okinawa-jima Island, Japan

*Takami Nobuhara[1], Robert Jenkins[2], Shin-ichi Nomura[3]

1. Science Education (Geology), Faculty of Education, Shizuoka University, 2. School of Natural System, College of Science and Engineering, Kanazawa University, 3. Chiba Prefectural Kisarazu High School

Fossil chemosynthetic lucinid communities occur with pipe- and burrow-cemented concretions from the Upper Pliocene muddy sand facies of the Shimajiri Group in the Miyagi-jima Island off the central part of Okinawa-jima Island, Japan. The outcrop is a sea-cliff wall along the west coast of Miyagi-jima Island, over 30 m high and 150 m long. The cliff consists of muddy sandstone sporadically yielding outer-shelf to upper-slope molluscan fossils, with intercalation of thin fine-grained sandstone layers. We could directly observe only the lower one-third of the cliff wall, but the fossil-lucinid occurrence seems to be restricted to about a five-meter thick horizon, which is associated with pipe- and burrow-cemented concretions.

Lucioma taiwanensis is dominant and forms shell beds and autochthonous shell clusters in matrix-supported condition. In addition “*Meganodontia*” sp., a gigantic lucinid over 10 cm in diameter, was obtained as floatstones, but all specimens are conjoined valves and maybe fell out from sites with abundant burrow-cemented concretions.

The burrow-cemented concretions look like calianassid nests in shape, irregularly sinuous to vertical to beddings, a few centimeters in diameter and over 1 m long. They amalgamated one another to form network-like clusters. The pipe concretions tend to be recognized below the network clusters of burrow-cemented types. The pipes are cylindrical and straight over 30 cm long, nearly vertical to beddings. They are composed of core calcitic cements (2 cm in diameter, -10 to -15 ‰of δ^{13}C) and surrounding dolomitic coating (4 to 5 cm thick, -20 to lower -40 ‰of δ^{13}C). The δ^{13}C value less than -30 ‰indicates methane seep influence in the sub-bottom of the lucinid community. The pipe concretions are also often recognized 5 m below the fossil lucinid horizons, which suggest that the pipe-like conduits of methane seep supported the lucinid communities.
The fossils of *Lucinoma taiwanensis* often preserve their life positions in matrices apart from the burrows and pipes. Therefore the methane-seep through focused pipe-like conduit were succeeded by into diffusive in sandy surface sediments. But some *Lucinoma* conjoined valves in life position are attached to outer walls of burrow-cemented concretions, which suggests that the burrows made contributions to promoting anaerobic oxidation of methane (AOM) and generating H_2S.

Keywords: chemosynthesis, cold seepage, Lucinidae, Okinawa, Pliocene

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Chemosynthetic fossil community in Early Cretaceous methane seep from Yubari City, Hokkaido

*Nanami Shimazu[1], Robert Jenkins[1]

1. Kanazawa University

Japanese archipelagoes have rich fossil record of the methane-seep communities since the Late Cretaceous, however, the Early Cretaceous record is poorly known. Thus, we have investigated the Early Cretaceous (Albian) carbonate rocks found in Utagoesawa Creek, Yubari City, Hokkaido. The locality was previously mentioned in several papers, but the comprehensive approaches including sedimentary petrological, isotope geochemical and paleontological aspects haven't been done.

Many carbonate boulders were found along the creek and it size distribution along the creek suggest its single origin of outcrop. The carbonate rocks show mosaic textures mainly composed of micritic grayish patchy blocks. Bladed calcite and sparry calcite are filled in void spaces. Detailed observation revealed the micrites and the bladed calcites were precipitated in early diagenetic stages, and its isotopic compositions are -45.8 to -35.8 ‰VPDB for carbon and -25.4 to -17.9 ‰VPDB for oxygen.

The petrological and geochemical features indicate that carbonate rocks were formed under influence anaerobic oxidation of methane(AOM) due to the microbial activity in methane seep.

The carbonate rocks yield many bivalves, such as *Caspiconcha*, lucinids, *Nucinella*, solemyids, and thyasirids, and some hokkaidoconchid species.

Those molluscan species are well known from Cretaceous seeps in the world. No brachiopods were found from the locality. The fossil assemblage indicates that the Utagoesawa seep was fully occupied by chemosynthetic molluscan species whereas the Early Cretaceous seeps in California are characterized to have brachiopods.

Campbell and Bottjer (1995) suggested the faunal composition has been changed mainly from brachiopods to bivalves through transition between Early to Late Cretaceous. The current study indicate the phenomenon occurred only restricted in California.

Keywords: methane seep, Early Cretaceous, Chemosynthetic fossil community

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Marine Snow Hypothesis: What is controling faunal composition of the methane-seep since Mesozoic?

*Robert Jenkins[1]

1. School of Geosciences and Civil Engineering, College of Science and Engineering, Kanazawa University

Fossil record of the methane-seep communities shows several interesting phenomena. One of it is the decreasing of epifaunal bivalve/brachiopod in Late Cretaceous. There are several hypotheses, e.g. “sulfate hypothesis” by Kiel (2015), are proposed to explain the situation. Here, I propose another hypothesis to explain the lacking of epifaunal bivalves/brachiopods in the Late Cretaceous. Occurring pattern of epifaunal bivalves/brachiopods through Paleozoic to Neogene is apparently corresponding to the oil resources in sedimentary rocks in each age. The oil production in the sediments are largely related to the primary production in marine, and the origin of methane is ultimately related to the organic matter in the sediment as almost same as oils. The organic matter, deposited on the sea floor, was subsequently used for the generation of methane in the anoxic condition beneath the sea floor after buried. In the case of increasing organic matter settled onto the sea floor, production of methane would be increasing, and if the organic matter decrease, the production rate of methane would be decrease. These methane is energy source for the chemosynthetic community, thus, the primary production rate at the sea surface level by the photosynthesis may control the presence/absence of epifaunal bivalve/brachiopod in seep environment. I coined this hypothesis as 'Marine Snow Hypothesis', because the particulated organic matter sinking to the sea floor is called marine snow.

Keywords: organic flux, methanogenesis, chemosynthetic community

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In situ Sr isotope analysis of methane-seep carbonates: insight into ancient subseafloor fluid circulation

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Along continental margins, tectonic activities trigger subseafloor migration and seepage of geofluids enriched in methane, which sustain chemosynthesis-based biological communities on the seafloor. Depending on their source and migration pathway, seeping fluids have various elemental and isotopic signatures that provide insights into subseafloor fluid–rock interactions and material cycling. At the methane seeps, precipitation of carbonate is induced by microbial oxidation of methane and resultant production of HCO_3^- ions. The methane-seep carbonates record elemental and isotopic signals of seeping fluids in the geological past, and several studies have aimed to decode the origin and migration pathways of ancient seeping fluids using geochemical signatures of the carbonates (e.g., Jakubowicz et al., 2015, 2019).

Strontium isotope ratio ($^{87}Sr/^{86}Sr$) is one of the common tracers of fluid circulation and fluid–rock interactions, and has been applied to seep carbonates (Peckmann et al., 2001; Joseph et al., 2012; Jakubowicz et al., 2019). Methane-seep carbonates are often characterized by complex textures composed mainly of clay- or detritus-rich matrix and detritus-free void cements, the latter of which could archive Sr isotope signals of subsurface fluids distinct from near-seafloor sediments. However, millimeter- or smaller-scale cement phases are difficult to sample using the conventional microdrills without contamination from the matrix. In this study, we applied a high spatial-resolution Sr isotope analysis to cement phases of seep carbonates using laser ablation multiple collector inductively coupled plasma mass spectrometry (LA-MC-ICP-MS), in order to detect “pure” isotope signals of ancient seeping fluids. We measured the Sr isotope ratios in isopachous cements of fossil seep carbonates collected from the Hollard Mound (Middle Devonian, Morocco) and Baška (Lower Cretaceous, Czech Carpathians). Results obtained by LA-MC-ICP-MS were consistent with the isotope ratios measured previously by thermal ionization mass spectrometry coupled with microdrill sampling technique (Jakubowicz et al., 2019). We also tested the method using radial calcite cements of Upper Cretaceous seep carbonates in Hokkaido that are hosted by forearc basin sediments (Yezo Group). The Yezo Group is underlain by Jurassic to Lower Cretaceous mafic basement rocks and input of deep-sourced fluids from the basement rocks could be recorded as ^{87}Sr-depleted signals in the carbonates. Pilot results from one of the Hokkaido seep carbonates, Gakkonosawa, yielded Sr isotope ratios less-radiogenic than those for the coeval seawater, implying deep-fluid input. Exploring the ^{87}Sr-depleted signals at other Cretaceous seeps in Hokkaido would provide more insights into the deep subseafloor fluid circulation in the Cretaceous subduction zone at the eastern margin of the Eurasian Continent.

Keywords: Carbonate, Fluid flow, LA-MC-ICP-MS, Methane seep, Strontium isotopes

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Monitoring CH_4 amounts deep inside deep-water mud volcanoes

*A. Kioka[1], T. Tsuji[2], H. Otsuka[3], J. Ashi[3]

1. Universität Innsbruck, Austria, 2. Kyushu University, Japan, 3. The University of Tokyo, Japan

Mud volcanoes are among the largest geological sources releasing CH_4 gas. Numerous studies have revealed their origins and compositions released from submarine mud volcanoes. Yet, quantification of the amount of gas inside submarine mud volcanoes has been challenging due to the difficulty of in situ measurements, which has hampered better evaluation for their contribution to the global methane budget. Here we provide a coupled geochemical and geophysical model that bridges bulk methane concentrations and seismic wave velocities in the mud conduit of submarine mud volcano. This model is applicable to most submarine mud volcanoes, and is able to estimate methane concentration at greater depths where methane hydrate cannot be present, using downhole logging data or seismic data. Our calculation for submarine mud volcanoes in the Eastern Mediterranean and the Nankai plate subduction zones shows that the weight fractions of gaseous and dissolved methane in total weight of sediment are 1,000--3,500 ppm within their mud conduits, which are much higher than previously expected from pore-water evidence from conventional shallow subsurface sampling. Although more definitive calculations cannot be made until the model parameters are better constrained, our approach provides an opportunity for re-estimating the global methane budget in submarine mud volcanoes, shedding new light upon the impact of submarine mud volcanism on carbon cycle.

Keywords: Submarine mud volcanoes, Methane concentration, Gaseous and dissolved methane, Chemical thermodynamics, Rock physics

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Discussion

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Discussion

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Mon. May 27, 2019 10:45 AM - 12:15 PM JST | Mon. May 27, 2019 1:45 AM - 3:15 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[M-GI33] Data-driven geosciences

convener:Tatsu Kuwatani(Japan Agency for Marine-Earth Science and Technology), Hiromichi Nagao(Earthquake Research Institute, The University of Tokyo), Kenta Ueki(Japan Agency for Marine-Earth Science and Technology), Masayuki Kano(Graduate school of science, Tohoku University), Chairperson:Kenta Ueki, Masayuki Kano(東北大学 大学院理学研究科 地球物理学専攻)

It is important to extract essential processes and structures from observed data sets in order to understand and predict the dynamic behavior of the earth and planetary systems. Recently, many powerful methodologies have been proposed to extract useful information from high-dimensional data sets in information sciences. This session aims to provide an opportunity to gather various geoscientists to have a productive discussion for interdisciplinary collaborations.

10:45 AM - 11:15 AM JST | 1:45 AM - 2:15 AM UTC

[MGI33-01] Forecasting volcanic eruption sequence based on field data and physical models

★Invited Papers

*Takehiro Koyaguchi[1], Kensuke Ishii[2], Kyle R. Anderson[3], Tomofumi Kozono[4] (1.Earthquake Research Institute, University of Tokyo, 2.Meteorological Research Institute, 3.US Geological Survey, 4.Graduate School of Science, Tohoku University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MGI33-02] Sparse modeling based feature selection of magmatic tectonic settings

*Kenta Ueki[1], Hideitsu Hino[2], Tatsu Kuwatani[1,3] (1.Japan Agency for Marine-Earth Science and Technology, 2.The Institute of Statistical Mathematics, 3.Japan Science and Technology Agency)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MGI33-03] Automatic Detection of Stationary Gravity Waves in the Venus' Atmosphere Using Deep Generative Models

*Minori Narita[1], Daiki Kimura[2], Atsushi Yamazaki[3], Takeshi Imamura[1] (1.The University of Tokyo, 2.IBM Research AI, 3.ISAS/JAXA)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MGI33-04] Fracture and mineral distribution analysis using hyper-resolution DEM and hyperspectral satellite imagery for detecting geothermal fluids paths

*Taiki Kubo[1], Hiroaki Gonnokami[1], Arie Naftali Hawu Hede[2], Mohamad Nur Heriawan[2], Irwan Iskandar[2], Katsuaki Koike[1], Sudarto Notosiswoyo[2] (1.Graduate School of Engineering, Kyoto University, 2.Bandung Institute of Technology)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[MGI33-05] **Geochemical characterization of deep-sea sediments in the western North Pacific Ocean by an integrated multivariate statistical technique**

*Kazutaka Yasukawa[1,2], Kentaro Nakamura[1], Koichiro Fujinaga[2,1], Hikaru Iwamori[3,4], Yasuhiro Kato[1,2] (1.School of Engineering, The University of Tokyo, 2.Ocean Resources Research Center for Next Generation, Chiba Institute of Technology, 3.Earthquake Research Institute, The University of Tokyo, 4.Department of Earth and Planetary Sciences, Tokyo Institute of Technology)

Forecasting volcanic eruption sequence based on field data and physical models

*Takehiro Koyaguchi[1], Kensuke Ishii[2], Kyle R. Anderson[3], Tomofumi Kozono[4]

1. Earthquake Research Institute, University of Tokyo, 2. Meteorological Research Institute, 3. US Geological Survey, 4. Graduate School of Science, Tohoku University

Volcanic eruptions often continue for more than a few months or years; the intensity and the style of eruptions remarkably change with time. It is, therefore, desired to forecast such eruption sequences on the basis of field observations during the eruptions. For this purpose, the basic idea of data assimilation is useful. The data assimilation is composed of two mathematical problems: forecasting the system evolution based on forward physical models and determining the model parameters based on inversion analyses of field observations. We are interested in how the mathematical characteristics of the forward models for volcanic eruptions affect those of their inversion problems. In this presentation, we focus on two problems: (1) the estimation of model parameters of magma plumbing system from field observations of magma discharge rate and ground deformation, and (2) the estimation of magma discharge rate of explosive eruptions from tephra-fall deposits.

The inversion problem of magma plumbing system

The eruption sequence is characterized by the evolution of magma discharge rate (Q) and chamber pressure (P) during eruption. To describe the evolution of Q and P, we formulated a model of magma plumbing system composed of a conduit and a magma chamber in elastic rocks. In this model, the effects of gas-exsolution and gas-escape on conduit flow are considered, which leads to complex features of volcanic eruptions such as a transition from a lava-dome forming eruption to an explosive eruption. The eruption style (i.e., evolution of Q and P) is sensitively dependent on model parameters related to geological and petrological conditions (e.g., volume and depth of magma chamber and magma properties). To forecast the eruption sequence, these model parameters need to be estimated from time-varying observations of Q and P through an inverse analysis.

Generally, because of the strong non-linearity of the conduit-flow model, it is mathematically and computationally difficult to investigate the influence of each observation on the estimation of the model parameters. We express the trade-off relationship between the model parameters utilizing analytical solutions of the conduit-flow model (e.g., Koyaguchi, 2005; Kozono and Koyaguchi, 2009), and show that the key parameters that affect the time evolution of P and Q are fundamentally different between explosive and effusive eruptions. Because of this difference, model parameters constrained from the observations of Q and P also depend on whether the eruption is effusive or explosive.

The inversion problem of tephra dispersion

The estimation of magma discharge rate (i.e., Q) is one of the key issues for forecasting volcanic eruption sequence. For explosive eruptions, the value of Q can be estimated from observations of tephra dispersion. The forward model of tephra dispersion is composed of the eruption column dynamics model and the advection-diffusion model. The former describes the supply rate of tephra particles from an eruption column just above the volcano as a function of altitude (referred to as the supply rate function). The latter describes the transportation of tephra particles from the source (i.e., the eruption column just

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above the volcano) to the ground surface.
The above two models have distinct features in the inversion problem. The singular value decomposition (SVD) analysis indicate that the inverse problems of the advection-diffusion model is highly ill-conditioned so that the number of basis functions expressing the supply rate function is limited regardless of the number of data of tephra-fall deposits. On the other hand, the eruption column model indicates that the form of the supply rate function is strongly correlated with the eruption conditions such as Q. We, therefore, attempt to develop a method to estimate the value of Q from the supply rate function expressed by the limited number of basis functions. Some preliminary results on this problem will be presented.

Keywords: volcanic eruption, data assimilation, conduit flow model, tephra dispersal model

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Sparse modeling based feature selection of magmatic tectonic settings

*Kenta Ueki[1], Hideitsu Hino[2], Tatsu Kuwatani[1,3]

1. Japan Agency for Marine-Earth Science and Technology, 2. The Institute of Statistical Mathematics, 3. Japan Science and Technology Agency

Understanding the magma generation processes and characteristic end-members in various tectonic settings is fundamental to understand the material circulation and compositional evolution of the solid Earth. Recent studies based on a machine learning approach revealed that volcanic rocks formed in different tectonic settings have unique geochemical signatures, indicating that both volcanic rock geochemistry and magma generation processes are closely connected to the tectonic setting. We present a result of a feature selection where sparse modeling approach is used. Sparse modeling is an approach in which automatically selects the smallest number of essential variables from high-dimensional data and constructs a succinct model. We used 24 elements and five isotopic ratios of igneous rocks formed in eight different tectonic settings for the feature selection of the settings. In addition to the major and trace element concentrations and isotopic ratios, we also considered combinations of elements, i.e., sum or ratio between two different elements, for the feature selection. This study uses sparse multinomial regression (SMR) approaches for feature selection. Multinomial regression is the classical linear discrimination method. Using the multinomial regression with the sparse modeling approach, a small number of essential geochemical information of tectonic settings are extracted. Based on the automatically selected features, we will discuss the geodynamical and geochemical process to derive various magmas and tectonics.

Keywords: Machine learning, Magma generation, Tectonic setting, Geochemical data

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Automatic Detection of Stationary Gravity Waves in the Venus' Atmosphere Using Deep Generative Models

*Minori Narita[1], Daiki Kimura[2], Atsushi Yamazaki[3], Takeshi Imamura[1]

1. The University of Tokyo, 2. IBM Research AI, 3. ISAS/JAXA

Venus is covered with thick clouds of sulfuric acid, and the entire upper atmosphere rotates much faster than the planet itself. Recently, interhemispheric large bow-shaped structures, remaining fixed above the highland in contrast to background wind fields, were observed in long-infrared and ultraviolet images by Venus Orbiter Akatsuki. These bow-shaped structures are said to be the result of atmospheric gravity waves generated in the lower atmosphere and propagate upwards to the cloud top, which has a significant influence on the Venus' atmospheric system. Not a few bow-shaped, stationary features indicative of topographic gravity waves have been reported so far. However, to unravel where and when these structures appear frequently, we need to analyze the phenomena comprehensively, using much more data. Detection of such characteristic cloud features in images has been done by human eye in Venus research, but to detect many more cases efficiently from massive amounts of image data, we need a framework to do it automatically and robustly. Moreover, most of the bow-shaped structures in ultraviolet images are small, which is almost impossible to find out every case by our eyes.

In this study, we propose a novel approach that detects these stationary features using a deep generative model that has deep neural networks (deep learning). There are various types of such deep models nowadays; we used a variational auto-encoder (VAE) because it has reported good results in dimensionality reduction fields and been a well-known method for image reconstruction. The input and the output of VAE are set to be the same, and the network is divided into two parts, which are the encoder that converts an image to latent representation, and the decoder that reconstructs an image from given latent variables. The detection of stationary features can be seen as an anomaly detection task, which treats images that have stationary features as the anomaly class and the normal cloud image as the normal class.

We used ultraviolet (283 nm) images for this analysis. Firstly, we performed photometric correction using Minnaert Law, and averaged several images taken successively in 24 hours to highlight structures that remains still. Then we extracted features that have scales smaller than 6 degrees by high-pass filtering. Lastly, we extracted image patches from these images. Each patch has the size of 24 degrees both in latitude and longitude. We used images taken in 25 days in 2016 and 2017.

The analysis procedure is as follows. First, we train this network using only normal cloud images that do not include stationary features to let it learn its latent features. When testing, we input test images composed of both normal and anomaly (stationary feature) images, and detect anomalies based on the reconstruction loss that is calculated by the sum of the pixel-wise distance between the original image and the reconstructed image that is output from the last layer in the network. The network has five convolutional layers in the encoder and the decoder, respectively. The latent space has 32 dimensions. We used 4,000 normal cloud images as the training data, and 1,000 normal and 255 anomaly images as the test data.

We evaluated our method by calculating the area under the curve (AUC) of the receiver operating characteristic (ROC) curve. As a result, the AUC was 0.93 (maximum is 1.00), which shows that the

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proposed method successfully detects stationary features. The reconstruction error of a stationary structure image is large because the network cannot reconstruct such bow-shaped structure properly. Our method can be easily applied not only to Venus but also various planetary images to detect characteristic structures.

Keywords: Venus, Deep Learning, Generative Model, Anomaly Detection, Image

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Fracture and mineral distribution analysis using hyper-resolution DEM and hyperspectral satellite imagery for detecting geothermal fluids paths

*Taiki Kubo[1], Hiroaki Gonnokami[1], Arie Naftali Hawu Hede[2], Mohamad Nur Heriawan[2], Irwan Iskandar[2], Katsuaki Koike[1], Sudarto Notosiswoyo[2]

1. Graduate School of Engineering, Kyoto University, 2. Bandung Institute of Technology

From criteria of power output and temporal stability, geothermal is the most promising renewable energy for electrical generation. However, high introduction cost for geothermal power generation, in particular the cost for exploration to identify the geothermal reservoir is a main issue against the plan. Development of more accurate geothermal-resource exploration is necessary for enhancement of geothermal energy use. Detection of geothermal fluids paths including water and steam from geothermal reservoir is a major target in the exploration stage. Topographic analysis is one of the effective methods for the detection. Thus, we have generated a hyper-resolution DEM (HR-DEM) of the Wayang Windu Geothermal Field (WWGF), situated in West Java, Indonesia using UAV. HR-DEM with high spatial resolution (0.5 m) covers an area of 5 km (E–W) by 10 km (N–S) in WWGF. The lineament density map of WWGF was produced by a topographic analysis through HR-DEM. Moreover, spatial distributions of geothermal alteration minerals such as alunite, calcite, and kaolinite were mapped from an image processing of hyperspectral satellite image, Hyperion. A combination of the lineament and mineral distributions specified highly permeable zones in which the fractures and geothermal alteration minerals were concentrated. The location of high igh radon concentration by in-situ measurements correspond well with these estimated permeable zones. Therefore, the integrated analysis is expected to increase the identification accuracy of fluid paths and clarify the geothermal system in WWGF. This research is supported by JST and JICA through Science and Technology Research Partnership for Sustainable Development (SATREPS).

Keywords: alteration mineral, digital elevation model, geothermal reservoir, hyperspectral satellite image, lineament

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Geochemical characterization of deep-sea sediments in the western North Pacific Ocean by an integrated multivariate statistical technique

*Kazutaka Yasukawa[1,2], Kentaro Nakamura[1], Koichiro Fujinaga[2,1], Hikaru Iwamori[3,4], Yasuhiro Kato[1,2]

1. School of Engineering, The University of Tokyo, 2. Ocean Resources Research Center for Next Generation, Chiba Institute of Technology, 3. Earthquake Research Institute, The University of Tokyo, 4. Department of Earth and Planetary Sciences, Tokyo Institute of Technology

Recently, deep-sea sediments highly enriched in rare-earth elements and yttrium (REY) were discovered within the Japanese exclusive economic zone (EEZ) surrounding Minamitorishima Island [1]. To clarify the distribution of the “extremely REY-rich mud”, eight research cruises (KR13-02, MR13-E02, KR14-02, MR14-E02, MR15-E01 Leg2, MR15-02, MR16-07, and KM17-14C) have collected 71 sediment core samples in total from 2013 to 2018. Now we have constructed a comprehensive dataset of major- and trace-element contents of 1,646 samples by X-ray fluorescence and inductively coupled plasma mass spectrometry analyses [1-8].

Here, in order to depict geochemical features of the deep-sea sediments including the extremely REY-rich mud, we applied an integrated method of k-means cluster analysis (KCA) and independent component analysis (ICA) [9] to the huge (1,646 samples x 41 elements) dataset of the deep-sea sediments in and out of the Minamitorishima EEZ. We demonstrate that the data clusters are distributed not randomly but systematically in the real space; the clusters are vertically aligned from the seafloor to depth in a specific order and thus constitute stratigraphic units defined by geochemical features. In addition, the downhole variation of an extracted independent component (IC) shows a stepwise transition across the extremely REY-enriched layer. This transition is ubiquitous in the studied area of several-hundred-kilometer wide. The geochemical clusters just below the IC transition are variable among the cores, which implies that the IC transition corresponds to an unconformity in the sediment column probably due to erosion [5, 6]. These characteristics of the spatial distributions of the geochemical clusters and ICs support a hypothesis previously proposed by Ohta et al. [10]: an enhanced bottom current caused a physical separation of sedimentary particles, or a winnowing effect, and contributed to form the extremely REY-enriched layer by a selective deposition of relatively coarse and dense grains of biogenic Ca-phosphate that significantly accumulate REY from ambient seawater.

[1] Iijima, K. et al., Geochemical Journal 50, 557-573 (2016). [2] Fujinaga, K. et al., Geochemical Journal 50, 575-590 (2016). [3] Takaya, Y. et al. Scientific Reports 8, 5763 (2018). [4] Yasukawa, K. et al., Ore Geology Reviews 102, 260-267 (2018). [5] Yasukawa, K. et al., under review. [6] Tanaka, E. et al., under review. [7] Fujinaga, K. et al., JpGU2018 SCG61-04. [8] Fujinaga, K. et al., JpGU2019. [9] Iwamori, H. et al., Geochemistry, Geophysics, Geosystems 18, 994-1012 (2017). [10] Ohta, J. et al., Geochemical Journal 50, 591-603 (2016).

Keywords: deep-sea sediment, multivariate analysis, independent component analysis, k-means cluster analysis, REY-rich mud, bulk chemical composition

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Mon. May 27, 2019 3:30 PM - 5:00 PM JST | Mon. May 27, 2019 6:30 AM - 8:00 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[M-GI33] Data-driven geosciences

convener:Tatsu Kuwatani(Japan Agency for Marine-Earth Science and Technology), Hiromichi Nagao(Earthquake Research Institute, The University of Tokyo), Kenta Ueki(Japan Agency for Marine-Earth Science and Technology), Masayuki Kano(Graduate school of science, Tohoku University), Chairperson:Tatsu Kuwatani(JAMSTEC), Suguru Yabe(JAMSTEC)

It is important to extract essential processes and structures from observed data sets in order to understand and predict the dynamic behavior of the earth and planetary systems. Recently, many powerful methodologies have been proposed to extract useful information from high-dimensional data sets in information sciences. This session aims to provide an opportunity to gather various geoscientists to have a productive discussion for interdisciplinary collaborations.

3:30 PM - 4:00 PM JST | 6:30 AM - 7:00 AM UTC

[MGI33-06] Markov Chain Monte Carlo: algorithms for multimodal distribution and their applications

★Invited Papers

*Yukito iba[1] (1.The Institute of Statistical Mathematics)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MGI33-07] **Specifying rate constants and reaction path on the water-rock chemical reaction based on exchange Monte Carlo method and sparse modeling**

*Ryosuke Oyanagi[1], Tatsu Kuwatani[1], Omori Toshiaki[2] (1.Japan Agency for Marine-Earth Science and Technology, 2.Kobe University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MGI33-08] Superresolution of X-ray CT images of core samples for understanding the multi-scale structures of water-rock interaction

*Toshiaki Omori[1], Atsushi Okamoto[2], Katsuyoshi Michibayashi[3], Oman Drilling Project Phase 2 Science Party (1.Kobe Univ., 2.Tohoku Univ., 3.Nagoya Univ.)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MGI33-09] 3-dimensional Fracture Network Analysis by Persistent Homology

*Miyuki Miyazawa[1], Anna Suzuki[2], Atsushi Okamoto[1], Hiroyuki Shimizu[3], Ippei Obayashi[4], Yasuaki Hiraoka[4,5], Takatoshi Ito[2] (1.Graduate School of Environmental Studies, Tohoku University, 2.Institute of Fluid Science, Tohoku University, 3.Kajima Corporation, 4.The Advanced Institute for Materials Research, Tohoku University, 5.Kyoto University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MGI33-10] Characteristic patterns and minimal dynamics of correlated seismicity in Japanese island region

*mitsuhiro toriumi[1] (1.Japan agency of marine science and technology)

Markov Chain Monte Carlo: algorithms for multimodal distribution and their applications

*Yukito iba[1]

1. The Institute of Statistical Mathematics

As introduction, history and software of Markov chain Monte Carlo is briefly discussed. Then, replica exchange method (parallel tempering) is explained as a useful tool for sampling multimodal distributions. It is also stressed that applications of Markov chain Monte Carlo are not rescricted to statistical physics or Bayesian computaion; it can deal with a variety of problems related to high dimensional probability, such as counting the number of discrete structures, sampling rare orbits in nonlinear dynamical systems, statistical testing under complicated null hypothesis.

Keywords: Markov Chain Monte Carlo, Replica Exchange Monte Carlo (Parallel Tempering), Bayesian modeling, rare event sampling

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Specifying rate constants and reaction path on the water-rock chemical reaction based on exchange Monte Carlo method and sparse modeling

*Ryosuke Oyanagi[1], Tatsu Kuwatani[1], Omori Toshiaki[2]

1. Japan Agency for Marine-Earth Science and Technology, 2. Kobe University

Water-rock interaction in surface and subsurface environments occurs in complex multicomponent systems and involves several reactions, including element transfer. Such kinetic information is obtained by fitting a forward model into the temporal evolution of solution chemistry or the spatial pattern recorded in the rock samples, although geochemical and petrological data are essentially sparse and noisy. Therefore, the optimization of kinetic parameters sometimes fails to converge toward the global minimum due to being trapped in a local minimum.

In this study, we present a novel framework to estimate multiple reaction-rate constants from the mineral distribution pattern in a rock by using the exchange Monte Carlo method (Hukushima & Nemoto, 1997; Iba, 2001). We applied the method to the synthetic data, which includes nine unknown parameters to be estimated (Oyanagi et al., 2018). As a result, probabilistic distribution of six unknown parameters among them showed normal distributions and the proposed method could find each true parameter. However, the probabilistic distribution of others showed uniform distributions and the proposed method failed to estimate each true value because these parameters did not contribute to the observed dataset. We suggest that effective reaction paths could be extracted from mineral distribution pattern in a rock, by excluding non-effective rate constant using a sparse Modeling.

References

Hukushima K, Nemoto K (1996) Exchange Monte Carlo method and application to spin glass simulations. J Phys Soc Japan 65:1604–1608. doi: 10.1143/JPSJ.65.1604

Iba Y (2001) Extended Ensemble Monte Carlo. Int J Mod Phys C 12:623–656. doi: 10.1142/S0129183101001912

Oyanagi R, Okamoto A, Tsuchiya N (2018) Multiple Kinetic Parameterization in a Reactive Transport Model Using the Exchange Monte Carlo Method. Minerals 8:579. doi: 10.3390/min8120579

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Superresolution of X-ray CT images of core samples for understanding the multi-scale structures of water-rock interaction

*Toshiaki Omori[1], Atsushi Okamoto[2], Katsuyoshi Michibayashi[3], Oman Drilling Project Phase 2 Science Party -

1. Kobe Univ., 2. Tohoku Univ., 3. Nagoya Univ.

X-ray computed tomography (CT) has become a common tool of earth sciences for the 3D imaging of various structures (layering, fractures, pores etc) of rocks. Recently, several scientific drilling projects has been carried out, and the X-ray CT of such cores provide us the 100 to 1000 m scale continuous data. However, the resolution of such X-ray CT for the cores (for example, ~0.17 mm by the X-ray CT of Drilling Chikyu) is slightly low compare to reveal the shape and geometry of mineral grains and thin fractures. In contrast, the resolution of X-ray CT in usual laboratories is high (~0.01 mm). Therefore, if we can link the high resolution X-ray CT in the lab of the limited samples to the low resolution drilling core CT data, we can obtain the valuable big data for the analyses of multi-scale structures.

For this purpose, we have tried to apply sparse superresolution techniques to the sample of serpentinezed dunite in the Moho transition zone taken by the Oman Drilling project (CM1A). We took the X-ray CT images of the samples with the voxel size of 10, 20, 40 and 80 micrometers. The X-ray CT image reveals that distribution of magnetite and spinel grains and fractures filled with serpentine. In sparse image representation framework, an image is expressed as a sparse linear combination of basis images. In learning phase, basis images are learned from multiple X-ray CT images. In superresolution phase, high resolution X-ray CT image is estimated from low resolution one through common sparse representation of basis images between high and low resolution images. By applying the sparse superresolution technique to the sample of serpentinezed dunite, we obtained results that 2x and 4x sparse superresolutions provide fine structure from low resolution X-ray image.

Keywords: Oman Drilling Project, superresolution, sparse modeling

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3-dimensional Fracture Network Analysis by Persistent Homology

*Miyuki Miyazawa[1], Anna Suzuki[2], Atsushi Okamoto[1], Hiroyuki Shimizu[3], Ippei Obayashi[4], Yasuaki Hiraoka[4,5], Takatoshi Ito[2]

1. Graduate School of Environmental Studies, Tohoku University, 2. Institute of Fluid Science, Tohoku University, 3. Kajima Corporation, 4. The Advanced Institute for Materials Research, Tohoku University, 5. Kyoto University

Persistent homology (PH) based on topology is a method for capturing sizes and shapes of “holes”, that is information of connectivity. Because PH enables to quantify complex structures, automatic pattern recognition of fractures can be carried out.

Fluid flow in rocks is dominated by connectivity between fractures, so it can be expected that the relationship between fracture patterns and fluid flow can be obtained by the PH.

In this study, we quantified the images of the results from crack propagations simulation and natural mesh structures in serpentinites. The PH analysis helps to estimate the flow conditions in which the mesh structures in serpentinites were formed. And we can quantify 3D fracture structure by PH. It can be expected that PH is applied to design for geothermal reservoir by coupling PH analysis result of 3D fracture models with feature of fracture (e.g., surface area, volume, connectivity and permeability).

Keywords: Topology, Data science, Mesh structure, 3D printer

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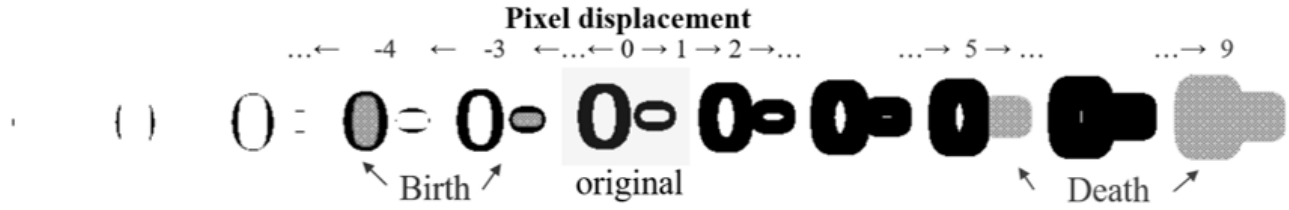


Fig.1 : Example of image analysis by persistent homology.

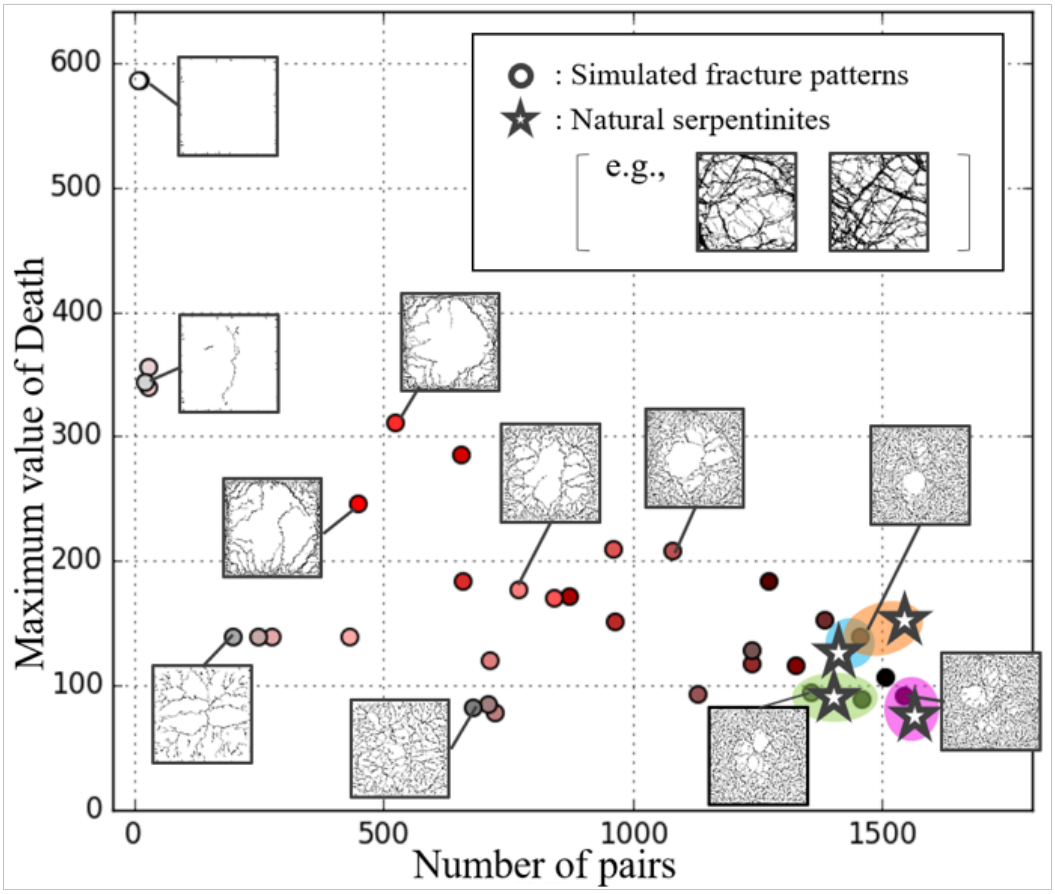


Fig.2 : PH analysis results.

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Characteristic patterns and minimal dynamics of correlated seismicity in Japanese island region

*mitsuhiro toriumi[1]

1. Japan agency of marine science and technology

The seismicity rates in this study are defined as the seismic event numbers of the given volume having one degree of longitude and 2.5 degree of latitude from the surface to 30 km depth and 30 to 660km depth in the Japanese islands region. It shows that the characteristic trends of time series of strongly correlated seismicity are possibly obtained as transformed seismicity rates by SVD; the one shows the long term change, second does the periodic time series with various periodicity involving annual variation, and third does nearly Gaussian noise. The first two types of time series can be mapped as five clusters in the diagram of newly transformed seismicity rate coordinates, suggesting existence of stable nodes with annual oscilation and gaussian noises. From these stable nodes, it concludes that the minimal dynamics of the seismicity of the Japanese island region is approximated as the simple low dimensional nonlinear dynamics with semi-periodic variable as is similar to van del Pol equation.

Keywords: spatio-temporal variation of seismicity, correlated seismicity time series, minimal non-linear dynamics

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[J] Oral | U (Union)：Union

Tue. May 28, 2019 9:00 AM - 10:30 AM JST | Tue. May 28, 2019 12:00 AM - 1:30 AM UTC | 101 1F

[U-03] Future of Scientific Publishing in Geosciences

convener:Hodaka Kawahata(Atmosphere Ocean Research Institute, the University of Tokyo), Hirokuni Oda(Institute of Geology and Geoinformation, Geological Survey of Japan, AIST), Chairperson:Hirokuni Oda, Hodaka Kawahata

JpGU has launched a new open journal "Progress in Earth and Planetary Science" (PEPS) in 2014 and Impact Factor has been given in 2018. Support from JSPS and MEXT for the promotion of open access journals are fundamental for the development of PEPS. In addition to PEPS, academic societies supporting JPGU also promote academic publishing. This session will discuss future of scientific publishing in Geosciences, specially focused on open access e-journal, data publishing and relationships with author ID etc. Keynote speakers will be invited.

9:00 AM - 9:30 AM JST | 12:00 AM - 12:30 AM UTC

[U03-01] Game-change of scholarly communication based on papers and the role of learned society and peer-review

★Invited Papers

*Kazuhiro Hayashi[1] (1.National Institute of Science and Technology Policy)

9:30 AM - 10:00 AM JST | 12:30 AM - 1:00 AM UTC

[U03-02] The future of the journal metrics and new trend of the scholarly publishing

★Invited Papers

*Yoshiko Tanahashi[1] (1.Clarivate Analytics)

10:00 AM - 10:30 AM JST | 1:00 AM - 1:30 AM UTC

[U03-03] Underlying Issues and Problems in Publishing International Scientific Journals in Japan. “DNA Research” As A Case Study.

★Invited Papers

*Michio Oishi[1] (1.Kazusa DNA Research Institute)

Game-change of scholarly communication based on papers and the role of learned society and peer-review

*Kazuhiro Hayashi[1]

1. National Institute of Science and Technology Policy

Author reviews current topics of game-changing in scholarly communication base on papers and discuss the significance of learned society and peer review. Both couldn't stay as they are, but still have potential to keep scholarly communication healthier, resulting in transformation of scholarly society to the new research paradigm.

Keywords: Open Science, Open Access, Research Platform, Peer review

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The future of the journal metrics and new trend of the scholarly publishing

*Yoshiko Tanahashi[1]

1. Clarivate Analytics

The future of the journal metrics and new trend of the scholarly publishing will be discussed.Clarivate Analytics has consistent selection criteria from the 1970s to the present as carefully selecting journals to be included in Web of Science. By looking at the selection criteria, I would like to consider a viewpoint for becoming a globally distinctive journal, managing journals from a global perspective, and seeing the journals originating from Japan to face the global research community with strategy. Furthermore, we summarize statistical data of Web of Science into journals related to JpGU, and present the benchmark which is the basis of grasping the current situation of the journal. I summarize the current status of OA journals, Japan's journal, China's journals on Web of Science as statistics and look at recent trends in the field related to JpGU, and a useful point for strategy formulation to raise the presence of the journal.

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Underlying Issues and Problems in Publishing International Scientific Journals in Japan. “DNA Research” As A Case Study.

*Michio Oishi[1]

1. Kazusa DNA Research Institute

In this presentation, I would like to discuss certain issues and problems in regards to publishing scientific journals in Japan. My talk is a reflection of my experience as the Editor-in-Chief of the journal “DNA Research” which was launched at the inauguration of the Kazusa DNA Research Institute in 1994.

Firstly, I would like to introduce the current status of DNA Research, an open access journal, regarding the editorial policy and processes, the scope, the publisher, the geographical distribution of the submitted and published papers, the acceptance rate, the impact factor (IF) and some other aspects.

Secondly, I would like to discuss some of the issues and problems in publishing scientific journals in Japan. One important issue is how to ensure objectivity in reviewing manuscripts; a problem often stemming from the unique cultural, social and academic environment of Japan. Another important issue is how to maintain a consistent editorial policy over the long term, ideally by the same Editor-in-Chief, Executive Editor and majority of associated editors. This may be difficult for some journals of academic societies in which editors selected from their members undergo turnover of their duties every few years. Furthermore, since any of these editorial jobs is quite demanding, few scientists active in research are willing to accept or assume these positions. Regarding the financing of scientific journals, we, DNA Research, decided not to seek financial support from outside; the reason will be presented.

Thirdly, I would like to list our efforts to improve the IF of our journal which now stands at between 5 and 6. Most researchers agree that it may not be correct to evaluate scientific journals by IF alone, but it is also true that there is no other reliable way to evaluate scientific journals objectively and quantitatively. In fact, the IF is now also being utilized for the evaluation of researchers themselves for the purposes of their promotion, job accession and others by taking into consideration the IF of the journals where their papers have appeared. These developments have prompted us to take steps to strive for a higher IF for our journal.

Fourthly, I would like to mention the challenge of dealing with online-publication (e-publication) and open access of scientific journals. Online-publication has virtually eliminated costs for the printing and delivery of journals, thus paving a way to publishing papers at lower cost which benefits scientific journals like ours without outside financial support. The open access movement, which was originally conceived as the result of the demand from the general public and research funders in US and EU countries, has become a mainstream trend in the publication of scientific journals. In an open access world, revenues come from the article processing charge (APC) rather than subscription charges, providing a new incentive for higher IF journals, since the level of APC often reflects the IF of the journal. Because of these trends, the number of journals which employ online only publication and/or open access is rapidly increasing, thus creating more competitions among scientific journals which are vying for higher-grade (IF) rankings.
Finally, I would like to discuss the need and possibility of creating a journal such as Nature or Science in Japan which focuses specifically on emerging research in the natural sciences in Asia.

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[J] Oral | U (Union)：Union

Tue. May 28, 2019 10:45 AM - 12:15 PM JST | Tue. May 28, 2019 1:45 AM - 3:15 AM UTC | 101 1F

[U-03] Future of Scientific Publishing in Geosciences

convener:Hodaka Kawahata(Atmosphere Ocean Research Institute, the University of Tokyo), Hirokuni Oda(Institute of Geology and Geoinformation, Geological Survey of Japan, AIST), Chairperson:Hirokuni Oda, Hodaka Kawahata

JpGU has launched a new open journal "Progress in Earth and Planetary Science" (PEPS) in 2014 and Impact Factor has been given in 2018. Support from JSPS and MEXT for the promotion of open access journals are fundamental for the development of PEPS. In addition to PEPS, academic societies supporting JPGU also promote academic publishing. This session will discuss future of scientific publishing in Geosciences, specially focused on open access e-journal, data publishing and relationships with author ID etc. Keynote speakers will be invited.

10:45 AM - 11:05 AM JST | 1:45 AM - 2:05 AM UTC

[U03-04] Review of editorial work for PEPS in 2018-2019 and new strategy for 2019–2020

★Invited Papers

*Yasufumi Iryu[1] (1.Institute of Geology and Paleontology Graduate School of Science Tohoku University)

11:05 AM - 11:25 AM JST | 2:05 AM - 2:25 AM UTC

[U03-05] "Earth, Planets and Space" An Open Access Journal: Past, Present and and Future

★Invited Papers

*Yasuo Ogawa[1], Kiyoshi Baba[2] (1.Volcanic Fluid Research Center, School of Science, Tokyo Institute of Technology, 2.Earthquake Research Institute, University of Tokyo)

11:25 AM - 11:55 AM JST | 2:25 AM - 2:55 AM UTC

[U03-06] Scientific Research Output and Publication: research article, data, and digital transformation

★Invited Papers

*Yasuhiro Murayama[1] (1.Strategic Program Produce Office, National Institute of Information and Communications Technology)

11:55 AM - 12:15 PM JST | 2:55 AM - 3:15 AM UTC

[U03-07] **Enhancing dissemination of research activities to international communities by Japanese Geoscience Union**

★Invited Papers

*Hodaka Kawahata[1] (1.Atmosphere Ocean Research Institute, the University of Tokyo)

Review of editorial work for PEPS in 2018-2019 and new strategy for 2019–2020

*Yasufumi Iryu[1]

1. Institute of Geology and Paleontology Graduate School of Science Tohoku University

Progress in Earth and Planetary Science (PEPS) is a peer-reviewed, open-access electric journal published by the Japan Geoscience Union in partnership with Springer. PEPS received its first manuscript at the end of 2013 and we published our first papers in April 2014. By the end of the year 2018 we had published 244 scientific articles. In the first half of the year 2018 PEPS received good news. PEPS received its first Impact Factor of 2.481, which was announced in the June 2018 edition of Clarivate Analytics Journal Citation Reports. PEPS currently ranks 66/189 in the category ‘Geosciences, Multidisciplinary’. Whilst this does not yet make us a Q1 journal we are close.

In addition to being funded by the JpGU, PEPS received a grant-in-aid for scientific research from the Japan Society for the Promotion of Science. As the period covered by this five year grant-in-aid drew to an end we applied for funds for the next five fiscal years (2018-2012). Unfortunately our application has been rejected. Due to this, we were forced to raise article processing charges (APC). Since its inception we have always planned for PEPS to become entirely supported by APCs and therefore completely self financing and we have done some analysis and planning towards this goal. Our analysis shows that the most important thing is that we all focus on maintaining and increasing PEPS’ status as one of the leading journals in our field because this is the surest way of increasing our APC income.

New strategy for 2019-2020 is in preparation and will be introduced in the JpGU meeting 2019.

Keywords: Earth and planetary science, Progress in Earth and Planetary Science, Open access e-journal, Japan Geoscience Union

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"Earth, Planets and Space" An Open Access Journal: Past, Present and and Future

*Yasuo Ogawa[1], Kiyoshi Baba[2]

1. Volcanic Fluid Research Center, School of Science, Tokyo Institute of Technology, 2. Earthquake Research Institute, University of Tokyo

EPS (Earth, Planets and Space) is a peer-reviewed open access journal published on behalf of the following five societies; The Society of Geomagnetism and Earth, Planetary and Space Sciences, The Seismological Society of Japan, The Volcanological Society of Japan, The Geodetic Society of Japan, The Japanese Society for Planetary Sciences. These five societies are all society members of the Japan Geoscience Union.

EPS was established in 1998 as a continuation of the two journals, the Journal of Geomagnetism and Geoelectricity (1949 to 1997) and the Journal of Physics of the Earth (1952 to 1997). In 2014 we started open access publication under the SpringerOpen platform. Open Access publication successfully shortened the publication time, increased visibility of the journal and widened its international readership. We publish average of 190 papers per year and half of the authors are from overseas. One of the qualification indices of the journal, impact factor (IF), is continuously increasing from 1.328 (2014) to 2.773 (2017) and it will also go over 2.6 in 2018. The increasing IF is supported both by increase of highly cited papers and by decrease of uncited papers, suggesting the success of quality control by the editorial board and possibly increasing of the visibility via open access.

The scope of EPS covers Earth and Planetary Sciences, particularly geomagnetism, aeronomy, space science, seismology, volcanology, geodesy, and planetary science. The EPS share common scopes as well as a common journal platform with PEPS (Progress in Earth and Planetary Science). In contrast to PEPS, which emphasizes review papers, EPS is characterized by the following article types: (1) “Express Letter” which aims at fast publications, (2) “Technical reports “, which describe technical developments for scientific researches and (3) “Frontier Letters” for leading edge researches only with the invitation from the editor in chief. EPS promotes topical article collections (what we call special issues) on the first results of geoscientific events (earthquakes and volcanic eruptions) and scientific missions (satellite missions). EPS has been recently successful in attractive special issues.

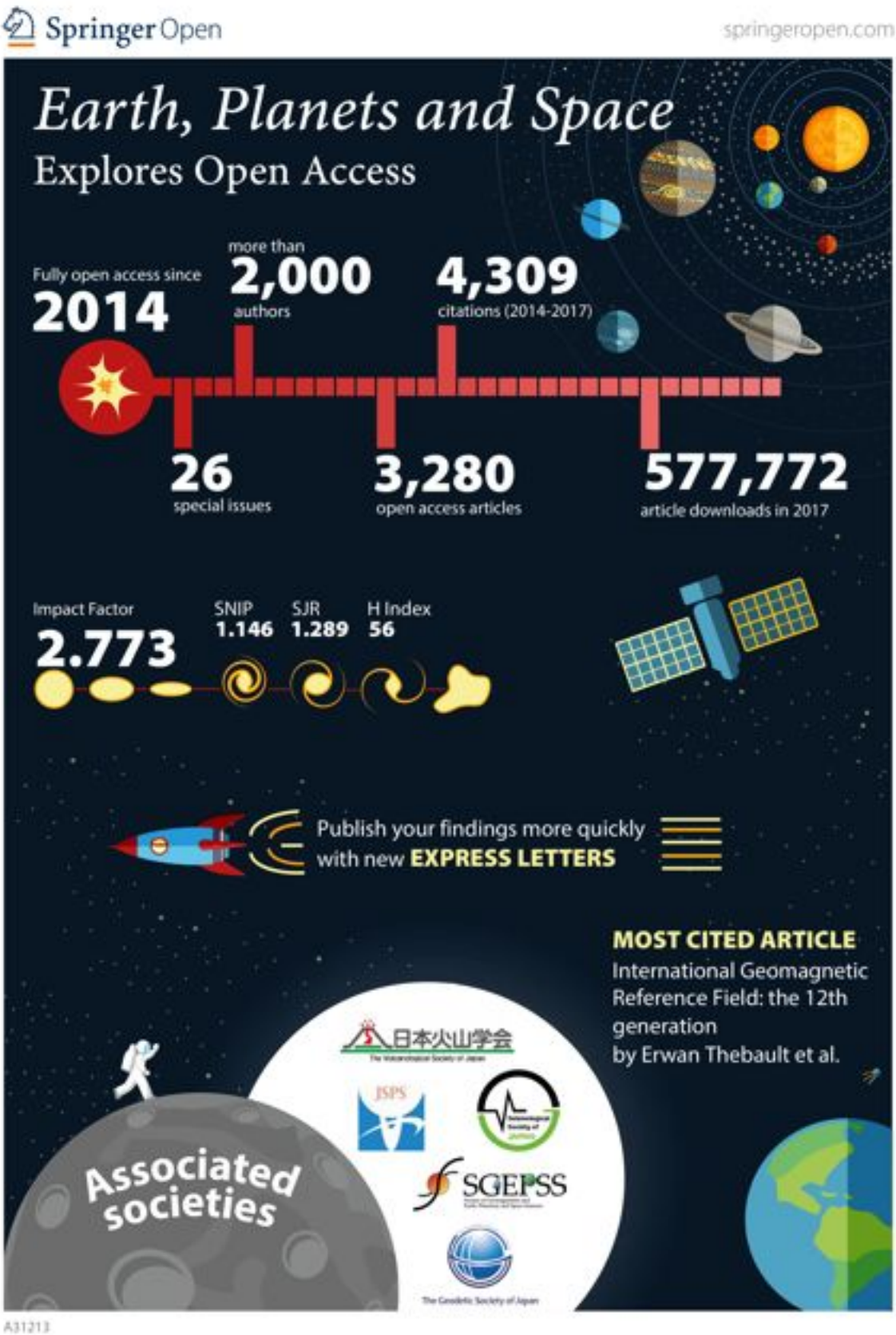
Aiming at fast and qualified review system, we have expanded editorial board members internationally since 2017. Now we have currently 50 regular editors (including 22 oversea editors). The oversea editors are 10 from Europe, 3 from North America, 5 from Asia, and 3 from Oceania.

As part of the promotion of the journal we have four annual awards to recognize authors and reviewers: (1) EPS Excellent paper awards, (2) EPS Young researcher award, (3) Highlighted Paper Awards and (4) Excellent Paper Awards.

From 2018, EPS has strengthened ties with JpGU. EPS has started collaborative advertisement activities at major domestic and international academic meetings, like JpGU, AGU, EGU and AOGS. EPS has updated the APC (Article Processing Charge) in September 2018 for sustainable operations of the journal.

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Keywords: open access journal, Earth and Planetary sciences



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Scientific Research Output and Publication: research article, data, and digital transformation

*Yasuhiro Murayama[1]

1. Strategic Program Produce Office, National Institute of Information and Communications Technology

Scientific Research Output and Publication will be argued in terms of original research paper, research data, and digital transformation of the society, which is expected to contribute to the better conduct of science and better contribution to the society and tax payers for a longer term with sustaianble ecocycle of scientific results, scientific data, scientists and scientific research invenstiment. This paper attempts to discuss the points.

Keywords: open access, research data, digital transformation

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Enhancing dissemination of research activities to international communities by Japanese Geoscience Union

*Hodaka Kawahata[1]

1. Atmosphere Ocean Research Institute, the University of Tokyo

Progress in Earth and Planetary Science (PEPS) is our official scientific journal established in April 2014 with 51 society members by partnership with Springer. 5 years have passed. This is an English-language peer-reviewed open access e-journal under a collaboration with Springer-Nature. The journal is to be devoted to original articles and reviews (>20%) in the research fields of space and planetary sciences; atmospheric and hydrospheric sciences; human geosciences; solid earth sciences; and bio-geosciences.

In June, 2018, PEPS got the first Impact factor of around 2.48. Now we are taking effective steps (measures) and then hope to get higher IF, around 3, in 2019, hopefully.

JpGU will make an effort to promote the journals which have been published by Japanese Geoscience Societies, taking part in JpGU, including EPS.

Keywords: open access, e-journal , Progress in Earth and Planetary Science

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[J] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

Tue. May 28, 2019 9:00 AM - 10:30 AM JST | Tue. May 28, 2019 12:00 AM - 1:30 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-PS06] Planetary Sciences

convener:Kenji Kurosaki(Department of Physics, Nagoya University), Yusuke Nakauchi(Japan Aerospace Exploration Agency), Chairperson:Ryo Suetsugu(University of Occupational and Environmental Health, Japan), Keisuke Sugiura(Nagoya University)

We call for general interest papers for Planetary Scienses. Planetary Sciences consist of a variety of studies on the past, present, and future of our solar system and exoplanetary systems, Discussions based on various backgrounds are encouraged.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[PPS06-25] Tensile Strength of Porous Dust Aggregates Measured with Dust N-body Simulations

*Misako Tatsuuma[1,2], Akimasa Kataoka[2], Hidekazu Tanaka[3] (1.The University of Tokyo, 2.National Astronomical Observatory of Japan, 3.Tohoku University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[PPS06-26] Filling factor dependence of the thermal conductivity understood from the graph structure of dust aggregates

*Sota ARAKAWA[1], Masaki TAKEMOTO[1], Taishi NAKAMOTO[1] (1.Tokyo Institute of Technology)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[PPS06-27] Collisional disruption of planetesimals: dependence of material strength

*Ryo Suetsugu[1], Hidekazu Tanaka[2], Hiroshi Kobayashi[3], Hidenori Genda[4] (1.University of Occupational and Environmental Health, 2.Tohoku University, 3.Nagoya University, 4.Tokyo Institute of Technology)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[PPS06-28] Size and cooling rate of chondrules formed thorough collision between planetesimals containing volatile materials

*Sin-iti Sirono[1] (1.Department of Earth and Planetary Sciences, Nagoya University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[PPS06-29] From Dust to Planet via collisional growth

*Hiroshi Kobayashi[1], Hidekazu Tanaka[2] (1.Department of Physics, Nagoya University, 2.Tohoku University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[PPS06-30] Impact Conditions for the Formation of the Extremely Elongated Shape of 1I/'Oumuamua

*Keisuke Sugiura[1], Hiroshi Kobayashi[1], Shu-ichiro Inutsuka[1] (1.NAGOYA UNIVERSITY Graduate School of Science)

Tensile Strength of Porous Dust Aggregates Measured with Dust N-body Simulations

*Misako Tatsuuma[1,2], Akimasa Kataoka[2], Hidekazu Tanaka[3]

1. The University of Tokyo, 2. National Astronomical Observatory of Japan, 3. Tohoku University

The formation process of μm-sized dust grains into km-sized planetesimals in planet formation has several theories such as direct coalescence growth and concentration due to instability and has not yet been unraveled. It is difficult to verify the formation process because we cannot directly observe planetesimals forming in protoplanetary disks. Therefore, we focus on comets which are the most primitive bodies in our solar system and are thought to be leftover planetesimals. Comets are capable of detailed observation by spacecraft. In this work, we focused on the tensile strength of 67P/Churyumov-Gerasimenko, which is one of the comets in our solar system and was observed by the Rosetta mission.

In order to investigate whether or not the formation process of planetesimals can be restricted by their tensile strength, we conducted N-body simulations considering the interaction model of dust particles (Wada et al. 2007, ApJ, 661, 320) and investigated the tensile strength of porous dust aggregates. The initial dust aggregates were isotropically and statically compressed to simulate their formation process (Kataoka et al. 2013, A&A, 554, A4). As a result of our numerical simulations, we found that tensile stress gradually increases as tensile displacement increases, and then the tensile stress takes the maximum value. In other words, the tensile strength was obtained. We also confirmed that cutting of contacts between particles in the dust aggregates begins to occur near the maximum tensile stress. We obtained the relation that the tensile strength of dust aggregates is proportional to the 1.8 power of the initial volume filling factor, inversely proportional to the constituent particle radius, and proportional to the surface energy of the constituent material. Moreover, we succeeded in reproducing numerical simulation results by using a semi-analytical model that the tensile strength is determined by cutting of contacts between particles. It was also revealed that the constituent particle radius of comet 67P has to be about 3.3–220 μm to reproduce its tensile strength using our model. In the conventional planet formation theory, the constituent particle radius is assumed to be 0.1 μm same as the interstellar dust radius and is different from the value obtained from our model. It is necessary to reconsider theories such as the time evolution of the constituent particle radius.

Keywords: Protoplanetary disks, Planetesimals, Comets, Tensile Strength

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Filling factor dependence of the thermal conductivity understood from the graph structure of dust aggregates

*Sota ARAKAWA[1], Masaki TAKEMOTO[1], Taishi NAKAMOTO[1]

1. Tokyo Institute of Technology

Previous studies (Arakawa *et al*. 2017; 2019) revealed that the thermal conductivity through the solid network of dust aggregates is proportional to the square of the filling factor. However, the reason why the thermal conductivity is given by the power-law function of the filling factor was still unclear. In order to understand the physical reason of this power-law dependence, we need to investigate the geometric structure of highly porous dust aggregates.
In this study, we study the graph structure of fractal aggregates called BCCA aggregates (e.g., Meakin 1991). The fractal dimension of BCCA aggregates is approximately 1.9 (e.g., Okuzumi *et al.* 2009) and the graph structure of BCCA aggregates is classified as a tree. Then the gyration radius r_g and the filling factor ϕ is connected by the following equation, $r_g \simeq \phi^{-1/(3-1.9)}$, and the number of the heat conduction path per unit area, σ, is given by $\sigma \simeq \phi^{2/(3-1.9)}$ for BCCA aggregates. In addition, we calculated the graph-theoretical distances of monomer grains within a BCCA aggregate. We found that the root mean square of the graph-theoretical distance d is given by $d \simeq r_g^{1.2}$. Therefore, the thermal conductivity of BCCA aggregates is proportional to $\sigma r_g / d \simeq \phi^2$.

Keywords: thermal conductivity, dust aggregate, powder and granular material

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Collisional disruption of planetesimals: dependence of material strength

*Ryo Suetsugu[1], Hidekazu Tanaka[2], Hiroshi Kobayashi[3], Hidenori Genda[4]

1. University of Occupational and Environmental Health, 2. Tohoku University, 3. Nagoya University, 4. Tokyo Institute of Technology

Collisions are one of the most important processes in planet formation because planetary bodies in the Solar System are thought to have experienced a lot of collisions during the accretion process. Thus, collisional processes have been examined extensively. Roughly speaking, collisional outcomes can be classified into disruptive collisions and erosive collisions by the specific impact energy Q_R. In particular, the specific impact energy required to disperse the largest body such that it has exactly half its total mass after the collision is called the critical specific impact energy Q_{RD}^*. In the case of $Q_R > Q_{RD}^*$, collisions between planetesimals are regarded as disruptive collisions, while they are non-disruptive collisions for $Q_R << Q_{RD}^*$, whose mass ejection is small. The values of Q_{RD}^* have been investigated by laboratory experiments and numerical simulations. When the target is small enough to neglect the effect of the target's gravity, the critical specific impact energy is mainly estimated by laboratory experiments. As target size increases, collision outcomes gradually become dominated by the gravity of the target. However, direct experimental measurements of a large scale collision are difficult to carry out in the laboratory. Thus, the values of Q_{RD}^* for large targets are estimated via shock-physics code calculations, which compute the propagation of the shock wave caused by a high velocity collision: Lagrangian hydrocode such as Smoothed Particle Hydrodynamics (SPH) methods, or a hybrid code of Eulerian hydrocode and N-body. These numerical simulations showed the dependence of the value of Q_{RD}^* on various impact conditions such as target size, impact velocity, material properties, impact angle, and numerical resolution. Recently, we performed impact simulation using the grid-based code (iSALE) in the gravity regime, because almost all high velocity collisions have been examined by the SPH method. We showed that collision outcomes of the iSALE simulation agree well with those of the SPH simulation.
As mentioned above, material properties of the target affect collisional outcomes. However, the dependence of Q_{RD}^* on material properties was not studied in detail. In this study, we perform impact simulations in the gravity regime by using shock-physics code, iSALE. We will discuss the dependence of Q_{RD}^* on material properties and impact conditions for a wide range of specific impact energy, and compare our results with previous studies.

Keywords: Planetary formation, Impact processes

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Size and cooling rate of chondrules formed thorough collision between planetesimals containing volatile materials

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1. Department of Earth and Planetary Sciences, Nagoya University

Chondrite meteorite contains "chondrules", which are silicate spheres with sizes of 0.1-2 mm. Volume fraction of chondrules exceeds 80% in some chondrites. Its shape and high fraction indicate that chondrules were formed through common heating event in the solar nebula. Cooling rate of chondule has been estimated as 10-1000 K/h from laboratory experiments. The size and cooling rate are the most important quantities which characterize chondrules. Although many models have been proposed, the parameter range suitable for chondrule formation is limited in most models.

Collision of planetesimals has been studied as a chondrule forming mechanism. It requires high velocity collision > km/s which is difficult to attain in the solar nebula. However, the formation of Jupiter can excite the motion of planetesimals. Nagasawa et al. (2019) showed that the impact velocity between planetesimals can exceed 10 km/s due to the exitation. Moreover, the age of chondrules ranges between 1 and 3 Myr after CAI. This is consistent to the timing of Jupiter fomation and duration of excited motion of planetesimals.

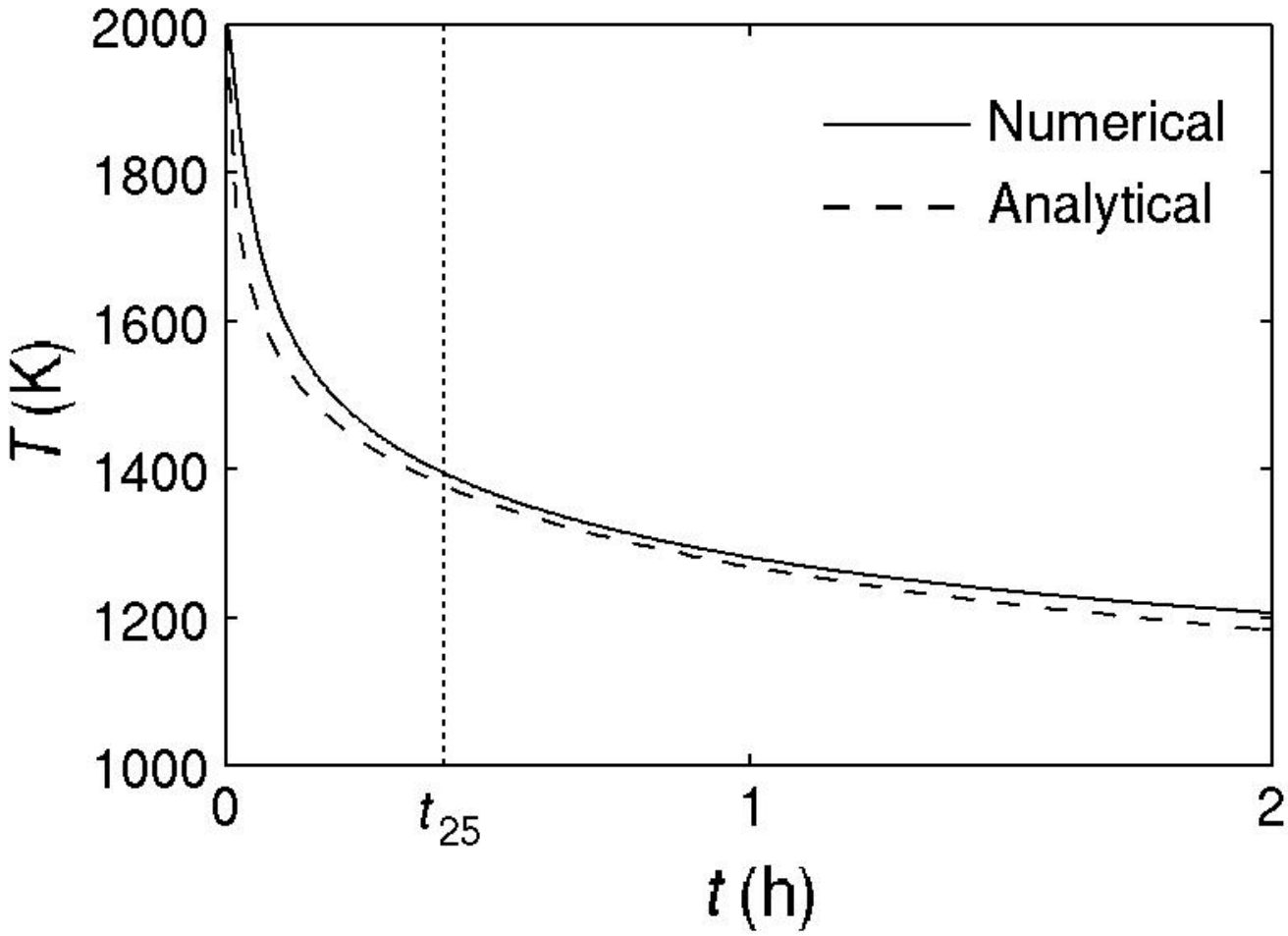
In order to form chondrules of 0.1-2mm size, high gas dynamic pressure is necessary. The gas in the solar nebula is too rare to breakup silicate melt down to the size range. If a colliding plantesimal contains volatile materials, they evapolate quickly and expand because of the collisional heating. The velocity difference between silicate melt and gas can lead to breakup of silicate melt. The size of melt droplet is determined by Weber number, which is a ratio between gas dynamic pressure and surface tension. I conducted 1-D numerical simulation of expansion of gas-melt mixture. The simluation parameters are the thickness of the mixture L, mass fraction of volatile materials f, and initial temperature $T_{0.}$ I adopted physical parameters of H_2O, and ideal gas is assumed for simplicity.

Figure shows typical evolution of temperatrure. The temperature of the mixture decreases by the expansion of the gas. In this case, the cooling rate is ~1000 K/h. I conducted simluations with various parameter sets. The range of droplet size is 0.3-2mm. Cooling rate is 100-10000 K/h. These ranges are consistent to those of chondrules.

It is possible that the volatile material is not water but organics. If this is the case, the gas is reducing and Fe becomes Fe metal, not FeO. Then the variation of oxidation condition of Fe can explain by the variation of volatile materials. Moreover, if the inside of a planetesimal is melted due to heating by ^{26}Al, Fe migrates to the center of a planetesimal and avoid collision. Then the variation of Fe content (seen as H, L, LL chondrites) can be explained by the internal melting of a planetesimal.

Keywords: chondrule, volatile material, planetesimal, size, cooling rate

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From Dust to Planet via collisional growth

*Hiroshi Kobayashi[1], Hidekazu Tanaka[2]

1. Department of Physics, Nagoya University, 2. Tohoku University

We investigate collisional evolution from dust to planets in protoplanetary disks. For the collisional growth of dust, the bulk density evolution of dust aggregates is important. On the other hand, the random velocity evolution is needed to be considered for planetesimal growth. We take into account both effects consistently and then carry out the simulation for collisional growth from dust to planets. We show planets are possible to be formed via collisional growth of dust.

Keywords: planet formation, protoplanetary disk

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Impact Conditions for the Formation of the Extremely Elongated Shape of 1I/’Oumuamua

*Keisuke Sugiura[1], Hiroshi Kobayashi[1], Shu-ichiro Inutsuka[1]

1. NAGOYA UNIVERSITY Graduate School of Science

1I/’Oumuamua is considered to be the first interstellar object observed by the Pan-STARRS telescope on October 2017. The eccentricity of 1I/’Oumuamua is about 1.2, which corresponds to the relative velocity with respect to the sun at infinity of 26 km/s. This relative velocity at infinity is comparable to the relative velocity of solar neighborhoods, and thus we consider that 1I/’Oumuamua came from a nearby planetary system. The absolute magnitude of this object is about 22 magnitude, which corresponds to the size of about 100 m with the albedo of 0.04. This object shows large light curve amplitude of at most 2.5 magnitude, and the shape of 1I/’Oumuamua is estimated to be the extremely elongated one with the ratio of the intermediate to major axis lengths less than 0.3.

To examine whether asteroidal impacts can form the extremely elongated shape of 1I/’Oumuamua or not, we conduct numerical simulations of collisions between asteroids. We use a Smoothed Particle Hydrodynamics code for elastic dynamics with the self gravity, a fracture model for rocky material, and a friction model for completely damaged rocks. We assume that impacting bodies do not have tensile strength of monolith bodies but have frictional forces of granular material. The diameter of target bodies is fixed to 100 m. We conduct impact simulations with various ratios of the masses of two impacting bodies, friction angles, impact angles, and impact velocities, and then we investigate the impact conditions required for the formation of the extremely elongated objects with the ratio of the intermediate to major axis lengths less than 0.3.

As a result of the impact simulations, we find that the formation of the extremely elongated bodies requires the mass ratio larger than 0.5, the friction angle larger than 40 degrees, the impact angle less than 30 degrees, and the impact velocity less than 40 cm/s. The most difficult condition to be realized among these conditions is the impact velocity; the required impact velocity is much smaller than the average impact velocity in the main belt ~ 5 km/s.

The impact velocities less than 40 cm/s require dynamically cold environments in protoplanetary disks. However, turbulent scattering due to gas or gravitational scattering due to larger bodies increase the relative velocities. We estimate required turbulent strength and the size of larger bodies and find that the Shakura-Sunyaev alpha parameter less than $10^{-4}$and the size of larger bodies less than 7 km realize the relative velocities between 100-m sized bodies less than 40 cm/s. This turbulent strength is realized at the places where magnetorotational instability is not active. The size of bodies less than 7 km is realized only in extremely young protoplanetary disks. Therefore,1I/’Oumuamua might have been formed in such an extremely primordial protoplanetary disk, then might have been ejected from the planetary system due to, for example, a stellar encounter, and then visited our solar system.

Keywords: 1I/’Oumuamua, extremely elongated shape, asteroidal impact, numerical simulation, SPH method

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[J] Oral | P (Space and Planetary Sciences)：P-CG Complex & General

Tue. May 28, 2019 9:00 AM - 10:30 AM JST | Tue. May 28, 2019 12:00 AM - 1:30 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[P-CG25] Planetary Magnetosphere, Ionosphere, and Atmosphere

convener:Kanako Seki(Graduate School of Science, University of Tokyo), Takeshi Imamura(Graduate School of Frontier Sciences, The University of Tokyo), Hiroyuki Maezawa(Department of Physical Science Osaka Prefecture University), Naoki Terada(Graduate School of Science, Tohoku University), Chairperson:Masaki Nishino(名古屋大学宇宙地球環境研究所), Hiroyuki Maezawa(大阪府立大学大学院理学系研究科)

Exploration of Moon, Venus, Mars, Mercury, Jupiter, Saturn, and beyond together with rapid developments of numerical simulations provides us new view of planetary environment. This session collects general contributions of new findings about planetary magnetosphere, ionosphere, and atmosphere. New methodology and technology development studies for future explorations are also welcome. In order to put the common knowledge at different planets into perspective, this session aims to facilitate discussions on comparative planetary environments.

9:00 AM - 9:30 AM JST | 12:00 AM - 12:30 AM UTC

Introduction

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[PCG25-01] On the observational constraint on time and spatial variation of Titan's atmospheric trace gases driven with the ALMA solar system big-data

*Takahiro IINO[1,2], Hideo Sagawa[3], Takashi Tsukagoshi[4] (1.The University of Tokyo, 2.Tokyo Univ. of Agr. and Tech., 3.Kyoto Sangyo University, 4.NAOJ)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[PCG25-02] Transport and energization of planetary ions in the magnetospheric flanks of Mercury

*Sae Aizawa[1], Dominique Delcourt[2], Naoki Terada[1] (1.Graduate School of Science,Tohoku University, 2.LPC2E, CNRS)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[PCG25-03] Exploring the real-time prediction of Mercury's magnetosphere

*Manabu Yagi[1], Kanako Seki[2], Yosuke Matsumoto[3], Dominique C. Delcourt[4], Francois Leblanc[4] (1.RIKEN Center for Computational Science, 2.Graduate School of Science, University of Tokyo, 3.Graduate School of Science, Chiba University, 4.The National Center for Scientific Research)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[PCG25-04] Model study on the contribution of various physical processes for generation and dissipation of Mercury's exosphere

*Yudai Suzuki[1], Kazuo Yoshioka[1] (1.University of Tokyo)

On the observational constraint on time and spatial variation of Titan's atmospheric trace gases driven with the ALMA solar system big-data

*Takahiro IINO[1,2], Hideo Sagawa[3], Takashi Tsukagoshi[4]

1. The University of Tokyo, 2. Tokyo Univ. of Agr. and Tech., 3. Kyoto Sangyo University, 4. NAOJ

Titan's atmosphere is characterized by the presence of the number of trace gases such as hydrocarbons and nitriles produced with complex photochemical processes. Cassini spacecraft, which completed its works in 2017, has played an important role to illustrate the dynamic variation of the trace gases. For example, on the high-latitudinal region of the southern hemisphere, both hydrogen cyanide (HCN) and benzene (C_6H_6) exhibited ~1000 times enhancement of their atmospheric abundances from 2011 to 2015 (Coustenis et al. 2016). For the understanding of complicated photochemical processes of Titan, long-term observation of the spatial distribution of such trace gases are crucial.

ALMA is a suitable tool for that purpose. We have constructed a large spectroscopic data-set of Titan's trace gases by converting ALMA's archival data obtained for the calibration purpose into the scientific data known as "FITS cube", which contains calibrated spectra in each 2-D image pixels. Extracted number of Titan's FITS data is more than 3000. Many trace gases such as carbon monoxide (CO), HCN, acetonitrile (CH_3CN), cyanoacetylene (HC_3N) and their isotopologues and other complex molecules are detected clearly. For the illustration of the time distribution, spectral intensity distribution maps of all detected species were produced.

From the analysis of the spectral intensity distribution map, from mid 2015, intensities of HC_3N measured on southern hemisphere is stronger than that of northern hemisphere. In turn, northern hemispheric CH_3CN and HCN intensities are still stronger than that of south in 2015 and 2017, respectively. Newly found difference of the time variation between the nitriles possibly reflects their photochemical production/destruction timescale against the seasonal variation of UV influx and atmospheric circulation. Currently, we are attempting to develop the semi-automated atmospheric retrieval code to reproduce the 3-D distribution of trace species to constrain the photochemical processes.

Keywords: Titan, ALMA, Planetary atmosphere

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Transport and energization of planetary ions in the magnetospheric flanks of Mercury

*Sae Aizawa[1], Dominique Delcourt[2], Naoki Terada[1]

1. Graduate School of Science,Tohoku University, 2. LPC2E, CNRS

The transport and energization of planetary ions within Kelvin-Helmholtz (KH) vortices developing in the magnetospheric flanks of Mercury are investigated using both numerical methods and data analysis. Due to the presence of heavy ions of planetary origin (e.g., O^+, Na^+, and K^+) and the complicated field structure present during the KH vortex development, the scale of electric field variations can be comparable to that of the ion gyromotion. Therefore, ions may experience non-adiabatic energization as they drift across the magnetopause. In this study, we focus on the effects of the spatial/temporal variations of the electric field along the ion path. We show that the intensification, rather than the change in orientation, is responsible for large non-adiabatic energization of heavy ions of planetary origin. This energization systematically occurs for ions with low initial energies in the direction perpendicular to the magnetic field. The energy gain is of the order of the energy corresponding to the maximum *ExB* drift speed. It is also found that the ion transport across the magnetopause is controlled by the orientation of the magnetosheath electric field. Analyzing data from MESSENGER allow us to compare the observational facts with our numerical results. We find that the counts of Na^+-group detected by FIPS increase with the existence of KH waves, which is consistent with our numerical results. Although some differences in the energy distribution are expected in our numerical results, the data show no significant differences. This will be the subject of further studies using the newly developed BepiColombo instruments.

Keywords: Non-adiabatic energization, Mercury's magnetosphere, FIPS/MESSENGER, Kelvin-Helmholtz instability

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Exploring the real-time prediction of Mercury's magnetosphere

*Manabu Yagi[1], Kanako Seki[2], Yosuke Matsumoto[3], Dominique C. Delcourt[4], Francois Leblanc[4]

1. RIKEN Center for Computational Science, 2. Graduate School of Science, University of Tokyo, 3. Graduate School of Science, Chiba University, 4. The National Center for Scientific Research

Observations by MESSENGER found that Mercury's magnetosphere is analogous to the Earth's while there are several differences of the two. Big differences from the Earth's magnetosphere are strong IMF-Bx component and dipole offset which could affect to the global configuration of Mercury's magnetosphere. In this study, first we performed many cases of MHD simulation solving an interaction with solar wind plasma and offset dipole of Mercury. Solar wind densities are given betwenn nominal(35cm^{-3}), high(70cm^{-3}), and extreme(140cm^{-3}), with velocities for 400km/s to 800km/s, which are realistic values in the Mercury's orbit. When solar wind density is nominal and no IMF-Bx, the structure of Mercury’s magnetosphere is not far from ‘miniature’ of Earth’s magnetosphere, while north-south asymmetry is outstanding because of the offset dipole. In the realistic IMF case, global configurations of magnetosphere drastically change and become more complicated structures which include stronger north-south and dawn-dusk asymmetry. IMF-Bx also affects to the intensity ratio of north and south cusp pressure. IMF-By component “twist” the cusp region to longitudinal direction. The heavy ions’ trajectories basically obey the global structure of magnetic field, so that the ions’ precipitation concentrate on the ‘magnetic cusp’ defined from MHD simulations, but the precipitation region is wider and diffusive compared to the MHD cusp. In the presentation, we will discuss more details of heavy ion precipitation pattern. The identification of global structures and ions’ precipitation region especially the cusp is important not only on the understanding of magnetospheric physics itself, but also making a proposal to the observational plan of spacecraft such as Bepi-Colombo.

Keywords: Mercury, magnetosphere, MHD

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Model study on the contribution of various physical processes for generation and dissipation of Mercury's exosphere

*Yudai Suzuki[1], Kazuo Yoshioka[1]

1. University of Tokyo

Mercury has tenuous atmosphere (~1e-10 Pa), which escapes into space due to weak gravity and constant exposure to strong solar photo pressure and solar wind.Since exosphere directly connects with ground surface, the amount of generated and dissipated atmosphere drastically variesdepending on the environment.

Exosphere contains several elements such as Na, Mg, H, K, Ca, He. H and He are derived from solar wind, while other species are thought to be supplied owing to desorption from ground surface. For example, thermal desorption, charged particle sputtering (CPS), photon stimulated desorption (PSD) and meteorite impact vaporization (MIV) are suggested as desorption process. The amount of thermal desorption depends on the surface temperature, which is a function of the distance between the Sun and Mercury due to revolution. The amount of CPS changes owing to flares and the intensity of solar wind. Variation of PSD amount is due to fluctuation of solar radiation. MIV is dominated by the amount of dust around Mercury. Therefore, estimating how much each process contributes to generation of atmosphere encourages understanding the environment of inner solar system.

Velocity distribution of emitted particles is different from process to process. Thus, contribution of each process is often presumed by temperature of emitted particles which can be estimated by density profile obtained by the observation of MESSENGER spacecraft. However, the accuracy of estimating the abundance of high-temperature component gas is not enough, and besides it is hard to make an estimate of the dominant process in high latitudes in northern hemisphere and mid-latitudes owing to geometry of the spacecraft’ s orbit.

Thermal desorption dominates the distribution of sodium atoms on ground surface since particles emitted by thermal desorption has small energy and return to the surface only in a short time (~10min). CPS is thought to generate the majority of atmosphere in high latitudes of northern hemisphere and mid latitudes.

In this research, the behavior of neutral sodium particle from generation to escape focused on thermal desorption and CPS is simulated using Monte Carlo method. In addition, the contribution of those processes will be discussed by comparing with the MESSENGER/MASCS/UVVS observation.

Keywords: Mercury, tenuous atmosphere , exosphere, thermal desorption, charged particle sputtering

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[J] Oral | P (Space and Planetary Sciences)：P-CG Complex & General

Tue. May 28, 2019 10:45 AM - 12:15 PM JST | Tue. May 28, 2019 1:45 AM - 3:15 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[P-CG25] Planetary Magnetosphere, Ionosphere, and Atmosphere

convener:Kanako Seki(Graduate School of Science, University of Tokyo), Takeshi Imamura(Graduate School of Frontier Sciences, The University of Tokyo), Hiroyuki Maezawa(Department of Physical Science Osaka Prefecture University), Naoki Terada(Graduate School of Science, Tohoku University), Chairperson:Hiromu Nakagawa(Planetary Atmosphere Physics Laboratory, Department of Geophysics, Graduate School of Science, Tohoku University), Kanako Seki(Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo,)

Exploration of Moon, Venus, Mars, Mercury, Jupiter, Saturn, and beyond together with rapid developments of numerical simulations provides us new view of planetary environment. This session collects general contributions of new findings about planetary magnetosphere, ionosphere, and atmosphere. New methodology and technology development studies for future explorations are also welcome. In order to put the common knowledge at different planets into perspective, this session aims to facilitate discussions on comparative planetary environments.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[PCG25-05] Updated status and science goals of the BepiColombo mission

*Go Murakami[1], Hajime Hayakawa[1], Masaki Fujimoto[1], BepiColombo Project Team (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[PCG25-06] A Novel High-Moment Multifluid Model for Mercury: From the Planetary Conducting Core to the Dynamic Magnetosphere

*Chuanfei Dong[1], Liang Wang[1], Ammar Hakim[1], Amitava Bhattacharjee[1], James A Slavin[2], Gina A DiBraccio[3], Kai Germaschewski[4] (1.Princeton University, 2.University of Michigan, Ann Arbor, 3.NASA Goddard Space Flight Center, 4.University of New Hampshire)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[PCG25-07] DSMC simulation of slow hydrodynamic escape from terrestrial planets

Kaori Terada[1], *Naoki Terada[1], Hitoshi Fujiwara[2] (1.Graduate School of Science, Tohoku University, 2.Faculty of Science and Technology, Seikei University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[PCG25-08] The influence of Martian crustal magnetic fields on atmospheric escape

*Dave A Brain[1,2], Robin Ramstad[1], Yaxue Dong[1], Tristan Weber[1], Shogo Inui[2], Kanako Seki[2], Andrew Poppe[3], Riku Jarvinen[4], Jim McFadden[3], Jasper Halekas[5], Jared Espley[6], David Mitchell[3], Laila Andersson[1], Bruce Jakosky[1] (1.University of Colorado, 2.University of Tokyo, 3.University of California Berkeley, 4.Finnish Meteorological Institute, 5.University of Iowa, 6.NASA Goddard Space Flight Center)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[PCG25-09] Effects of the IMF direction on atmospheric escape under a weak intrinsic magnetic field at Mars

*Shotaro Sakai[1], Kanako Seki[1], Naoki Terada[2], Hiroyuki Shinagawa[3], Ryoya Sakata[1], Takashi Tanaka[3,4], Yusuke Ebihara[5] (1.Graduate School of Science, The University of Tokyo, 2.Graduate School of Science, Tohoku University, 3.National Institute of Information and Communications Technology, 4.International Center for Space Weather Science and Education, Kyushu University, 5.Research Institute for Sustainable Humanosphere, Kyoto University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[PCG25-10] Simulating solar energetic electron precipitation and drift at Mars

*Rebecca Jolitz[1], Chuanfei Dong[2], Dave A Brain[1], Steve Bougher[3], Christina Lee[4], Rob Lillis[4], Shannon Curry[4], Bruce Jakosky[1] (1.Univ. of Colorado Boulder, 2.Princeton Univ., 3.Univ. of Michigan, 4.Univ. of California Berkeley)

Updated status and science goals of the BepiColombo mission

*Go Murakami[1], Hajime Hayakawa[1], Masaki Fujimoto[1], BepiColombo Project Team

1. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency

The ESA-JAXA joint mission BepiColombo is now on the track to Mercury. Two spacecraft for BepiColombo, "MIO" (Mercury Magnetospheric Orbiter: MMO) and "Bepi" (Mercury Planetary Orbiter: MPO), were launched by Ariane-5 launch vehicle from Kourou in French Guiana on 20 October 2018. During the cruise to Mercury, in addition to two spacecraft MMO Sunshield and Interface Structure (MOSIF) and Mercury Transfer Module (MTM) are all integrated together. The critical phase just after launch and the near Earth commissioning phase were successfully finished in end of 2018, and the first electrical propulsion started from Decemeber 2018. The next activities are delta commissioning of high voltage instruments in mid 2019, and the first flyby around the Earth in April 2020. Here we report the updated status of BepiColombo mission and the overview of its science goals.

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A Novel High-Moment Multifluid Model for Mercury: From the Planetary Conducting Core to the Dynamic Magnetosphere

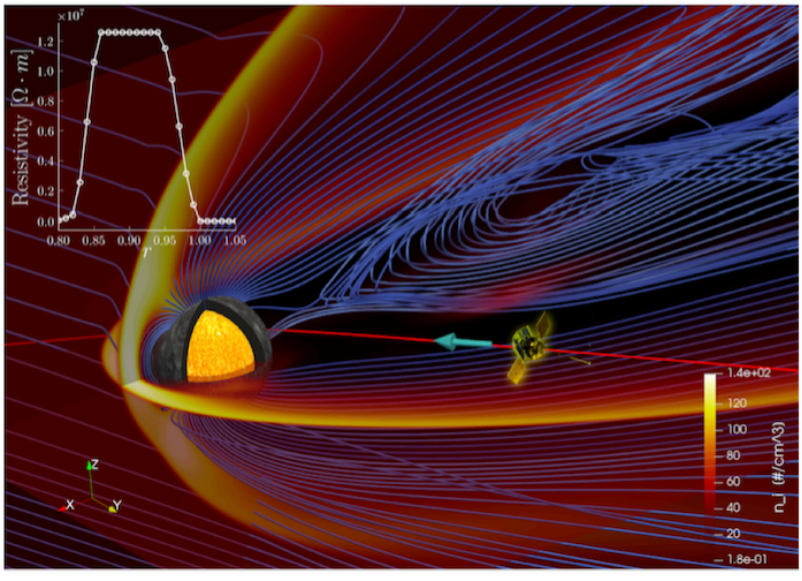
*Chuanfei Dong[1], Liang Wang[1], Ammar Hakim[1], Amitava Bhattacharjee[1], James A Slavin[2], Gina A DiBraccio[3], Kai Germaschewski[4]

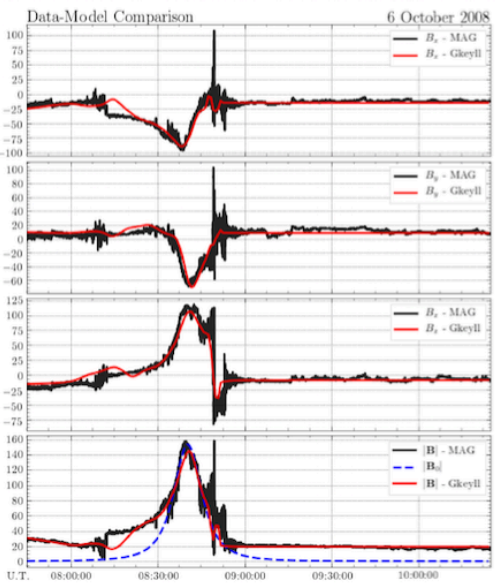
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We have developed a novel three-dimensional ten-moment multifluid model and applied it to investigate the tightly coupled interior-magnetosphere system of Mercury. This new multifluid model self-consistently solves the continuity, momentum and pressure tensor equations of each species, together with the full Maxwell equations. As a result, non-ideal effects including the Hall effect, inertia, and tensorial pressures are self-consistently embedded without the need for explicitly solving a generalized Ohm's law.

Our simulation results from this new model are in good agreement with observations from MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft. The model is able to reproduce the magnetic field vectors, field-aligned currents and cross-tail current sheet asymmetry observed by MESSENGER. We also investigate collisionless magnetic reconnection in Mercury's magnetotail and at dayside magnetopause. In addition, we study the magnetospheric response of Mercury to a hypothetical extreme event with an enhanced solar wind dynamic pressure, which demonstrates the significance of electromagnetic induction effects resulting from the coupled interior. Moreover, two plasmoids (or flux ropes) are formed in Mercury's cross-tail current sheet during this hypothetical extreme event, indicating the extremely dynamic nature of Mercury's magnetotail. Thus, this novel high-moment, multifluid, interior-magnetosphere-coupled model is crucial for understanding Mercury's dynamic magnetosphere and has the potential to enhance the science returns of both the MESSENGER and BepiColombo missions.

Keywords: Mercury's dynamic magnetosphere, ten-moment multifluid model, induction effect, tightly coupled interior-magnetosphere system, collisionless magnetic reconnection, extreme events





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DSMC simulation of slow hydrodynamic escape from terrestrial planets

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Slow hydrodynamic escapes of atmospheric components from terrestrial planets subject to intense EUV radiation are investigated by DSMC simulations to understand the long-term evolution of planetary atmospheric composition.

Sun-like stars in earlier stages of their evolution emit intense EUV radiation. For example, the young sun of 4.5 billion years ago may have emitted 100 times stronger EUV radiation than today. After the formation of planets in a protoplanetary disk, planets get their atmospheres from the remnants of the disk gas and the outgassing due to impacts. The atmospheres were subject to the intense EUV radiation from a young central star, which caused significant heating and massive escape of planetary atmospheres.

The energy-limited escape rate is an upper limit of an atmospheric escape rate. The energy-limited escape is a category of the hydrodynamic escape. After an EUV radiation from a central star became weak, a planetary atmosphere was in hydrostatic equilibrium, and an escape rate became equal to the Jeans escape rate. While hydrodynamic escape and Jeans escape are understood well, there is an incomplete understanding of transition from hydrodynamic to Jeans escapes.

The thermal escape processes such as hydrodynamic escape and Jean escape depend on atmospheric composition. A previous study showed that the exobase temperature of Earth exceeded 10000 K and the atmosphere was well within the hydrodynamic regime when exposed to 20 times stronger EUV levels than present-day Earth. The exobase temperature of a CO2 dominated atmosphere like Mars was not heated as much as Earth’ s exobase because of efficient CO2 IR cooling. Nonetheless a previous simulation study using a fluid model showed that the exobase temperature reached about 2500 K and the Martian atmosphere was not in the hydrostatic equilibrium when exposed to 20 times stronger EUV levels.

In this study, escape rates from Earth-like and Mars-like planets for different EUV radiation intensities are estimated by DSMC simulations. Our full-particle upper thermosphere simulation model can solve the escape rates self-consistently. We show the escape rates of each species including the transition from hydrodynamic through slow hydrodynamic to Jeans escapes to understand the long-term evolution of planetary atmospheric composition.

Keywords: Atmospheric escape, Terrestrial planets, DSMC simulation

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The influence of Martian crustal magnetic fields on atmospheric escape

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1. University of Colorado, 2. University of Tokyo, 3. University of California Berkeley, 4. Finnish Meteorological Institute, 5. University of Iowa, 6. NASA Goddard Space Flight Center

At present the influence of Martian crustal magnetic fields on atmospheric escape rates is debated. Since Mars lacks a significant global dynamo magnetic field, the presence of strong crustal fields over a significant fraction of the surface could shield portions of the atmosphere from the incident solar wind. The crustal fields could also allow or even enhance atmospheric escape through numerous cusp regions that are magnetically connected to the solar wind. This issue is of interest because the answer has implications for how atmospheric escape has operated on Mars over the history of the planet, including earlier times when Mars was more widely magnetized or even possessed a dynamo field. It is also relevant for assessing whether a global magnetic field is important for atmospheric retention. To this point, both modeling and observational studies appear to disagree on whether crustal fields significantly influence the escape of ions.

We will present the results of a new analysis of ion measurements from the Mars Atmosphere and Volatile EvolutioN (MAVEN) spacecraft mission made over four years. We examine how escape rates vary as Mars rotates and as a function of the solar zenith angle of strong crustal fields, including the dependence on ion energy and species. We also explore whether ion escape rates are larger, in a global sense, above crustal fields compared to non-magnetized regions. Finally, we introduce recent results relevant for evaluating ion escape from individual cusps, including from kinetic models of Martian cusp regions.

Keywords: Mars, Atmospheric escape, Magnetospheres

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Effects of the IMF direction on atmospheric escape under a weak intrinsic magnetic field at Mars

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The planetary intrinsic magnetic field is significantly important in considering the atmospheric escape from planets. The strength of intrinsic field particularly affects the interaction between the solar wind and terrestrial-type planets (e.g., Seki et al., 2001), and it would change the escape mechanism. In contrast, Mars would have kept the warm and wet climate around 4 Ga. However, atmosphere and water are lost by certain processes, resulting in that present Mars only leave thin atmosphere. One candidate of the escape mechanism is the ion outflow from the upper atmosphere associated with the magnetic field. It is expected that ancient Mars had a global intrinsic magnetic field because there exists the crustal magnetic field in present Mars, and thus investigating the effect of intrinsic magnetic field on the ion escape leads to understanding the climate change of Mars from past through present.

Sakai et al. (2018) investigated the effect of an intrinsic magnetic field of 100 nT at the Martian equatorial surface on the escape mechanism. It was shown that the existence of the weak field results in an enhancement of the ion escape rate. A parker-spiral interplanetary magnetic field (IMF) was used in order to obtain the escape rate in this earlier study.

In this study, influences of the IMF direction on the ion escape mechanism under the intrinsic magnetic field of 100 nT at the equatorial surface are investigated based on global multispecies single-fluid magnetohydrodynamics simulations (Terada et al., 2009; Sakai et al., 2018). Ion escape processes from Mars under two IMF conditions, namely, a northward and southward cases, are compared to those of the parker-spiral case. For the parker-spiral case, heavy ions escape through the channel associated with the open field lines and another channel associated with a magnetic reconnection between the planetary and solar wind magnetic fields at the flank magnetopause (Sakai et al., 2018). For the north-IMF case, the heavy ions mainly escape through the open or draped field lines formed by double lobe reconnections. The escape rate of heavy ions is about one order of magnitude smaller than for the parker-spiral IMF case and it is even smaller than for the no-dipole case. On the other hand, the heavy ions escape by the mass loading of draped field lines in the ionosphere for the south-IMF case. The escape rate of heavy ions is about one order of magnitude greater than for the parker-spiral case. For the north-IMF case, the interaction of the weak intrinsic magnetic field and IMF forms the firm magnetosphere, resulting in suppressing the ion escape. In contrast, the erosion of IMF into the deep ionosphere yields the increment of the ion escape rate for the south-IMF case.

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Keywords: Mars, Atmospheric escape, Intrinsic magnetic field, Interplanetary magnetic field, MHD simulation

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Simulating solar energetic electron precipitation and drift at Mars

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Solar disturbances release energetic charged particles that are expected to directly precipitate into the atmospheres of weakly magnetized planets like Mars. However, draped magnetic fields can influence the motion of energetic electrons. Using a test particle model of 1 keV - 100 keV electrons moving in magnetic fields from a multifluid magnetohydrodynamic simulation, we find that energetic electrons with steep pitch angles are affected by gradient drifts over the dayside of Mars. For an interplanetary magnetic field directed in the away sector, electrons will drift southwards, perpendicular to the direction of the draped magnetic field. Gradient drifts at Mars can facilitate increased precipitation by directing electrons towards the magnetized southern hemisphere and into magnetic field cusps. These findings suggest energetic electrons precipitate non-uniformly and are attenuated at low altitudes above the dayside northern hemisphere of Mars.

Keywords: Mars, solar energetic particles, gradient drift, particle precipitation

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[J] Oral | P (Space and Planetary Sciences)：P-CG Complex & General

Tue. May 28, 2019 1:45 PM - 3:15 PM JST | Tue. May 28, 2019 4:45 AM - 6:15 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[P-CG25] Planetary Magnetosphere, Ionosphere, and Atmosphere

convener:Kanako Seki(Graduate School of Science, University of Tokyo), Takeshi Imamura(Graduate School of Frontier Sciences, The University of Tokyo), Hiroyuki Maezawa(Department of Physical Science Osaka Prefecture University), Naoki Terada(Graduate School of Science, Tohoku University), Chairperson:Takeshi Imamura(Graduate School of Frontier Sciences, University of Tokyo), Naoki Terada(School of Science, Tohoku University)

Exploration of Moon, Venus, Mars, Mercury, Jupiter, Saturn, and beyond together with rapid developments of numerical simulations provides us new view of planetary environment. This session collects general contributions of new findings about planetary magnetosphere, ionosphere, and atmosphere. New methodology and technology development studies for future explorations are also welcome. In order to put the common knowledge at different planets into perspective, this session aims to facilitate discussions on comparative planetary environments.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[PCG25-11] Effects of the intrinsic magnetic field on the ion loss from ancient Mars

*Ryoya Sakata[1], Kanako Seki[1], Shotaro Sakai[1], Naoki Terada[2], Hiroyuki Shinagawa[3], Takashi Tanaka[3,4] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2.Graduate School of Science, Tohoku University, 3.National Institute of Information and Communications Technology, 4.International Center for Space Weather Science and Education, Kyushu University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[PCG25-12] Global characterization of wave perturbations in the middle atmosphere on Mars

*Hiromu Nakagawa[1], Naoki Terada[1], Hannes Groller[7], Roger Yelle[7], Montmessin Franck[8], Schneider M Nicholas[4], England Scott[5], Kanako Seki[6], Takeshi Kuroda[3], Hitoshi Fujiwara[2], Takeshi Imamura[6], Kaori Terada[1], Nao Yoshida[1], Justin I Deighan[4], Sonal K Jain[4], Bruce M Jakosky[4] (1.Planetary Atmosphere Physics Laboratory, Department of Geophysics, Graduate School of Science, Tohoku University, 2.Seikei University, 3.National Institute of Information and Communications Technology, 4.Laboratory for Atmospheric and Space Physics, University of Colorado, 5.Aerospace and Ocean Engineering, Virginia Tech, 6.Department of Earth and Planetary Science, University of Tokyo, 7.Lunar and Planetary Laboratory Science, University of Arizona, 8.LATMOS, UVSQ/CNES/IPSL)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[PCG25-13] Seasonal variation of the dayside N_2/CO_2 at 140 km altitude derived from MAVEN/IUVS

*Nao Yoshida[1], Hiromu Nakagawa[1], Naoki Terada[1], Nicholas Schnider[2], Scott Evans[3], Sonal Jain[2], Hitoshi Fujiwara[4], Takeshi Imamura[5], Justin Deighan[2], Ian Stewart[2], Michael Stivens[6], Roger Yelle[7] (1.Dep. Geophysics Graduate School of Science Tohoku University, 2.Laboratory for Atmospheric and Space Physics, Boulder, USA, 3.Computational Physics, Inc., Springfield, Virginia, USA, 4.Faculty of Science and Technology, Seikei University, 5.Department of Complexity Science and Engineering, Graduate School of Frontier Sciences, The University of Tokyo, 6.Naval Research Laboratory, Washington, USA, 7.Department of Planetary Sciences, University of Arizona)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[PCG25-14] Automated segmentation of Martian dust storms in MGS/MOC images using a deep learning technique

*Kazunori Ogohara[1], Ryusei Gichu[2] (1.School of Engineering, University of Shiga Prefecture, 2.Graduate School of Engineering, University of Shiga Prefecture)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[PCG25-15] Investigation of variation mechanisms of the Jovian radiation belt using ALMA

*Hajime Kita[1], Hideo Sagawa[2], Takahiro Iino[3], Chihiro Tao[4], Takeshi Kuroda[4], Fuminori Tsuchiya[5], Hiroaki Misawa[5], Yasumasa Kasaba[5], Masaki Fujimoto[1] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency , 2.Faculty of Science, Kyoto Sangyo University, 3.Nature and Science Museum, Tokyo University of Agriculture and Technology, 4.National Institute of Information and Communications Technology, 5.Tohoku University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[PCG25-16] Jupiter's radio Riddle arcs observed by LWA and Juno

*Kazumasa Imai[1], Charles A. Higgins[2], Masafumi Imai[3], Tracy Clarke[4] (1.Department of Social Design Engineering, National Institute of Technology, Kochi College, 2.Middle Tennessee State University, 3.University of Iowa, 4.Naval Research Laboratory)

Effects of the intrinsic magnetic field on the ion loss from ancient Mars

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Mars had a thick atmosphere before 4 Ga, but it lost most of them. Ion escape to space could play an important role in the atmosphere loss. The astronomical observations suggest that the solar XUV (X-ray and extreme ultra-violet) flux and the solar mass loss rate were more intense (Ribas et al., 2005; Wood et al., 2002). Previous studies pointed out that the ion loss was several orders of magnitude stronger under such intensified solar conditions (Terada et al., 2009a). On the other hand, the existence of the crustal magnetic field indicates that Mars had an intrinsic magnetic field before 4.1 Ga. The conventional idea is that the intrinsic magnetic field prevents the direct interaction between the solar wind and the atmosphere and thus restrains the ion loss (Lundin et al., 2007). On the contrary, some studies suggested that the existence of an intrinsic magnetic field promotes the ion loss (Sakai et al., 2018). Thus it is important to clarify the effect of the intrinsic magnetic field on the ion loss to understand the atmospheric evolution at Mars.

In this study, we investigated the ion loss processes from Mars under extreme solar conditions and the existence of an intrinsic magnetic field using a 3D multi-species MHD model (Terada et al., 2009b). The solar wind proton density, the solar wind velocity, and the solar XUV flux were assumed to be 1000 /cm^3, 2000 km/s, and 100 times higher than the present-day XUV flux, respectively. The interplanetary magnetic field was assumed to be in Parker spiral and its strength was 60 nT. These parameters are same as those used in Terada et al. (2009a). We conducted four cases of simulations with different intrinsic magnetic field conditions, i.e., dipole fields with the strength of 0 nT, 100 nT, 1000 nT, and 5000 nT on the equatorial surface.

In 0 nT case, there were two major ion loss processes: escape of O^+, O_2^+ and CO_2^+ from the polar region and pickup O^+ carried by the deflected solar wind. In 1000 nT case, O_2^+ and CO_2^+ mainly came from the dayside cusp region through open magnetic field lines. In 5000 nT case, O^+, O_2^+ and CO_2^+ fluxes had almost the same structure and originated from the dayside cusp region. In 0 nT, 100 nT, and 1000 nT cases, the loss rates of O_2^+ and CO_2^+ were higher under the existence of the stronger dipole field, while the O^+ loss rate was nearly the same in these three cases. In 5000 nT case, the loss rates of O_2^+ and CO_2^+ were about three orders of magnitude lower than those of the other weaker dipole cases, while the O^+ loss rate was five times lower. These results suggest that the existence of a weak intrinsic magnetic field facilitates the loss of heavier ions such as O_2^+ and CO_2^+, and there is a threshold strength of the intrinsic magnetic field for this facilitation effect.

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Keywords: ancient Mars, multi-species MHD simulation, atmospheric escape, intrinsic magnetic field

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Global characterization of wave perturbations in the middle atmosphere on Mars

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Small-scale atmospheric waves, such as internal gravity waves, are recognized as an important part of the terrestrial climate system. They ubiquitously exist on the Earth's upper atmosphere and affect the dynamics, composition, and thermal structure of the terrestrial middle atmosphere and thermosphere. Global characteristics of gravity waves on Earth have been extensively investigated over decades. On Mars, large fluctuations in density and temperature with short vertical wavelengths were first detected in Viking, Opportunity, Spirit, and Mars Pathfinder entry profiles. Wave amplitudes in the Martian atmosphere are larger than those in the terrestrial atmosphere and the important role of gravity waves of tropospheric origin in the middle atmosphere has been appreciated in early modeling studies. Gravity waves strongly affect the large-scale winds, thermal balance, density in the mesosphere and lower thermosphere. Since October 2014, NASA's Mars Atmosphere and Volatile EvolutioN (MAVEN) mission have been performed comprehensive studies of the Martian atmosphere. In-situ measurements of the upper atmosphere, from 300 km down to 130 km, revealed that wavelike perturbations ubiquitously exist in ions and neutrals in the upper thermosphere. Wavelike perturbations have also been detected by remote sensing with the Imaging Ultraviolet Spectrograph (IUVS) onboard MAVEN at altitudes between 20 and 150 km. These IUVS measurements provide opportunities for investigating possible links between waves in the Martian troposphere and thermosphere.
In order to clarify a global characteristic of waves and its upward propagating processes, we use IUVS stellar occultation measurements to characterize a global distribution of waves in the middle atmosphere between 24 March 2015 and 12 April 2018 for two Martian Years. This study first revealed global characteristics of wave perturbations in the night side temperature profiles derived from MAVEN/IUVS stellar occultations at 20 - 160 km altitudes on Mars. The peak amplitudes of waves on Mars exceed 20 % which is larger than those in Earth's mesosphere/thermosphere (~5-13 %). Perturbations were found to be notably large in summer hemisphere at L_s = 0-180. These waves can be interpreted as resulting from superposed harmonics of internal gravity waves and thermal tides. The superposition of thermal-tides and small-scale perturbations generate extensive instability layer around 70 - 100 km, which potentially causes wave-breaking and turbulences. Vertical wavenumber spectral density in the Martian middle atmosphere shows a power-law dependence with the logarithmic spectral slope of -3. This is similar to the features seen in the Earth's atmosphere. The spectral density in southern hemisphere at L_s = 225-315 tends to follow the semi-empirical spectrum of saturated gravity waves on the high-wavenumber side. The spectral power at high-wavenumbers is lower at 80 - 160 km than that at 20 - 80 km. This suggests that the strong radiative damping by CO_2 15-micron could effectively dissipates shorter waves. Instead, the spectral power at low-wavenumbers suggests the amplitude growth with height of unsaturated waves toward upper thermosphere.

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Keywords: Mars, mesosphere, thermosphere, waves, tides

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Seasonal variation of the dayside N_2/CO_2 at 140 km altitude derived from MAVEN/IUVS

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It is believed that liquid water was abundant on early Mars, despite Mars being too cold today to sustain significant amounts of liquid water. The most likely explanation is that early Mars had a more-effective greenhouse atmosphere and most part of atmosphere and water have lost to space. Mars Atmosphere and Volatile EvolutioN (MAVEN) mission was designed to explore the loss of gas to space at the present. MAVEN spacecraft revealed highly variable nature of upper atmosphere in density, temperature, and atmospheric compounds (e.g. Mahaffy et al., 2015; Elrod et al., 2017; Stone et al., 2018; Slipski et al., 2018). However, the controlling factor of the variations has yet to be fully characterized due to the limited spatial- and temporal- observing geometry by in-situ measurements. In addition to the effects by the external force, such as solar wind and solar EUV on the upper atmosphere, the effect of lower atmospheric phenomena is also required to account for the substantial variations of upper atmosphere. For instance, the homopause (~120 km altitude) influences the upper thermospheric composition, thereby the species escaping to space [Imamura et al., 2016]. The fractionation between the homopause and exobase determines the relative abundance of species to escape to space [Jakosky et al., 2017]. For this purpose, further investigation around atmospheric boundary from the middle atmosphere to lower thermosphere is crucial for understanding regional coupling between lower and upper atmosphere.
We have investigated the seasonal variation of the N_2/CO_2 ratio at 140 km altitude derived from ultraviolet spectroscopy remote-sensing measurements by Imaging Ultraviolet Spectrograph (IUVS) aboard MAVEN. We used the dataset of level 2 version 13 revision 1 data provided by the Planetary Data System, which includes retrieved CO_2 and N_2 number density profiles derived from dayglow emissions. We analyzed N_2 and CO_2 number densities observed from October 2014 to May 2018. Observations cover in the dayside from 7 to 19 hr. The observations covered almost all solar longitudes within the two Martian Years. The retrieved CO_2 density has small uncertainty but the retrieved N_2 density has relatively larger uncertainty in particular above ~170 km due to the dimmer emission intensity. For precise analysis of the N_2/CO_2 ratio, we confine our analysis to the data at 140 km altitude where N_2/CO_2 has uncertainty less than 50%. We found that the N_2/CO_2 ratio at 140 km altitude significantly varies in the range of 0.02 to 0.20, which shows an annual sinusoidal trend. The higher ratio appears during aphelion and the lower ratio appears during perihelion. CO_2 and N_2 number densities also have similar annual variations. It is noted that the CO_2 density varies by a factor of 100, while N_2 density by a factor of 10. This large CO_2 variation affects the N_2/CO_2 ratio at 140 km. The potential sources of the seasonal variation we found are variations (1) of the surface mixing ratio, (2) of the homopause altitude, and (3) of the thermospheric temperature. In this paper, the effect of surface mixing ratio is discussed using Mars Climate Database version 5.3 [Forget et al., 1999; Lewis et al., 1999]. We also address the effects of other sources by considering the seasonal variation of homopause altitude [Slipski et al., 2018] and background temperature [Bougher et al., 2017; Stone et al., 2018].

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Keywords: Thermosphere, Mixing ratio, Homopause, MAVEN, escape

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Automated segmentation of Martian dust storms in MGS/MOC images using a deep learning technique

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The shape, texture, and size of dust storms and the climatology of these characteristics are important clues to understanding Martian dust storms. The relations between such characteristics and the phases of the variety of atmospheric waves as well as the frequency of textured/curvilinear dust storms and the spatial and seasonal variations of the cumulative area are also worth investigating (Wang 2007; Wang et al. 2011; Guzewich et al. 2015, 2017). However, it is time-consuming to detect all dust storms visually because of the vast number of images taken by just two instruments, the MGS/MOC and MRO/MARCI. It is also difficult to objectively define which features characterize dust storms. Even approximate categorization of dust events into textured dust storms, untextured yet discrete dust storms, and haze depends on the subjective experience of the human observer. For these reasons, visual detection and categorization of the three types of dust storm textures introduced by Kulowski et al. (2017) would not be exactly reproduced by another human viewing and characterizing the images. Furthermore, we perceive a need to update the criteria for detecting dust events, especially obscured ones such as untextured yet discrete dust storms and haze, via visual detection. Therefore, it would be useful to be able to automatically detect dust events, measure their shape, pattern, and size, and improve the objectivity and reproducibility of dust storm detection.
We have developed a novel algorithm for automated segmentation of Martian dust storms using a encoder-decoder type of Convolutional Neural Network. We can separate dust storm areas from the surface and cloud areas in subsets of the global swath images taken by MGS/MOC without any information from other instruments (e.g. MGS/TES). Assuming that segmentation based on authors' experience is the ground truth, 84% of the true dust storm areas in the Arabia Terra is recognized as dust strom. On the other hand, just 69% of the true dust storm areas in the Hellas Basin is correctly recognized as dust storm.

Keywords: Mars, dust storm, deep learning

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Investigation of variation mechanisms of the Jovian radiation belt using ALMA

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1. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency , 2. Faculty of Science, Kyoto Sangyo University, 3. Nature and Science Museum, Tokyo University of Agriculture and Technology, 4. National Institute of Information and Communications Technology, 5. Tohoku University

Jupiter is now considered as an archetype for gas giants widely exist in extrasolar systems. At the outermost layer of this giant planet, there is a 300 km-depth of the nearly isothermal atmospheric layer (stratosphere) above the massive troposphere. Jupiter is also known to be a fast rotator (with a period of 9.9 h) with an enormous magnetic field. High energy particles trapped in the magnetic field form a radiation belt around the planet, much stronger than the terrestrial Van Allen's belt. In the case of the Earth, the primary control factor of the radiation belt is the solar wind, while the solar wind is difficult to impact the Jovian radiation belt because of the intense magnetic field.

It is theoretically expected that the driving mechanism of Jovian radiation belt is due to the interaction between the radiation belt and the upper atmospheric dynamics: neutral wind perturbations and diurnal wind system control the radial diffusion and spatial distribution of the energetic particles, respectively. Therefore, precise measurements of Jovian wind field are essential for not only the dynamics of the stratosphere but also the magnetosphere.

ALMA's unprecedented high spatial-spectral resolution enables us to extract the limb emission of the trace gasses in the Jovian upper stratosphere with a few tens m/s sensitivity. It is well known that HCN and CS have been injected into Jupiter by the Shoemaker-Levy 9 impact and they distribute only in the upper atmosphere (p ~0.4-1mbar). Therefore, the Doppler shift of those molecular emission lines can be used to investigate the dynamics in the upper atmosphere particularly at the limb of the Jovian disk where the line-of-sight direction is equal to the horizontal direction of the atmosphere. Here we present the sensitivity of ALMA observation to measuring Jovian stratospheric winds, and discuss its capability of constraining the magnetosphere-atmosphere coupling. A test analysis is carried out using JVO ALMA archive data.

Keywords: Jupiter, ALMA, stratosphere, radiation belt

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Jupiter's radio Riddle arcs observed by LWA and Juno

*Kazumasa Imai[1], Charles A. Higgins[2], Masafumi Imai[3], Tracy Clarke[4]

1. Department of Social Design Engineering, National Institute of Technology, Kochi College, 2. Middle Tennessee State University, 3. University of Iowa, 4. Naval Research Laboratory

The Riddle arcs were found in the dynamic spectrum of Jupiter's decametric radio emissions observed by the Voyager spacecraft [Riddle, 1983]. On a frequency time plot these Riddle arcs have the same slope at the same frequency and System III longitude. (The typical System III longitude is about 260 degrees at 20 MHz.) An isolated Riddle arc can be easily recognized inside of the Io-A arc structures. This emission of Riddle arcs was concluded to be from the instantaneous Io flux tube.

The modulation lane method [Imai et al., 1992,1997,2002] is based on the measurements of the slope of modulation lanes on the dynamic spectrum of Jupiter's decametric radio emissions. We usually measure the slope with a 1 MHz bandwidth and determine the most probable value of the lead angle between activated flux tubes to fit the value of the slope. The lead angle is the longitudinal angle between the instantaneous Io flux tube and the previously energized flux tube (real emitting region). The longitudinal location of the magnetic field line of the radio emitting sources can be calculated by this lead angle.

The Long Wavelength Array (LWA) is a low-frequency radio telescope designed to produce high-sensitivity, high-resolution spectra in the frequency range of 10-88 MHz. The sensitivity of the LWA, combined with the low radio frequency interference environment, allows us to observe wide band modulation lanes of Jupiter's decametric radio emissions [Clarke et al., 2014]. We have analyzed the modulation lane data including the Riddle arcs observed by LWA. We found almost all of the Riddle arcs correspond to a zero degree lead angle. This means that the radio sources related to the Riddle arcs are located along the instantaneous Io flux tube. This result is consistent with Riddle's conclusion.

The Juno spacecraft [Bolton et al., 2017] was inserted into polar orbit around Jupiter on 04 July 2016. Juno's highly eccentric orbits have a period of about 53 days with apojove near 113 Jovian radii and perijove near 1.06 Jovian radii. With the advantage of this unique orbit, Juno's Waves instrument [Kurth et al., 2017] is observing for the first time the polar beaming patterns and geometry of Jupiter's decametric radio emission sources. The dynamic spectra recorded by the Waves instrument show the Riddle arcs very clearly. We are continuing to analyze the Waves data to find the Riddle arcs in each Juno orbit. The Riddle arcs can be used as a reference point to understand the latitudinal beaming patterns of Jupiter's decametric radio emissions and the location of radio sources. We present the preliminary results of this study.

Keywords: Jupiter radio, decametric emissions, Riddle arcs, modulation lanes, radio source parameters

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Tue. May 28, 2019 10:45 AM - 12:15 PM JST | Tue. May 28, 2019 1:45 AM - 3:15 AM UTC | 106 1F

[A-OS17] Kuroshio Large Meander

convener:Toru Miyama(Japan Agency for Marine-Earth Science and Technology, Application Laboratory), Norihisa Usui(Meteorological Research Institute), Takashi Setou(National Research Institute of Fisheries Science, Fisheries Research and Education Agency), Chairperson:Toru Miyama, Takashi Setou, Norihisa Usui

The Kuroshio has taken large meander path since the end of August 2017. Although it is unknown whether it is continuing at the time of the JpGU meeting, this notable event of the coastal area south of Japan after 12 years later from the last one has already attracted societal interests. In this session, behaviors, dynamics, influences, comparisons with past cases, etc. are discussed. Presentations from various perspectives of ocean physics, biology, chemistry, and meteorology are welcome.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[AOS17-01] The progress of the Kuroshio large meander in and after 2017

★Invited Papers

*Toshiyuki Sakurai[1], Mikitoshi Hirabara[1], Yoshikazu Fukuda[1], Mika Kimura[1], Kotaro Mine[1], Masaomi Takahashi[1], Kensaku Kobayashi[1], Yuka Okunaka[1], Hiromu Kobayashi[1] (1.Japan Meteorological Agency)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[AOS17-02] Influences of the Kuroshio path variation south of Honshu on summer surface air temperature in Kanto district, Japan

*Shusaku Sugimoto[1] (1.Graduate School of Science, Tohoku University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[AOS17-03] Bio-chemilcal difference between the large meander and the non case of the Kuroshio current

*Takashi Setou[1], Tuneo Ono[2], Kiyotaka Hidaka[1], Yugo Shimizu[1], Atsushi Nishimoto[1], Sayaka Sogawa[1], Akira Kusaka[1], Daisuke Ambe[1], Daiki Itoh[1], Takashiko Kameda[1], Yutaka Hiroe[3] (1.National Research Institute of Fisheries Science, Fisheries Research and Education Agency , 2.National Research Institute of Far Seas Fisheires,Fisheries Research and Education Agency , 3.National Research Institute of Far Seas Fisheires,Seikai National Fisheries Research Institute)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[AOS17-04] The late arrival of 2017-18 Japanese eel recruitment and its links to ocean circulation

*Yu-Lin Eda Chang[1], Yasumasa Miyazawa[1], Michael Miller[2], Katsumi Tsukamoto[2] (1.Application Laboratory, Japan Agency for Marine-Earth Science and Technology, 2.Department of Aquatic Bioscience, The University of Tokyo)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[AOS17-05] A probabilistic forecast of the Kuroshio current path variability using an 80-member ensemble simulation.

*Kunihiro Aoki[1], Yasumasa Miyazawa[1], Tsutomu Hihara[1] (1.JAMSTEC)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[AOS17-06] Long-term forecast of the Kuroshio large meander in 2017

*Norihisa Usui[1], Nariaki Hirose[1], Kei Sakamoto[1], Yosuke Fujii[1], Nadao Kohno[1] (1.Meteorological Research Institute)

The progress of the Kuroshio large meander in and after 2017

*Toshiyuki Sakurai[1], Mikitoshi Hirabara[1], Yoshikazu Fukuda[1], Mika Kimura[1], Kotaro Mine[1], Masaomi Takahashi[1], Kensaku Kobayashi[1], Yuka Okunaka[1], Hiromu Kobayashi[1]

1. Japan Meteorological Agency

Office of Marine Prediction (OMP) at Japan Meteorological Agency (JMA) has been routinely operating an ocean data assimilation and prediction system for the western North Pacific (MOVE/MRI.COM-WNP) since March 2008. This system aims to represent ocean characteristics such as the Kuroshio/Oyashio current and meso-scale eddies. Using MOVE/MRI.COM-WNP, OMP provides ocean state information of major currents around Japan (Kuroshio/Oyashio/Tsushima-Warm-Current) and water temperatures in the western North Pacific mainly through the JMA website.
In August 2017, the Kuroshio developed a large meander (LM) for the first time in 12 years. A small meander that developed southeast of Japan’ s Kyushu Island in late March 2017 and propagated eastward to waters off the country’ s Tokai region in August is considered to have induced the Kuroshio LM. In August, MOVE/MRI.COM-WNP successfully forecasted the generation of the Kuroshio LM and JMA published a press release about the probabilityof the Kuroshio LM.
This presentation shows the progress of the Kuroshio LM in and after 2017 as contrasted with the past cases.

Keywords: The Kuroshio, Kuroshio large meander, Forecast, Ocean Data Assimilation

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Influences of the Kuroshio path variation south of Honshu on summer surface air temperature in Kanto district, Japan

*Shusaku Sugimoto[1]

1. Graduate School of Science, Tohoku University

In the Kuroshio and its extension (KE), the warm surface waters compared to the surrounding waters enhance upward heat release in winter, indicating that the ocean affects the atmosphere. On the other hand, in summer, atmospheric response to the Kuroshio/KE remains unclear because of a small difference between sea surface temperature (SST) and surface air temperature (SAT) over the Kuroshio/KE and of its-associated weak SST gradient. Here we investigated summertime (June-August) SST variations south of Japan, using high spatial resolution satellite-derived measurements of 2003–2018. The result showed that the variation is dominant in the region off Kanto-Tokai district, which was related to the Kuroshio path state; the SST increases off Kanto-Tokai district when the Kuroshio takes the meander path, which would reflect the following two points. In the meander period, (1) the Kuroshio shifted southward around Cape Shionomisaki, moves to the north around the Izu Islands, and then reaches very close to south coast of Kanto district, and (2) westward warm flow, which is a flow on the north edge of the anticlockwise eddy north of the Kuroshio, runs very close to the south coast of Tokai district. To reveal the extent to which the warm surface waters off Kanto-Tokai district influence the atmospheric fields, we conducted regional atmospheric model experiments using the high-resolution Japan Meteorological Agency nonhydrostatic model (JMA-NHM) with 5 km horizontal grid spacing. The experiment showed that, over the warm surface waters, evaporation increased considerably, and the northward water vapor transport by low-level wind caused an increase of moisture in Kanto district. The warm-water-induced moisture increase enhances downward longwave radiation at the surface in Kanto district, leading to the SAT increase. Actually, the SST off Kanto-Tokai district is significantly correlated with the SAT in Kanto district, from the Automated Meteorological Data Acquisition System (AMeDAS) of the Japan Meteorological Agency. Our results indicate that, in summer, the Kuroshio path state (meander or straight path) affect the overlying atmosphere and climate on Japan.

Keywords: Kuroshio meander path, SST off Kanto-Tokai district, SAT in Kanto district, Regional atmospheric model experiment

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Bio-chemilcal difference between the large meander and the non case of the Kuroshio current

*Takashi Setou[1], Tuneo Ono[2], Kiyotaka Hidaka[1], Yugo Shimizu[1], Atsushi Nishimoto[1], Sayaka Sogawa[1], Akira Kusaka[1], Daisuke Ambe[1], Daiki Itoh[1], Takashiko Kameda[1], Yutaka Hiroe[3]

1. National Research Institute of Fisheries Science, Fisheries Research and Education Agency , 2. National Research Institute of Far Seas Fisheires,Fisheries Research and Education Agency , 3. National Research Institute of Far Seas Fisheires,Seikai National Fisheries Research Institute

Since 2001, FRA has set up a regular monitoring line, called O-line north and south along 138E off Omaezaki south of Japan and has been conducting the monitoring four or five times a year until now. O-line, the monitoring line was named after Omaezaki City, which is near the starting point of the line. The line has been mainly conducted by the National Research Institute of Fisheries Science and has been carried out for the measure of water temperature, salinity, nutrient, some phytoplankton and zooplankton. In this presentation, the bio-chemical difference on the line between the large meandering case and the non case of the Kuroshio current has been focused on.

Keywords: Kuroshio

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The late arrival of 2017-18 Japanese eel recruitment and its links to ocean circulation

*Yu-Lin Eda Chang[1], Yasumasa Miyazawa[1], Michael Miller[2], Katsumi Tsukamoto[2]

1. Application Laboratory, Japan Agency for Marine-Earth Science and Technology, 2. Department of Aquatic Bioscience, The University of Tokyo

In the year 2018, the Japanese eel (*Anguilla japonica*) recruitment almost vanished in Japan in the early recruitment season, and the eel catch peaked up in late recruitment period when the recruitment was usually small. Coincidently, the Kuroshio meander occurring south of Japan was revisiting since the previous event ends in 2005. The role of ocean circulation in 2018 unusual Japanese eel larvae recruitment was investigated using a three-dimensional particle tracking model, in which swimming behaviors of virtue larvae (v-larvae) was included in addition to passively drift by ocean currents. Similar results appeared in the simulation, showing none v-larvae arrival to the south of Japan in early recruitment period and increased substantially in the late recruitment period. The late arrival could be explained by the change of ocean circulation. The southward shifting and weak North Equatorial Current near spawning area, less Subtropical Countercurrent eddies, and weak Kuroshio during the early migration and recruitment period prevented v-larvae transport. In the late recruitment period, the Kuroshio was strengthened and strong near the East China Sea and south of Japan that transported v-larvae downstream efficiently. The maximum eel catch reduction in Tokai region where Kuroshio bifurcated offshore could be related to large meander. The Kuroshio large meander could potentially influence the local eel recruitment, but its actual role remained to be explored.

Keywords: Japanese eel, North Equatorial Current, Kuroshio large meander

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A probabilistic forecast of the Kuroshio current path variability using an 80-member ensemble simulation.

*Kunihiro Aoki[1], Yasumasa Miyazawa[1], Tsutomu Hihara[1]

1. JAMSTEC

This study aims to describe the probabilistic behavior of the Kuroshio current path variability using an 80-member ensemble simulation in a high-resolution numerical regional ocean model, JCOPE. This simulation provides the outputs for 4 months starting from the initial conditions optimized by the data assimilation (LETKF) for one months. All the members are found to predict the non-large meander path at first 2 months, but some members predict the large meander path after that. We propose a method of quantifying the occurrence/non-occurrence of the branch, the probabilities of each path, and a set of the mean and spread for each path by a machine learning method.

Keywords: Ensemble forecast, Data assimilation, Clustering

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Long-term forecast of the Kuroshio large meander in 2017

*Norihisa Usui[1], Nariaki Hirose[1], Kei Sakamoto[1], Yosuke Fujii[1], Nadao Kohno[1]

1. Meteorological Research Institute

The Kuroshio large meander (KLM) occurred in the end of August 2017 for the first time in 12 years, and has maintained for more than a year. Changes in the oceanic condition south of Japan associated with the KLM have a large impact on various fields such as fisheries, marine transportation, and local weather. The KLM has, therefore, been received much attention. In this presentation, we discuss prospects of the KLM in 2017 on the basis of a long-term forecast experiment using an eddy-resolving ocean model. First, the actual Kuroshio state in the end of August 2018 is reproduced by applying data assimilation. We then conduct ensemble simulations with 40 members, in which atmospheric forcing data are replaced by those on the same day from 1975 to 2014 and the model is integrated for more than three years starting from 28 August 2018. In most cases, the KLM maintains for more than one and a half years (i.e. February 2020). After that, differences in the Kuroshio state among the ensemble members become large. As pointed out be former studies, these behaviors of the Kuroshio path are largely explained by the Sverdrup transport estimated from the wind stress field used in the experiment. In the presentation, we will evaluate the ensemble simulations results using the actual Kuroshio state in May 2019, and will show more detailed results.

Keywords: Kuroshio large meander, Kuroshio transport, long-term forecast

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Tue. May 28, 2019 1:45 PM - 3:15 PM JST | Tue. May 28, 2019 4:45 AM - 6:15 AM UTC | 106 1F

[A-OS18] Physical Oceanography (General)

convener:Yoshimi Kawai(Research and Development Center for Global Change, Japan Agency for Marine-Earth Science and Technology), Tomoki Tozuka(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Kitade Yujiro(Tokyo University of Marine Science and Technology), Chairperson:Yoshimi Kawai(Japan Agency for Marine-Earth Science and Technology), Tomoki Tozuka(The University of Tokyo)

This session invites presentations on a wide variety of topics related to physical oceanography.

1:45 PM - 1:50 PM JST | 4:45 AM - 4:50 AM UTC

Introduction

1:50 PM - 2:05 PM JST | 4:50 AM - 5:05 AM UTC

[AOS18-01] **Real-Time Subsurface Moorings as a Promising Component of Global Ocean Monitoring System**

*Jianing Wang[1], Fan Wang[1] (1.Institute of Oceanology, Chinese Academy of Sciences)

2:05 PM - 2:20 PM JST | 5:05 AM - 5:20 AM UTC

[AOS18-02] Seasonal Variation of the Mixed Layer Depth at 60°S and its governing dynamics

*Matheus Ferreira Azevedo[1], Yujiro Kitade[1], Shigeru Aoki[2] (1.Tokyo University of Marine Science and Technology, 2.Institute of Low Temperature Science, Hokkaido University)

2:20 PM - 2:40 PM JST | 5:20 AM - 5:40 AM UTC

[AOS18-03] **21st-Century Flood Hazards along the U.S. Atlantic Coast: Impacts of Sea Level Rise and Tropical Cyclone Climatology Change**

★Invited Papers

*Reza Marsooli[1], Ning Lin[2], Kerry Emanuel[3] (1.Stevens Institute of Technology, 2.Princeton University, 3.Massachusetts Institute of Technology)

2:40 PM - 3:00 PM JST | 5:40 AM - 6:00 AM UTC

[AOS18-04] **The Effect of Ocean Waves on an Explosive Cyclone Development: Investigation with a Coupled Model**

★Invited Papers

*Yuki Kita[1], Takuji Waseda[1] (1.University of Tokyo)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

Discussion

Real-Time Subsurface Moorings as a Promising Component of Global Ocean Monitoring System

*Jianing Wang[1], Fan Wang[1]

1. Institute of Oceanology, Chinese Academy of Sciences

Subsurface moorings have advantage in providing long term and full-depth ocean monitoring parameters. Traditional moorings normally release data once a year, which put constraints on the mooring data usage in the weather and short-term climate forecasts. Recently, the Institute of Oceanology, Chinese Academy of Sciences (IOCAS) has overcome difficulties in the long-term transmission of real-time data from subsurface moorings. Data from sensors up to 3000 m depth can be transmitted to the surface floating body through wireless acoustic communications and then to the shore through satellite. In 2016, the IOCAS had realized real-time transmission of three dimensional velocities over the upper 1000 m from one mooring for more than 280 days. In 2017, real-time transmission module was equipped on the majority of the moorings, and the depth range of data has been extended from 1000 to 3000 m; this real-time observing network has successfully been conducted for 300 days until now. The aim of this abstract is to make recommendation for Real-Time Subsurface Moorings (RTSMs) as a promising component of global ocean observing systems.

The present prediction skill of ENSO at short lead time still leaves much to be desired. Beyond surface ocean data delivered by moored buoys and satellites in real time, the RTSMs can provide the time-depth variations of temperature and velocity at the subsurface and intermediate layers (e.g., the Equatorial Undercurrent variability), which also play a crucial role in the evolution of ENSO. Assimilation of these data will further improve the ENSO prediction skill. Deep-sea data acquiring in real time are also useful to many marine applications, including shipping, fishing, ocean emergent search and rescue, and pollution monitoring. RTSMs will provide data without the need of the use of a ship. This reduces the cost of ship and the risk of data loss due to mooring damage, making the fixed observation system in a more cost-effective manner.

Keywords: Real-Time Subsurface Mooring, Global Ocean Observing Systems

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Seasonal Variation of the Mixed Layer Depth at 60°S and its governing dynamics

*Matheus Ferreira Azevedo[1], Yujiro Kitade[1], Shigeru Aoki[2]

1. Tokyo University of Marine Science and Technology, 2. Institute of Low Temperature Science, Hokkaido University

In this research, data from a yearlong M-TRITON type mooring system deployed in 2012 is used to study the seasonal variability of the dynamics governing the Southern Ocean and its influence on the mixed layer depth by measuring temperature, salinity and current velocity data. GHRSST Satellite data and reanalysis ERA-interim wind data were used to complement the mooring, identifying spatial variation in wind and sea surface temperature (SST). This is relevant in the context of coupling readily available surface information (via satellite) and punctual information from ship CTD casts with corresponding subsurface phenomena.

A major factor of mixing was identified as the work on upper-ocean inertial motions (period T =13.8186 hours) associated with variable wind forcing, corroborating with the work of Alford (2001, 2003), Watanabe & Hibiya (2002) and Furuichi et al. (2008). Strong wind peaks, were observed to break stability, parametrized as the Buoyancy frequency N^2, which varied from an order of 10^{-4} s^{-2} to 0 or negative values in the original mixed layer depth (MLD) at the period, while enhancing stability at deeper layers in the same proportion it decreases at the layer above. As a consequence, the MLD increases by around 25m during these events. Wind forcing was found to influence stability and MLD not only through the work of storm induced near-inertial motion but also through meso-scale meridional transport, modulating the frontal structure of the Antarctic Convergence. During winter, the system response to wind weakened as surface cooling induced large scale convection. In particular a cold front reached the mooring at May 28th, starting the convection process. MLD responded by deepening to as far as 150m, and upward salinity flux could be observed.

Strong shear could be observed, usually bellow the mixed layer and generally agreeing with other reports of momentum penetration beyond the scalar mixed layer (e.g. Johnston & Rudnick, 2009). Shear comparison could not be made throughout the year, however, as the mixed layer goes bellow the ADCP detection range during winter. The strong stratification at the base of the mixed layer was seen to generate a complex internal wave field, where shear instability dissipates through high frequency internal waves of period between 2 and 4 hours. These waves seem to become trapped at the stratified layer and evolve to inertial period oscillations, increasing in amplitude until they break, generating high frequency waves once again. This process was observed to repeat at every mixed layer deepening event, either in summer or winter. The relation between internal waves, mixing and MLD at the Southern Ocean is a step to understand nutrient availability and the formation of important water masses of global influence.

Keywords: Southern Ocean, Internal waves, Mixing

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21st-Century Flood Hazards along the U.S. Atlantic Coast: Impacts of Sea Level Rise and Tropical Cyclone Climatology Change

*Reza Marsooli[1], Ning Lin[2], Kerry Emanuel[3]

1. Stevens Institute of Technology, 2. Princeton University, 3. Massachusetts Institute of Technology

Flooding due to tropical cyclones (TC) is among the most destructive coastal hazards along the U.S. Atlantic Coast. TC-induced coastal flooding will worsen under sea level rise (SLR) and climate change. To effectively adapt to these evolving hazards, it is essential to understand potential changes in future flood return levels. The present study investigates the impact of 21st-century sea level and TC climatology on flood return levels along the U.S. East and Gulf Coasts. We use extreme value theory and combine probabilistic estimates of sea level rise and TC storm tides to determine flood return levels for the historical period of 1980-2005 and the future period of 2070-2100 (under the emission scenario RCP8.5). A basin-scale hydrodynamic model is implemented to simulate storm tides for large numbers of synthetic TCs that are generated by a statistical-deterministic TC model under climate conditions observed during the historical period and projected by six climate models for the future period. We present and discuss flood return level projections and the contribution of sea level rise and TC climatology change to the projected changes in the return levels.

Keywords: Storm Surge, Tropical Cyclone, Sea Level Rise, Climate Change, U.S. Atlantic Coast

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The Effect of Ocean Waves on an Explosive Cyclone Development: Investigation with a Coupled Model

*Yuki Kita[1], Takuji Waseda[1]

1. University of Tokyo

Violent ocean waves are generated by the explosive cyclone. Since ocean waves affect the development of tropical cyclones, the impacts of ocean waves on the development of explosive cyclones are expected. Ocean waves have several impacts on the atmospheric surface layer: surface friction, sea spray, and momentum flux. We implemented sensitivity experiments to clarify how much ocean waves affect the development of an explosive cyclone with an atmosphere-ocean-wave coupled model, especially focusing on surface friction affected by ocean waves. The test case is the explosive cyclone emerged in early January 2018 over the Northwestern Atlantic. The atmospheric model is Weather Research and Forecasting Model (WRF), the ocean model is Coastal and Regional Ocean COmmunity model (CROCO), and the ocean wave model is WAVEWATCH III (WW3). We compared the numerical simulation results between the WRF-CROCO model and the WRF-CROCO-WW3 model. In the WRF-CROCO-WW3 coupled model considering ocean wave impacts just on surface friction, it is found that the deepening of the explosive cyclone was intensified by about 2hPa in the central sea level pressure, and the center track slightly shifted. In the fully coupled model, the surface roughness reduced and the wind speed was intensified by and large. Compared with observation data above the ocean, the fully coupled model had more accurate wind speed and sea level pressure than the atmosphere-ocean coupled model. It is also revealed that the boundary surface layer scheme in the atmospheric model is critical for accurate reproduction of surface atmospheric process and ocean waves. To reproduce accurate wind speed and wave height, the YSU (Yonsei University) scheme had a better performance than the MYNN (Mellor-Yamada-Nakanishi-Niino) 3rd scheme. As the next step, it is necessary that a coupled model takes into account the turbulent momentum flux produced by ocean waves to reproduce complete accurate air-sea interactions.

Keywords: Explosive cyclone, Ocean surface waves, Air-sea interaction, Coupled model

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Tue. May 28, 2019 9:00 AM - 10:30 AM JST | Tue. May 28, 2019 12:00 AM - 1:30 AM UTC | 106 1F

[A-OS20] Global ocean observing systems, obtained results and system optimization: toward OceanObs19

convener:Shigeki Hosoda(Japan Marine-Earth Science and Technology), Shuhei Masuda(Japan Agency for Marine-Earth Science and Technology), Yosuke Fujii(Meteorological Research Institute, Japan Meteorological Agency), Fujiki Tetsuichi(Japan Agency for Marine-Earth Science and Technology), Chairperson:Shigeki Hosoda(Japan Agency for Marine-Earth Science and Technology)

Almost twenty years have been passed since the beginning of Argo programme to construct global ocean observing system. The Argo observing system have been covering the global ocean with more than 3000 Argo floats with collaboration of many countries. The Argo is well known as one of the best practices of ocean observing systems, as lots of scientific results and social/industrial benefits have been gained based on indispensable huge amount of oceanic data which has never obtained before. Recently, the Argo observing system is rapidly expanded to monitor deeper ocean (Deep Argo; >4000m depth) and bio-geochemical parameters (Biogeochemical Argo) in addition to upper layer temperature and salinity (Core Argo; <2000m depth).
On the other hand, sustainability of the Argo is not guaranteed and its observing array is still developing as international infrastructure. For example, Argo float distribution recently tends to be inhomogeneous since a part of float deployment and operation is still conducted by voluntary works. Therefore, improving the observing systems to be more effective and sustainable is a mandatory task in the oceanographic community. In this background, various efforts are forwarded to evaluate impacts of ocean observations by the support of GODAE OceanView which is endorsing the Argo programme. In coming OceanObs19, development, expansion and enhancement of the sustainability of the Argo observing systems will be discussed based on scientific results and application researches.
In this session, current status, recent issues, future works on large-scale ocean observing systems are discussed in related to Argo and other research infrastructures such as GO-SHIP, OceanSITES etc., focusing on the global ocean observing system in coming next decade.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[AOS20-01] Global Ocean Observing System: The Past, the Present and the Future

★Invited Papers

*Toshio Suga[1,2] (1.Graduate School of Science, Tohoku University, 2.JAMSTEC)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[AOS20-02] Observed long-term change and variability in the global upper-ocean stratification

*Ryohei Yamaguchi[1], Toshio Suga[1,2] (1.Graduate School of Science, Tohoku University, 2.Japan Agency for Marine-Earth Science and Technology)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[AOS20-03] Estimation of changes in salinity and dissolved oxygen based on observational networks

★Invited Papers

*Shinya Kouketsu[1] (1.JAMSTEC Japan Agency for Marine-Earth Science and Technology)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[AOS20-04] Remotely forced decadal physical and biogeochemical variability of North Pacific Subtropical Mode Water over the last 40 years

*Daisuke Sasano[1], Eitarou Oka[2], Yudai Yamada[2], Enyo Kazutaka[1], Toshiya Nakano[1], Masao Ishii[3] (1.Japan Meteorological Agency, 2.Atmosphere and Ocean Research Institute, The University of Tokyo, 3.Meteorological Research Institute)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[AOS20-05] Asessing the impact of the global ocean observing system using ocean data assimilation systems

*Yosuke Fujii[1] (1.Meteorological Research Institute, Japan Meteorological Agency)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[AOS20-06] **Global ocean state estimation with new float observations**

*Shuhei Masuda[1], Satoshi Osafune[1], Tadashi Hemmi[1] (1.Japan Agency for Marine-Earth Science and Technology)

Global Ocean Observing System: The Past, the Present and the Future

*Toshio Suga[1,2]

1. Graduate School of Science, Tohoku University, 2. JAMSTEC

A global ocean observing system with the first letters capitalized is the name of the international program led by the Intergovernmental Oceanography Committee (IOC) of the UNESCO: the Global Ocean Observing System (GOOS). GOOS is responsible for coordinating global ocean observations for three critical themes: climate, operational services, and marine ecosystem health. GOOS was launched in 1991 by the IOC in response to calls from the Second World Climate Congress held in 1990. The ocean research community has been intrinsically involved in the subsequent development of GOOS. The two international conferences, OceanObs '99 and OceanObs' 09, were milestones both for GOOS as the international program and for the global ocean observation system as the system consisting of various observing networks. Focusing on the outcomes and significance of these two conferences, the history of GOOS will be briefly described. At the moment, preparation of OceanObs'19 to be held this coming September is going on. The objective of the conference is to "bring people from all over the planet together to communicate the decadal progress of ocean observing networks and to chart innovative solutions to society’ s growing needs for ocean information in the coming decade." The relevant and background information of OceanObs'19 will be presented and the role of the research community will be discussed.

Keywords: Global Ocean Observing System, Essential Climate Variables, Essential Ocean Variables, observing network, Framework for Ocean Observing

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Observed long-term change and variability in the global upper-ocean stratification

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With the progress of global warming, enhanced upper-ocean thermal stratification from the 1970s has been reported by IPCC AR5. Many studies on future climate projection using CMIP climate models also point out that upper-ocean stratification will strengthen in this century. The strengthened stratification will reduce vertical nutrient supply from the subsurface by futher stabilizing the upper-ocean water column, and then the primary production of the whole ocean is concerned to decrease.

However, large uncertainties in the observational estimate of the long-term change in the upper-ocean stratification still remain. Strengthening trend of the upper-ocean thermal stratification due to the surface intensification of the warming signals has been detected from estimation using globally-averaged sea surface and subsurface temperature time series. On the other hand, some observational studies focusing on some specific regions or using relatively short time series demonstrate that the upper-ocean stratifications are weakening in recent decades, rather than strengthening associated with global warming.

We investigated globally the long-term change and variability in the upper-ocean stratification defined here as the difference between the surface and subsurface density. To resolve spatial patterns of the trends and superposed decadal variability, we used temperature and salinity observations with as spatial and temporal coverage as wide as possible from World Ocean Database 2013. As a result, strengthening trends of the upper-ocean stratification associated with global warming were detected over the global ocean, except for the Arctic Ocean. In the global average, the increase in density stratification corresponds to a 6.6–11.8% of the mean stratification from the 1960s. In addition to the well-documented cause, that is the surface intensified warming, the subsurface temperature changes and haline stratification changes also have significant impacts on the long-term changes in the upper-ocean stratification. The decadal/interannual variabilities in the upper-ocean stratification associated with each particular climate mode are also detected in some ocean regions: The density stratification is correlated with the Niño 3.4 index in the tropical Pacific, negatively lagged correlated with the North Atlantic Oscillation (NAO) index in the North Atlantic, and shows correspondences with SST variations associated with the Pacific Decadal Oscillation (PDO) in the North Pacific.

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Estimation of changes in salinity and dissolved oxygen based on observational networks

*Shinya Kouketsu[1]

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Changes in temperature and salinity can be captured by Argo float networks more clearly than before the 2000s. For example, the global changes in ocean heat content can be comparable to the ones in sea surface height and net radiative flux into the earth system. Furthermore, various studies have been focusing on the changes in water masses, especially around surface layers. However, quantitative evaluation of regional changes has not been sufficiently clarified. For example, the salinity changes in the deeper layers cannot be easily captured by a float observation due to measurement uncertainty, and the changes in dissolved materials (ex. dissolved oxygen) remained not to be observed sufficiently. In this study, with the combination of autonomous observations and high accurate ship-based observations, we try to examine the possibility to capture and evaluate more accurately long-term changes with observation network.

As the first step, I will present the results based on the monthly salinity (temperature) distributions on the isopycnal surfaces obtained from Argo float observations. Based on the dataset, the long-term mean circulation with the spatial distribution of diffusivity coefficients was estimated, and the budgets for salinity (and temperature) changes in the recent decade were calculated. Especially, in the deeper layer (below 400m), the diapycnal diffusion effects were relatively large to the salinity (and temperature) increases. The salinity (and temperature) increases on the isopycnal surfaces might be consistent with the temperature increased on iso-depths. As the large-scale patterns of the changes revealed by the datasets were similar to the ones detected by twice occupations of the highest accurate observations, the salinity (and temperature) changes in this study were not so much influenced by biases in autonomous measurements (especially of salinity), and the present observation systems might be able to detect such small changes potentially.

The dissolved oxygen budgets were also estimated in the North Pacific with a long-term climatological distribution of the oxygen. The residuals of the budgets seemed to be consistent with the oxygen utilization estimation in previous studies. However, in some regions, temporal changes in oxygen, which included in temporal changes due to the changes in circulations and biological activities, were in the same order of magnitude of the residuals. Thus, spatial and temporal dense (and relatively high accurate) observation network will be needed to clarify the roles of mean biological activities on oxygen circulations as well as the temporal variabilities.

In the presentation, I will show some results of comparisons with assimilation or numerical models, and the other results (regional changes) appearing in the dataset.

Keywords: ocean observations, long-term ocean variability

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Remotely forced decadal physical and biogeochemical variability of North Pacific Subtropical Mode Water over the last 40 years

*Daisuke Sasano[1], Eitarou Oka[2], Yudai Yamada[2], Enyo Kazutaka[1], Toshiya Nakano[1], Masao Ishii[3]

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Half-century-long observations at the 137ºE hydrographic section across the western North Pacific have been analyzed to demonstrate remotely forced decadal physical and biogeochemical variability of Subtropical Mode Water (STMW) over the last 40 years. During unstable periods of the Kuroshio Extension (KE) that lagged the warm phase of the Pacific Decadal Oscillation by 3–4 years, high regional eddy activity reduced the formation rate and salinity of STMW in its main formation region south of the KE. At the 137ºE section south of Japan, decreasing advection of oxygen-rich STMW from the east resulted in decreases of dissolved oxygen and pH and increases of nutrients and dissolved inorganic carbon, accelerating acidification. Such changes reversed and acidification slowed down during stable-KE periods, especially in the current period since 2010 exhibiting a hiatus of acidification. These results indicate a new mechanism by which climate variability affects physical and biogeochemical structure in the ocean interior.

Keywords: North Pacific Subtropical Mode Water, Kuroshio Extension, Decadal variability, physical and biogeochemical linkage

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Asessing the impact of the global ocean observing system using ocean data assimilation systems

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Ocean and climate prediction systems are one of the important applications of the data observed by the global ocean observing system. In a prediction system, the oceanic field is estimated as accurately as possible through an ocean data assimilation system first, and then forecast integration of a numerical model is started using the estimated field as the oceanic initial condition. Data assimilation systems require ocean observation data for estimating the oceanic field, and the accuracy of the predictions, thus, severely depends on how much oceanic information effective for the predictions are included in the assimilated observation data, as well as the quality of the numerical model and the data assimilation scheme. Therefore, developing observing systems is an important factor of improving the prediction skills. Meanwhile, building up and maintenance of an observing system are conducted by public money or funds by stakeholders, and in order to sustain and to extend the observing system, we need to show that the system brings social benefits that is equivalent to or more than the investigation. Since observation data are exploited in the society mostly through the prediction systems, assessing impact of observation data on the accuracy of analysis and predictions in ocean data assimilation and prediction systems is an effective way to show the value of the observing system in the society.
GODAE OceanView (Its follow-on program “Oceanpredict” will take over the activity from May 2019) has established the Observing System Evaluation Task Team (OS-Eval TT) since the program was started, promotes data-impact assessments and information sharing for that, and builds up international collaboration for the relevant activities. These activities are also supported by CLIVAR Global Synthesis and Observation panel (GSOP). Operational centers, such as JMA and ECMWF, and research institutes, such as JAMSTEC and Scripps Institution of Oceanography, conducted observing system evaluation studies for various observations such as Argo, TAO-TRITON, and satellite altimetry under these supports. Those results are exploited in the evaluation of the TAO-TRIRON array for its reconstruction for example, but they have a limitation due to its system dependency and the importance of multi-system evaluation with common metrics is indicated. Achievements and resent challenges of observing system evaluation studies are summarized in a community white paper for OceanObs’19. This presentation will introduce some achievements of observing system evaluation studies and show a future perspective on this field.

Keywords: Observing System Evaluation, Ocean Data Assimilation, GODAE OceanView, Ocean Prediction, OceanObs'19

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Global ocean state estimation with new float observations

*Shuhei Masuda[1], Satoshi Osafune[1], Tadashi Hemmi[1]

1. Japan Agency for Marine-Earth Science and Technology

Argo floats are successfully contributing to global ocean state estimation. As the important roles of deep ocean to global changes has been recognized, sustainable deep ocean monitoring networks that use autonomous profiling floats have been widely proposed by the ocean observation community. An increasing number of deep-float deployment initiatives around the world. Deployed floats promise to provide unprecedented deep ocean information. Here we applied deep float data deployed by JAMSTEC to a deep ocean state estimation by using a four-dimensional variational approach. The results demonstrate that the available float data enables some corrections of the modeled ocean state locally for each float although the impact of the data on a basin-scale deep ocean state estimation was still limited in this study due to sparseness of used float data. This implies strategic deployments of deep float in the world’s ocean can immediately contribute to improvement of a current global deep ocean state estimation.

Keywords: Ocean Observation, Global, data assimilation

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CC Cryospheric Sciences & Cold District Environment

Tue. May 28, 2019 9:00 AM - 10:30 AM JST | Tue. May 28, 2019 12:00 AM - 1:30 AM UTC | 201B 2F

[A-CC26] Ice cores and paleoenvironmental modeling

convener:Ryu Uemura(University of the Ryukyus), Kenji Kawamura(National Institute of Polar Research, Research Organization of Information and Systems), Ayako Abe-Ouchi(Atmosphere and Ocean Research Institute, The University of Tokyo), Nozomu Takeuchi(Chiba University), Chairperson:Ryu Uemura(University of the Ryukyus), Ikumi Oyabu(National Institute of Polar Research)

Analyses of ice cores from polar and mountain regions have contributed to the reconstruction and understanding of the past environmental changes on timescales from years to several hundred thousand years. In this session, we welcome paleoenvironmental studies using ice cores and paleoclimatic modeling. Studies on reconstruction methods, recording processes and new paleoenvironmental proxies, technical aspects of paleo-modeling are also welcomed. Studies with marine sediment cores, terrestrial sediment cores and tree-rings on similar timescales are also important and welcomed, in order to discuss past environmental changes from multidisciplinary viewpoints.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[ACC26-01] Aerosols and climate change in the Arctic in the historical experiments using the MRI Earth System Model

★Invited Papers

*Naga Oshima[1], Taichu Y Tanaka[1], Tsuyoshi Koshiro[1], Makoto Deushi[1], Takuro Aizawa[1], Masahiro Hosaka[1], Hideaki Kawai[1], Seiji Yukimoto[1], Iizuka Yoshinori[2], Kumiko Goto-Azuma[3], Teruo Aoki[4] (1.Meteorological Research Institute, 2.Institute of Low Temperature Science, Hokkaido University, 3.National Institute of Polar Research, 4.Okayama University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[ACC26-02] Particles in ice layers of SIGMA-A ice core, northwestern Greenland

*Kaoru Kawakami[1,2], Yoshinori Iizuka[2], Sumito Matoba[2], Teruo Aoki[3], Shin Sugiyama[2], Takuto Ando[4] (1.Graduate School of Environmental Science, Hokkaido University, 2.Institute of Low Temperature Science, Hokkaido University, 3.Graduate School of Natural Science and Technology, Okayama University, 4.Arctic Research Center, Hokkaido University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[ACC26-03] Snow modification due to climate change in southeastern high-accumulation area of Greenland over the last 60 years evaluated by physical properties of firn core.

*Takuto Ando[1], Iizuka Yoshinori[2,3], Mai Shibata[2,3], Sumito Matoba[2,3], Shin Sugiyama[2,3], Satoru Adachi[4], Satoru Yamaguchi[4], Koji Fujita[5], Akira Hori[6], Teruo Aoki[7], Shuji Fujita[8] (1.Arctic Research Center, Hokkaido University, 2.Institute of Low Temperature Science, Hokkaido University, 3.Graduate School of Environmental Science, Hokkaido University, 4.National Research Institute for Earth Science and Disaster Resilience, 5.Graduate School of Environmental Studies, Nagoya University, 6.Department of Civil and Environmental Engineering, Kitami Institute of Technology, 7.Graduate School of Natural Science and Technology, Okayama University, 8. National Institute of Polar Research)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[ACC26-04] Temporal variations of concentrations, size distributions, and seasonal variations of anthropogenic and natural black carbon in Greenland

*Kumiko Goto-Azuma[1,2], Yoshimi Ogawa-Tsukagawa[1], Yutaka Kondo[1], Remi Dallmayr[1,10], Motohiro Hirabayashi[1], Jun Ogata[1], Kyotaro Kitamura[1], Kenji Kawamura[1,2], Hideaki Motoyama[1,2], Sumito Matoba[3], Teruo Aoki[4], Nobuhiro Moteki[5], Sho Ohata[5], Tatsuhiro Mori[6], Makoto Koike[5], Yuki Komuro[7], Akane Tsushima[8,9], Naoko Nagatsuka[1], Wataru Shigeyama[1,2], Koji Fujita[9] (1.National Institute of Polar Research, 2.SOKENDAI, 3.Hokkaido University, 4.Okayama University, 5.University of Tokyo, 6.University

of Science, 7.Yamagata University, 8.Research Institute for Humanity and Nature, 9.Nagoya University, 10.AWI)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[ACC26-05] Mineral composition of dust layers in a shallow ice core drilled in Pamir Alay Mountains of Central Asia

*Shunsuke Takeuchi[1], Nozomu Takeuchi[1], Koji Fujita[2], Kenji Kawamura[3], Akane Tsushima[2], Vladimir Aizen[4] (1.Chiba University, 2.Nagoya University, 3.National Institute of Polar Research, 4.Idaho University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[ACC26-06] Estimation of snow surface patterns from the coast to the inland, Dome-Fuji Station, of Antarctica, using camera images

*Konosuke Sugiura[1], Kengo Watanabe[1], Naohiko Hirasawa[2], Kenji Kawamura[2], Fumio Nakazawa[2], Hiroshi Ohno[3], Shuji Fujita[2], Ikumi Oyabu[2], Takashi Yamanouchi[2], Hideaki Motoyama[2] (1.University of Toyama, 2.National Institute of Polar Research, 3.Kitami Institute of Technology)

Aerosols and climate change in the Arctic in the historical experiments using the MRI Earth System Model

*Naga Oshima[1], Taichu Y Tanaka[1], Tsuyoshi Koshiro[1], Makoto Deushi[1], Takuro Aizawa[1], Masahiro Hosaka[1], Hideaki Kawai[1], Seiji Yukimoto[1], Iizuka Yoshinori[2], Kumiko Goto-Azuma[3], Teruo Aoki[4]

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Atmospheric aerosols modify the global radiation budget directly through scattering and absorption of solar radiation and indirectly through modification of the microphysical properties of clouds. However, there remain large uncertainties in estimates of aerosol effects on the climate system because of the insufficient prediction of aerosols in the Arctic by previous climate models.
Meteorological Research Institute (MRI) has developed a new version of MRI Earth System Model (MRI-ESM2) for participating in the Coupled Model Intercomparison Project Phase 6 (CMIP6). MRI-ESM2 is an updated version of MRI-ESM1 and consists of four major component models; an atmospheric general circulation model with land processes (a horizontal resolution of approximately 120 km), an ocean-sea-ice general circulation model, an aerosol model (approximately 180 km), and an atmospheric chemistry model (approximately 280 km). The number of vertical levels of MRI-ESM2 is 80 (model top at 0.01 hPa). As MRI-ESM2 shows the improvement of prediction of aerosol variations in the recent Arctic, we estimate effects of aerosols on climate change in the Arctic from the pre-industrial to present conditions.
We conducted the CMIP6 historical experiment (1850-2014) by MRI-ESM2 and compared the model results with the ice core data in Greenland. In the comparisons, we used three types of model calculation results; the MRI-ESM2 calculation with the CMIP6 emission inventory, the MRI-ESM2 calculation with the CMIP5 emission inventory, and the previous MRI-ESM1 calculation with the CMIP5 emission inventory. The comparison with the Greenland SouthEastern Dome (SE-Dome) ice core data shows that the MRI-ESM2 calculations successfully reproduce the temporal variation of deposition flux of sulfate, although the previous MRI-ESM1 calculation largely underestimates the sulfate. The historical experiments by MRI-ESM2 show that sulfate at SE-Dome was mostly originating from anthropogenic sources in winter, but natural sources also played an important role in summer. The comparison with the ice core data at the D4 site shows that the MRI-ESM2 calculation with the CMIP6 emission could not reproduce the enhancement of black carbon concentrations in the early 20th century, but the MRI-ESM2 calculation with the CMIP5 emission could. This result suggests that there still remain large uncertainties in the emission inventory of black carbon. The CMIP6 historical experiments by MRI-ESM2 suggest that the aerosols play an important role for temperature changes in the Arctic. The predictions of the surface air temperature changes by MRI-ESM2 are improved from the previous model both in global and the Arctic. These results indicate the importance of analyses of ice cores for improvement of predictions of climate models and the usefulness of climate models for interpretation of ice core data.

Keywords: Aerosol, Climate model, Ice core, Climate change, Environmental change, Arctic

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Particles in ice layers of SIGMA-A ice core, northwestern Greenland

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1. Graduate School of Environmental Science, Hokkaido University, 2. Institute of Low Temperature Science, Hokkaido University, 3. Graduate School of Natural Science and Technology, Okayama University, 4. Arctic Research Center, Hokkaido University

Arctic atmospheric warming accelerates surface melting on the Greenland ice sheet. In the accumulation areas of the Greenland ice sheet, ice layers are formed by snowmelt and refreezing processes during summer. In the snowmelt water, chemical substances originated from atmospheric soluble aerosols exist as dissolved anion and cation species. After refreezing process, the ions are preserved in the state of acid or salt in the refrozen ice layer. However, the behavior of inclusions in refreezing ice layers is still unclear. In this study, we observed salt inclusions in ice layers of a Greenlandic ice core to understand how and where inclusions were formed along the snowmelt and refreezing process.
During spring 2017, a 60m ice core (hereinafter referred to as SIGMA-A core) was drilled on the northwestern Greenland (78º 03′06″N, 67º 37′42″W, 1490 m a.s.l), which covers the past 100 years. The SIGMA-A core has 243 ice layers (longer than 1mm in thickness), whose mean thickness is 13.8mm.Both the number and the thickness of ice layers have increased in recent 30 years. In a -20℃ cold room of Institute of Low Temperature Science, Hokkaido University, ice layers formed in 2006 and 2014 were selected from the SIGMA-A ice core. The two ice layers were cut to three sections of 40*6.56*25 mm(the 2014 sample), 40*5.45*75 mm(the bottom part of 2006 sample), 40*6*80 mm(the top part of 2006 sample) in the -20℃ cold room. Then, the size and location of inclusions in the sections were observed by a measuring microscope (OLYMPUS, STM-UM) in the cold room. The chemical composition of inclusions were identified by Raman spectroscopy in a cold chamber at -30℃ with the same method described in Ohno et al.[1].
The location of inclusions tends to be the bottom part of the both ice layers. The mean particle size is 17.6μm, which is larger than that in other dry ice cores. For example, the mean size of particles in Greenland NEEM core is about 1-4μm[2], and that in Dome Fuji core is 1-3 μm[1]. Also, inclusions are identified as $Na_2SO_4 \cdot 10H_2O$ and $CaSO_4 \cdot 2H_2O$ by the Raman measurements. The snowmelt and refreezing processes may produce huge salt inclusions at the last stage of refreezing due to ion redistribution.

References

[1] Ohno, H., et al. (2006), Characteristics of salt inclusions in polar ice from Dome Fuji, East Antarctica, *Geophysical Research Letters*, **33**, 8, L08501.

[2] Oyabu, I., et al. (2015), Chemical compositions of solid particles present in the Greenland NEEM ice core over the last 110,000 years, *J. Geophys. Res. Atmos.*, **120**, 9789–9813.

Keywords: ice core, Greenland, SIGMA-A

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Snow modification due to climate change in southeastern high-accumulation area of Greenland over the last 60 years evaluated by physical properties of firn core.

*Takuto Ando[1], Iizuka Yoshinori[2,3], Mai Shibata[2,3], Sumito Matoba[2,3], Shin Sugiyama[2,3], Satoru Adachi[4], Satoru Yamaguchi[4], Koji Fujita[5], Akira Hori[6], Teruo Aoki[7], Shuji Fujita[8]

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Information of ice sheet albedo in the past is necessary for improving climatic models and future prediction. Snow grain size is indispensable property for evaluating surface albedo of ice sheets. The large parts of firn/ice core samples, however, have already lost information of initial snow grain size after densification. It is important to develop indicators to evaluate history of snow grain modification from firn/ice core samples. There is a correlation between specific surface area (SSA) and near-infrared reflectance (NIR). Continuous SSA values of core samples can be obtained by near-infrared reflectance analysis. We collected the firn core from SE-Dome, the southeastern Greenland in 2015. The SE-Dome firn core records the seasonal variations over the last 60 years due to their higher accumulation rate (~1m/year). In the present study, we focused on relationship between density and NIR and reconstructed the relationship between climate change and snow grain modification over the last 60 years.
Density and NIR data from the SE-Dome ice core are negatively correlated in the long-term trend. These negative correlations show SSA values basically decrease with snow densification. On the other hand, there is positive correlation between density and NIR data in the short-time trend. Both density and NIR of summer samples particularly tend to be lower value than those of samples deposited during other seasons in same year. Timing and number of the low-SSA and low-density layers are related to those of the periods in which air temperature reaching over -5 ℃ continued. This relationship shows the formation of low-SSA and low-density layers enhanced even though air temperature was less than 0℃. The low-SSA and low-density layers are caused by density reduction due to snow sublimation on the surface of ice sheet.

Keywords: Greenland, physical property, near-infrared reflectance , firn, snow grain, albedo

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Temporal variations of concentrations, size distributions, and seasonal variations of anthropogenic and natural black carbon in Greenland

*Kumiko Goto-Azuma[1,2], Yoshimi Ogawa-Tsukagawa[1], Yutaka Kondo[1], Remi Dallmayr[1,10], Motohiro Hirabayashi[1], Jun Ogata[1], Kyotaro Kitamura[1], Kenji Kawamura[1,2], Hideaki Motoyama[1,2], Sumito Matoba[3], Teruo Aoki[4], Nobuhiro Moteki[5], Sho Ohata[5], Tatsuhiro Mori[6], Makoto Koike[5], Yuki Komuro[7], Akane Tsushima[8,9], Naoko Nagatsuka[1], Wataru Shigeyama[1,2], Koji Fujita[9]

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An ice core retrieved at the SIGMA-D site, Northwest Greenland, in 2014 was analyzed down to the depth of 113 m. Between 6 and 113 m depths, we used a Continuous Flow Analysis (CFA) system developed at the National Institute of Polar Research. The CFA system enabled us to obtain high resolution data of black carbon (BC), stable isotopes of water, microparticles and six elements (Na, K, Mg, Ca, Fe, and Al). The top 6 m of the core was cut at a ca 5 cm interval, melted and analyzed. For BC analysis, we used a recently developed Wide-range SP2 (Single Particle Soot Photometer). We dated the core by annual layer counting using mainly Na and water stable isotopes, with occasional use of other impurities. We divided a year into 12 months and calculated monthly averaged BC concentrations and size distributions.
Here we report the variability of monthly resolved BC concentrations and size distributions over the past 350 years. BC number and mass concentrations started to increase in the 1870s, reached its maximum in the 1920s - 1930s, and decreased again since then. The increases are likely due to anthropogenic input. The increases are most significant in fall and winter months. We find anthropogenic changes in seasonality of BC concentration: annual concentration peak shifted from summer to winter. We also find anthropogenic changes in size distribution of BC: the mode diameter of mass concentration and average mass of BC particles became larger. This suggests that anthropogenic BC particles are larger than natural ones in the snow deposited in Greenland. Apart from anthropogenic BC, BC concentration occasionally showed large spikes in summer. They are likely originated from biomass burnings. We will compare the results from the SIGMA-D core with those from other ice cores drilled in Greenland and discuss spatial variations of BC.

Keywords: Black carbon, Greenland, Ice core

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Mineral composition of dust layers in a shallow ice core drilled in Pamir Alay Mountains of Central Asia

*Shunsuke Takeuchi[1], Nozomu Takeuchi[1], Koji Fujita[2], Kenji Kawamura[3], Akane Tsushima[2], Vladimir Aizen[4]

1. Chiba University, 2. Nagoya University, 3. National Institute of Polar Research, 4. Idaho University

Dust (mineral particles) contained in the ice core has been used as a proxy of past atmospheric circulation or arid climate condition. Most of dust studies have just analyzed dust flux and size distribution, but little study focused the meteorological type and composition of dust. Since the type and composition of dust varies depending on its origin and transport process, they are potential to reveal detailed source of dust and atmospheric circulation fluctuation. In this study, we analyzed mineral composition of dust layers of a shallow ice core drilled in the Pamir Alay Mountains of Central Asia of Kyrgyz Republic in August 2016, using an optical microscope and a scanning electron microscope.
The depth profiles of dust differed between small size ($1<d\leqq15$ μm) and large size ($d>15$ μm). The dust layers consisting mainly of small size dust contained abundant yellow colored minerals, while those with large size dust contained more abundant red colored minerals. Furthermore, the dust layers of large size dust contained calcite originating from limestone, which is an unique geology of Pamir region, indicating they are originate from near the glacier. Results revealed that the mereological type and composition differed significantly among the dust layers of the ice core. In particular, they are possibly originated from two different sources, including a short distance consisting of calcite and red mineral, and a long-distance without them.

Keywords: Glacier, Ice core, Dust, Colored mineral, Mineral composition, Pamir

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Estimation of snow surface patterns from the coast to the inland, Dome-Fuji Station, of Antarctica, using camera images

*Konosuke Sugiura[1], Kengo Watanabe[1], Naohiko Hirasawa[2], Kenji Kawamura[2], Fumio Nakazawa[2], Hiroshi Ohno[3], Shuji Fujita[2], Ikumi Oyabu[2], Takashi Yamanouchi[2], Hideaki Motoyama[2]

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Snow surface patterns in Antarctica are of practical concern and are important from the standpoint of developing an optimum route in Antarctica. In this study, we estimate snow surface patterns from the coast to the inland of Antarctica using camera images during JARE-59. The interval camera was used to capture the image of snow surface. Snow surface was photographed from November 13, 2017 to December 9, 2017. The number of images from the southern latitude of 69 degrees to 77 degrees was about 14,000 sheets. One sheet was divided into eight zones to distinguish a small-scale snow surface pattern. The pattern of snow surface was classified in three kinds such as 1) deposition, 2) equilibrium, and 3) erosion. We judged the snow surface patterns by sight. When Snow dune/Snow barchan was observed, it was classified as a deposition pattern. When Sastrugi/Glazed surface was observed, it was classified as an erosion pattern. In addition, when snow ripples were observed, it was classified as an equilibrium pattern.
The result of our analysis shows that the frequency of the deposition pattern decreases as latitude rises to 73 degrees south (Katabatic wind region) and then it increases slightly. In contrast, the frequency of the erosion pattern increases as latitude rises to 73 degrees south above which it decreases slightly. On the other hand, there have been no outstanding changes in the equilibrium pattern. The analyzed results of latitude dependence agree with the previous research qualitatively. However, the dominant surface pattern in the inland plateau region was still the erosion pattern. Since we analyzed the data of the outward trip, it is necessary to analyze the data of the return trip from the inland to the coast and to investigate a time scale of the surface pattern changes.

Keywords: snow dune, snow barchan, sastrugi, glazed surface, snow ripple

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CC Cryospheric Sciences & Cold District Environment

Tue. May 28, 2019 10:45 AM - 12:15 PM JST | Tue. May 28, 2019 1:45 AM - 3:15 AM UTC | 201B 2F

[A-CC26] Ice cores and paleoenvironmental modeling

convener:Ryu Uemura(University of the Ryukyus), Kenji Kawamura(National Institute of Polar Research, Research Organization of Information and Systems), Ayako Abe-Ouchi(Atmosphere and Ocean Research Institute, The University of Tokyo), Nozomu Takeuchi(Chiba University), Chairperson:Nozomu Takeuchi(千葉大学), Kenji Kawamura(国立極地研究所)

Analyses of ice cores from polar and mountain regions have contributed to the reconstruction and understanding of the past environmental changes on timescales from years to several hundred thousand years. In this session, we welcome paleoenvironmental studies using ice cores and paleoclimatic modeling. Studies on reconstruction methods, recording processes and new paleoenvironmental proxies, technical aspects of paleo-modeling are also welcomed. Studies with marine sediment cores, terrestrial sediment cores and tree-rings on similar timescales are also important and welcomed, in order to discuss past environmental changes from multidisciplinary viewpoints.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[ACC26-07] Isolation of living fungi from Antarctic ice cores

★Invited Papers

*Masaharu Tsuji[1] (1.National Institute of Polar Research)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[ACC26-08] **Study of ancient fungi resting in the polar ice cores and its future prospects**

*Fumio Nakazawa[1,2], Masaharu Tsuji[1], Satoshi Imura[1,2] (1.National Institute of Polar Research, 2.SOKENDAI (The Graduate University of Advanced Studies))

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[ACC26-09] **Flux, provenance and modification of terrestrial dust and sea salt in the Dome C and Dome Fuji ice cores from Last Glacial Maximum to early Holocene by ice-sublimation and single-particle measurement of soluble and insoluble particles**

*Ikumi Oyabu[1,2], Iizuka Yoshinori[3], Kenji Kawamura[1,4,5], Eric Wolff[6], Mirko Severi[7], Margareta Hansson[8] (1.National Institute of Polar Research, Research Organization of Information and Systems, 2.Japan Society for the Promotion of Science, 3.Institute of Low Temperature Science, Hokkaido University, 4.SOKENDAI (The Graduate University of Advanced Studies), 5.Japan Agency for Marine Science and Technology (JAMSTEC), 6.Department of Earth Sciences, University of Cambridge, 7.Department of Chemistry “Ugo Schiff”, University of Florence, 8.Department of Physical Geography, Stockholm University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[ACC26-10] Spatial variation of surface mass balance over the last few millennia in the Dome Fuji area from the analyses of shallow ice cores

*Kenji Kawamura[1], Ikumi Oyabu[1], Fumio Nakazawa[1,2], Shuji Fujita[1,2], Kyohei Yamada[1], Naoyuki Kurita[4], Shun Tsutaki[5], Hiroshi Ohno[6], Konosuke Sugiura[7], Kumiko Goto-Azuma[1,2], Hideaki Motoyama[1,2], Ayako Abe-Ouchi[5,3] (1.National Institute of Polar Research, Research Organization of Information and Systems, 2.SOKENDAI (The Graduate University of Advanced Studies), 3.JAMSTEC, 4.Nagoya University, 5.University of Tokyo, 6.Kitami Institute of Technology, 7.University of Toyama)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[ACC26-11] Sensitivity of global nonhydrostatic atmospheric model to changes in orbital forcing for the early Holocene

*Minoru Chikira[1], Ayako Abe-Ouchi[1], Masaki Satoh[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[ACC26-12] **Roles of sea ice–surface wind feedback in maintaining contrasting modes of glacial Atlantic meridional overturning circulation and climate**

*Sam Sherriff-Tadano[1], Ayako Abe-Ouchi[1] (1.Atmosphere and Ocean Research Institute, the University of Tokyo)

Isolation of living fungi from Antarctic ice cores

*Masaharu Tsuji[1]

1. National Institute of Polar Research

15 million years ago, the temperature of Antarctica was about 11 ℃ higher than the current temperature [(1)]. Many of fungi reported from Antarctica have also been reported from a variety of extreme, perennial cold environments including the Arctic, Siberia, the Alps, Alaska, Patagonia. Since these fungi have only been reported from the environment like the polar desert, fungi currently inhabited in Antarctica are thought to have come after 15 million years ago. However, the origins of the fungi inhabiting Antarctica are unknown.

In this presentation, to elucidate the origin and evolution of Antarctic fungi, I would like to introduce the isolation of Antarctic fungi from Antarctic ice cores.

Keywords: Ice core, Ancient fungi, Antarctica

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Study of ancient fungi resting in the polar ice cores and its future prospects

*Fumio Nakazawa[1,2], Masaharu Tsuji[1], Satoshi Imura[1,2]

1. National Institute of Polar Research, 2. SOKENDAI (The Graduate University of Advanced Studies)

This study attempted to culture ancient fungi preserved in the polar ice cores dated from ~1000 to ~9000 years ago. The samples of several hundred grams of ice collected at depths of 97, 470 and 670 m from Mizuho station (70°42'S, 44°20'E; 2230 m a.s.l.) and at depths of 116, 141 and 169 m from Dome Fuji station (77°19'S, 39°42'E; 3810 m a.s.l.) in Antarctica (Fujii, 1985; Dome-F Deep Coring Group, 1998). The ages of these samples were estimated to be ~1000, ~5500 and ~9000 years for the Mizuho ice core (Nakawo et al., 1989) and ~3000, ~4000 and ~5000 years for the Dome Fuji deep ice core (Dome Fuji Ice Core Project Members, 2017) respectively. In addition, an ice core sample from Åsgardfonna in the northeastern part of Svalbard (79°27'N, 16°43'E; 1140 m a.s.l.) (Uchida et al., 1993) was used for the cultivation. The information on the sample depth and age were unclear. In this study, we successfully cultivated fungi from all the samples. The nucleotide sequences were obtained by DNA analyses of the strains. Many of these sequences showed low homology to those registered in the NCBI DNA database, therefore it was believed that ancient fungi were actually obtained. This suggested that the culture of ancient fungi and its DNA analysis enable to be done over time by using deep ice cores such as the Dome Fuji ice core. This allows to study the physiological ecology of ancient fungi and to use decomposition and fermentation characteristics of ancient fungi for industrial purposes. Also, DNA analyses of the ancient fungi may enable to examine the diversity of fungi with climate and environmental changes and to study the evolutionary history on fungi. In our presentation, we will introduce the results obtained and discuss the prospects and developments of the study using the ancient fungi preserved in the polar ice cores in the future.

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Keywords: snow and ice, microorganism, ancient DNA, population genetics, evolution, biotechnology

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Flux, provenance and modification of terrestrial dust and sea salt in the Dome C and Dome Fuji ice cores from Last Glacial Maximum to early Holocene by ice-sublimation and single-particle measurement of soluble and insoluble particles

*Ikumi Oyabu[1,2], Iizuka Yoshinori[3], Kenji Kawamura[1,4,5], Eric Wolff[6], Mirko Severi[7], Margareta Hansson[8]

1. National Institute of Polar Research, Research Organization of Information and Systems, 2. Japan Society for the Promotion of Science, 3. Institute of Low Temperature Science, Hokkaido University, 4. SOKENDAI (The Graduate University of Advanced Studies), 5. Japan Agency for Marine Science and Technology (JAMSTEC), 6. Department of Earth Sciences, University of Cambridge, 7. Department of Chemistry “Ugo Schiff”, University of Florence, 8. Department of Physical Geography, Stockholm University

We analyzed chemical compositions of dust and sea-salt particles in the EPICA Dome C (EDC) ice core between 26 and 7kyr BP by using an ice sublimation technique, and compared the results with existing data of the Dome Fuji (DF) ice core. Combining the results of non-sea-salt Na and sea-salt Na fractions in total Na from the sublimation measurement and Na^+concentrations from ion measurement, we estimated that sea-salt flux in the two cores are roughly the same, while dust flux in the EDC core is significantly lower than that in the DF core throughout the studied period. Al/Si ratio of dust particles in the EDC core increased since around 16 kyr BP, suggesting that the average mixing ratios of minerals, presumably from different source locations, are different before and after 16 kyr BP. The composition of calcic dust also changed around 16 kyr BP; the fraction of calcium sulfate (calcic dust sulfatized during transport through lower troposphere) decreased and that of calcium nitrate (calcic dust reacted with nitric acid during transport through the middle to upper troposphere) increased. Previous studies on the mineralogy of EDC dust have suggested that dominant dust source area was Patagonia before 16 kyr BP and that multiple dust sources may have contributed thereafter (Siggaard-Andersen et al., 2007; Marino et al., 2008; Vallelonga et al., 2010).On the other hand, atmospheric model simulations have suggested that Patagonian dust is transported via lower troposphere, while Australian dust is transported via middle to upper troposphere (Li et al., 2008; Krinner et al., 2010). Thus, our data collectively confirm the dominance of Patagonian dust during the LGM and support the hypothesis of increased Australian dust contribution during the Termination and Holocene. The Dome Fuji Al/Si ratios were lower than those in the EDC core, and the fraction of calcium sulfate in the DF core are higher than those in the EDC core after around 16 kyr BP. The results suggest that Patagonian dust continued to be the dominant contributor to the Dome Fuji region after 16 kyr BP.

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Keywords: Ice core, Antarctica, aerosol, dust, sea salt

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Spatial variation of surface mass balance over the last few millennia in the Dome Fuji area from the analyses of shallow ice cores

*Kenji Kawamura[1], Ikumi Oyabu[1], Fumio Nakazawa[1,2], Shuji Fujita[1,2], Kyohei Yamada[1], Naoyuki Kurita[4], Shun Tsutaki[5], Hiroshi Ohno[6], Konosuke Sugiura[7], Kumiko Goto-Azuma[1,2], Hideaki Motoyama[1,2], Ayako Abe-Ouchi[5,3]

1. National Institute of Polar Research, Research Organization of Information and Systems, 2. SOKENDAI (The Graduate University of Advanced Studies), 3. JAMSTEC, 4. Nagoya University, 5. University of Tokyo, 6. Kitami Institute of Technology, 7. University of Toyama

One of the main targets in the current Japanese Antarctic program is to identify the drilling site for the oldest ice around Dome Fuji. The site selection activities (during JARE 59 and 60 summer seasons) include national and international ice-penetrating radar surveys, four shallow ice corings, and firn air sampling at one site. In this presentation, we report the shallow drillings and their analytical results for DEP (dielectric profiling) for deducing spatial differences of accumulation rate among the shallow drill sites.

During the JARE 59 surveys (2017-2018), the first core was drilled at 55 km south of Dome Fuji (New Dome Fuji; NDF) to the depth of 151.9 m, second one was drilled at 40 km southeast of Dome Fuji (DFSE) to 41 m, and third one was drilled at 30 km northwest of Dome Fuji (DFNW) to 41 m. The DEP of these cores were analyzed in summer 2018 at the NIPR cold laboratory, and major volcanic signals were identified back to 13thcentury for all three cores. During the JARE 60 surveys (2018-2019), we set up one base camp 5 km north of NDF (~50 km south of Dome Fuji) (NDFN) and drilled a shallow core to 142 m. The DEP analyses will be conducted for detecting volcanic signals along the core.

We also found a visible 20-mm-thick volcanic ash layer at 118.9 m in the NDF core, and a 10-mm-thick layer at 122.18 m in the NDFN core. Visible ash layers from probably the same origin have also been found in the Dome C (< 1-mm-thick layer at 132.6 m) and Vostok (~30-mm-thick layer at 103.04 m) ice cores. These ash layers were dated at 3500–3600 years before present (Basile et al., 2001; Kohno et al., 2004). On the other hand, volcanic ash layer was not found in the first Dome Fuji deep ice core (Narcisi et al., 2005) but in the second Dome Fuji deep ice core at 133.6 m.

The DEP and in-situ density data are used to date the horizons by comparing the DEP peaks to published volcanic data sets from several ice cores including the WAIS Divide core (Sigl et al., 2014), and to deduce surface mass balance between the volcanic signals for the three cores from JARE 59.

We identified 6 volcanic signals to 40-m depth and 12 signals to ~150-m depth (from the DF and NDF cores). We also use the data from the previously drilled cores (e.g. one from 6-km south of DF drilled in JARE 52, and one from 195-km south of DF in JARE 54) to discuss spatial patterns of accumulation rate from the corings. In the near future, the data will be combined with shallow ice-radar data from the JARE

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60 international surveys to expand the spatial estimate of accumulation rate over the Dome Fuji area.

Keywords: Ice core, Volcanic ash, Antarctica, Dome Fuji

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Sensitivity of global nonhydrostatic atmospheric model to changes in orbital forcing for the early Holocene

*Minoru Chikira[1], Ayako Abe-Ouchi[1], Masaki Satoh[1]

1. Atmosphere and Ocean Research Institute, The University of Tokyo

Various types of geological records have extensively shown consistent patterns of warmer and moister areas over Asia and Africa during the early to mid-Holocene. Previous sensitivity simulations of many global climate models to the changes in the earth’s orbital parameters during this period have equally shown the enhancement of the Asian and African monsoons, providing a successful interpretation on the qualitative patterns of these records. This study aims to shed a new light on the climate of this period by running sensitivity simulations by a global nonhydrostatic atmospheric model which began to be available for climate studies in recent years. The model used in this study is Nonhydrostatic ICosahedoral Atmospheric Model (NICAM) developed by a Japanese meteorological community: a framework of a cloud resolving model which resolves cumulus convection when used with a proper resolution and does not adopt any cumulus parameterizations. Because of the limit of computational resources, we use NICAM with a horizontal resolution of 56km. Despite not resolving cumulus convection, previous studies confirmed that it behaved similarly to the one with much higher resolution and provided practically reasonable mean-states and variability. The simulations were run with a slab ocean model and orbital parameters of 9000 years B.P. (9kBP). The Integrations were continued for 5 years. The seasonal mean precipitation in the control run is largely overestimated, however, it shows very good spatial distributions in terms of the locations of the ITCZs and peak precipitation. In particular, because of the high resolution enough to represent the steep terrain of the Tibetan Plateau, the model successfully reproduces a narrow rain band along its southern edge. The boreal summer precipitation of the 9kBP simulation shows a well-known northward shift of the African ITCZ, consistent with previous studies. Over Asia, the narrow precipitation band at the south of the Tibetan Plateau is significantly enhanced. The precipitation also increases over the Indian ocean. In between, there is a band-like structure of the suppressed precipitation over the India and Indochinese Peninsula. Although the resolution is not sufficient to resolve cumulus convection, the global nonhydrostatic atmospheric model appears to have a potential to represent small structures of the earth’s topography and evaluate its effect on precipitation which had not been discussed in previous studies. It is expected to be useful in discussing regional scale patterns of the geological records.

Keywords: Paleoclimate, Climate model, Holocene

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Roles of sea ice–surface wind feedback in maintaining contrasting modes of glacial Atlantic meridional overturning circulation and climate

*Sam Sherriff-Tadano[1], Ayako Abe-Ouchi[1]

1. Atmosphere and Ocean Research Institute, the University of Tokyo

During the glacial period, climate varied on millennial-time scale between two contrasting modes. These climate changes are often associated with drastic reorganizations of North Atlantic sea ice and Atlantic meridional overturning circulation (AMOC). However, processes affecting the periodicity of AMOC and climate variability remain unclear. Here, through performing simulations with a comprehensive climate model, we show that sea ice and associated changes in surface winds play a key role in maintaining the contrasting modes of AMOC and climate. Experiments highlights the importance of the suppression of atmosphere-ocean heat exchange by sea ice in inducing a weakening of surface winds. The surface wind anomaly then causes a reduction of salt transport and weakens AMOC, which triggers further expansion of sea ice. Our results show that sea ice–surface wind interactions over the North Atlantic plays an important role in inducing the long periodicity of the climate variability.

Keywords: millennial time-scale climate variability, sea ice-surface wind interaction, AMOC

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CC Cryospheric Sciences & Cold District Environment

Tue. May 28, 2019 1:45 PM - 3:15 PM JST | Tue. May 28, 2019 4:45 AM - 6:15 AM UTC | 201B 2F

[A-CC26] Ice cores and paleoenvironmental modeling

convener:Ryu Uemura(University of the Ryukyus), Kenji Kawamura(National Institute of Polar Research, Research Organization of Information and Systems), Ayako Abe-Ouchi(Atmosphere and Ocean Research Institute, The University of Tokyo), Nozomu Takeuchi(Chiba University), Chairperson:Ayako Abe-Ouchi(東京大学大気海洋研究所), Sam Sherriff-Tadano(University of Tokyo)

Analyses of ice cores from polar and mountain regions have contributed to the reconstruction and understanding of the past environmental changes on timescales from years to several hundred thousand years. In this session, we welcome paleoenvironmental studies using ice cores and paleoclimatic modeling. Studies on reconstruction methods, recording processes and new paleoenvironmental proxies, technical aspects of paleo-modeling are also welcomed. Studies with marine sediment cores, terrestrial sediment cores and tree-rings on similar timescales are also important and welcomed, in order to discuss past environmental changes from multidisciplinary viewpoints.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[ACC26-13] Simulated Dansgaard-Oeschger like oscillations and abrupt climate changes

*Ayako Abe-Ouchi[1,2,3], Wing-Le Chan[1], Sam Sherriff-Tadano[1], Takashi Obase[1], Masakazu Yoshimori[1], Akira Oka[1], Kenji Kawamura[3], Rumi Ohgaito[2] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.JAMSTEC, 3.National Institute of Polar Research)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[ACC26-14] Reproduction of the increasing amplitude and period in the glacial cycles using a model incorporating diatomaceous activity.

*Tasuku Akagi[1], Takahiro Hasegawa[2] (1.Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University, 2.Graduate School of Science, Kyushu University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[ACC26-15] Development of an Ice Sheet Model coupled General Circulation Model and application of Energy Balance Model on the estimation of Ice Sheet mass balance

*Ryouta O'ishi[1], Ayako Abe-Ouchi[2,1], Fuyuki SAITO[2], Takashi Obase[1] (1.Atmosphere and Ocean Research Institute, the Universitoy of Tokyo, 2.JAMSTEC)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[ACC26-16] An ice-flow modeling study for evaluation of sites for and oldest ice core around Dome Fuji, Antarctica

★Invited Papers

*Takashi Obase[1], Ayako Abe-Ouchi[1,2], Fuyuki SAITO[2], Shun Tsutaki[1], Shuji Fujita[3], Kenny Matsuoka[4], Kenji Kawamura[3,5,2], Ralf Greve[6] (1.Atmosphere and Ocean Research Institute, the University of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology, 3.National Institute of Polar Research, Research Organization of Information and Systems, 4.Norwegian Polar Institute, 5.SOKENDAI (The Graduate University of Advanced Studies), 6.Institute of Low Temperature Science, Hokkaido University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[ACC26-17] International studies of ice sheet and bedrock at Dome Fuji, East Antarctica

*Shuji Fujita[1,2], Kenji Kawamura[1,2,10], Prasad Gogineni[3], Ayako Abe-Ouchi[4], David Braaten[5], Jean-Charles Gallet[6], Elisabeth Isaksson[6], Brice van Liefferinge[6], Kenny Matsuoka[6], Charles O'Neill[3], John Paden[5], Fernando Rodriguez-Morales[5], Ryan A. Taylor[3], Shun Tsutaki[4], Jie-Bang Yan[3], Kumiko Goto-Azuma[1,2], Ralf Greve[7], Stephen Hudson[6], Jack Kohler[6], Shriniwas Kolpuke[3], Linfeng Li[3], Geir Moholdt[6], Hideaki Motoyama[1,2], Fumio Nakazawa[1], Takashi Obase[4], Hiroshi Ohno[8], Ikumi Oyabu[9,1], Fuyuki Saito[10],

Konosuke Sugiura[11] (1.National Institute of Polar Research, Research Organization of Information and Systems(ROIS), 2.Department of Polar Science, The Graduate University for Advanced Studies (SOKENDAI), Japan, 3.The University of Alabama, USA, 4.Atmosphere and Ocean Research Institute, The University of Tokyo, Japan, 5.CReSIS, University of Kansas, USA, 6.Norwegian Polar Institute, Norway, 7.Institute of Low Temperature Science, Hokkaido University, Japan, 8.Kitami Institute of Technology, Japan, 9.JSPS, Japan, 10.Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Japan, 11.University of Toyama, Japan)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[ACC26-18] Possible cause for rapid deformation of ice from glacial periods, investigated from laboratory-based deformation experiments and microstructural observations

*Tomotaka Saruya[1], Morimasa Takata[1], Tomoyuki Homma[1], Nobuhiko Azuma[1], Kumiko Goto-Azuma[2,3] (1.Nagaoka University of Technology, 2.National Institute of Polar Research, 3.SOKENDAI (The Graduate University for Advaced Research))

Simulated Dansgaard-Oeschger like oscillations and abrupt climate changes

*Ayako Abe-Ouchi[1,2,3], Wing-Le Chan[1], Sam Sherriff-Tadano[1], Takashi Obase[1], Masakazu Yoshimori[1], Akira Oka[1], Kenji Kawamura[3], Rumi Ohgaito[2]

1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. JAMSTEC, 3. National Institute of Polar Research

During the last termination of ice age cycle (deglaciation), Heinrich event 1 as well as B/A, Antarctic Cold Reversal (ACR) and Younger Dryas occurred as millennial scale climate changes. On the other hand, millennial scale climate changes such as D-O cycles recorded in ice core and deep sea cores in both hemisphere seem to occur more frequently during the mid-glacial state than during the early or late glacial state. Here we ran several sensitivity experiments and deglaciation simulations using a coupled atmosphere and ocean GCM (MIROC4m AOGCM) developed in Japan and analyzed the stability of AMOC and climate. Many model experiments were run for longer than10000 years under many different conditions of constant Greenhouse Gas levels, obliquity with/without glacial ice sheet and with and without freshwater flux into North Atlantic region. The results show large self-sustained oscillation of AMOC and high latitude temperature change similar to D-O cycles, which are consistent with ice core data and deep-sea data in both low and high latitude. Furthurmore, the results imply that both Northern Atlantic ocean-atmosphere-sea ice coupled system and Southern Ocean are important to maintain the oscillation with periodicity longer than 2000 years, for which we propose “Bipolar thermohaline oscillation” as its mechanism. We show that the D-O like oscillation occur with Glacial ice sheets under limited range of CO2, obliquity, and freshwater forcing. Implication on the mechanism and the conditions of the millennial scale climate changes for the past time period is discussed.

Keywords: Climate, Ice age cycle, Atlantic Meridional Overturning Circulation

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Reproduction of the increasing amplitude and period in the glacial cycles using a model incorporating diatomaceous activity.

*Tasuku Akagi[1], Takahiro Hasegawa[2]

1. Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University, 2. Graduate School of Science, Kyushu University

The mode changes in the glacial cycle, smaller amplitudes with 20 kyr periods before 2.7 BP; medium amplitudes with 40 kyr periods between 2.70 and 1 Ma BP; greater amplitudes with around 100 kyr periods after 1 Ma BP, remain unanswered.

Carbon cycling is closely coupled with silicon cycling in the Earth surface. Oceanic silica is supplied from weathering of terrestrial matter, which depends on the atmospheric pCO_2. The atmospheric pCO_2, in turn, is influenced by the diatomaceous biological pump. Silicon can be a crucial driver of the Earth surface environment. Oceanic silica is removed by the burial of amorphous silica produced by diatoms. We have reported that the non-linear dissolution behavior of diatom frustules, where greater diatomaceous production tends to suppress dissolution of dissolved silica forming greater-sized frustule-aggregates.

Here we have developed a numerical model expressing the carbon and silicon cycling in the Earth surface, with diatomaceous biological pump and the non-linear dissolution behavior of diatom frustules being introduced.

The results of the model runs show interesting outcomes: when the amount of circulating carbon is reduced with time, both the amplitude and period of atmospheric pCO_2increase with time. When the insolation changes by Milankovitch forcing were loaded on the model temperature, the mode changes are successfully reproduced.

We propose that the glacial cycles may be understood by the coupling of ice-sheet dynamics and change in the oceanic Si inventory.

Keywords: the glacial cycles, amplitude and period, silicon cycling, diatom activity

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Development of an Ice Sheet Model coupled General Circulation Model and application of Energy Balance Model on the estimation of Ice Sheet mass balance

*Ryouta O'ishi[1], Ayako Abe-Ouchi[2,1], Fuyuki SAITO[2], Takashi Obase[1]

1. Atmosphere and Ocean Research Institute, the Universitoy of Tokyo, 2. JAMSTEC

A sea level rise is an important topic in a future climate projection. In the past warm period known as the Last Interglacial (LIG), paleoevidences indicate sea level rise of several meters. Paleoclimate modeling community applies past GCM results on ice sheet models and tries to reproduce past sea level rises.
We designed a coupling procedure between an ice sheet model and a general circulation model and are planning to introduce a surface mass balance of ice sheet not only by a typicall empirical method called PDD (Positive Degree Days) but also surface mass balance on the ice sheet as an upper boundary condition. The PDD only refers the surface atmosphere temperature and snowfall. In the present study, we use a process-based land surface model MATSIRO to estimate surface mas balance forced not only by temperature and snowfall but also by other surface variables including shortwave and longwave radiation. We compare the characteristics of resultant ice melt amount from PDD and MATSIRO to evaluate the inclusion of process-based heat and water balance instead of empirical equation.
We apply this procedure on the estimation of Grennland mass balance in the LIG.

Keywords: ice sheet, mass balance, grneral circulation model

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An ice-flow modeling study for evaluation of sites for and oldest ice core around Dome Fuji, Antarctica

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The recovery of a new Antarctic ice core to cover one million years will advance our understandings of the Quaternary climate. Previous ice flow modeling studies indicate that such old ice may exist in inland areas of the Antarctic continent, where horizontal ice flow is slow, the ice is thick, accumulation rate is low, basal temperature is well below the pressure melting point (Pattyn 2010; Fischer et al. 2013). We have been analyzing the field data taken by 59th Japanese Antarctic Research Expedition (JARE 59, 2017-2018) and conducting ice flow modelings as the essential parts of the site selection activities. In the present study, we show results of ice flow modeling to estimate the temperature and age of ice, and age resolution of the ice near the bed at a dome of the ice sheet. We use an one-dimensional ice flow-thermodynamic model, in which the vertical velocity of the ice is parameterized with empirical functions applied to the area near ice sheet domes. At first, the calculated age and temperature profiles of the ice are compared with depth-age profile of the Dome Fuji ice core and borehole temperature at Dome Fuji to assess the model performance for our purposes. Next, we investigate the influence of parameters (ice thickness, accumulation rate, geothermal heat flux, profile of vertical velocity of the ice) on the age of ice especially in the lowest few hundred meters. The results indicate that a fine resolution of oldest ice (~age of 1.0 Ma before present) is expected from a thick ice and a low accumulation, but the thick ice increases the chance of basal melting. The one-dimensional model is applied to the vicinity of Dome Fuji along the transect of JARE 59 surveys, using estimated ice thickness and simplified pattern of surface mass balance and geothermal heat flux. The calculated distribution of the age of ice are compared with internal layers of the ice (isochrone) derived from ground radar surveys. The calculated age of ice roughly follows observed internal layers of ice, and a smaller accumulation near NDF compared to Dome Fuji increases the agreement between calculated age of ice and internal layers of ice.

Keywords: Antarctic ice sheet, ice core, modeling, Dome Fuji

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International studies of ice sheet and bedrock at Dome Fuji, East Antarctica

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1. National Institute of Polar Research, Research Organization of Information and Systems(ROIS), 2. Department of Polar Science, The Graduate University for Advanced Studies (SOKENDAI), Japan, 3. The University of Alabama, USA, 4. Atmosphere and Ocean Research Institute, The University of Tokyo, Japan, 5. CReSIS, University of Kansas, USA, 6. Norwegian Polar Institute, Norway, 7. Institute of Low Temperature Science, Hokkaido University, Japan, 8. Kitami Institute of Technology, Japan, 9. JSPS, Japan, 10. Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Japan, 11. University of Toyama, Japan

Climatic histories from about 800 kyr BP up to present have been studied using very deep ice cores drilled at dome summits in East Antarctica at Dome Fuji and Dome C. Knowledge gained from ice cores studies are crucial to understand the past and present climate and to predict the impacts of future climate changes. International Partnership for Ice Core Sciences (IPICS) identified that ice cores covering ages of the mid-Pleistocene Transition are necessary step to better understand climate dynamics. Multiple ice cores older than 1 M yrs BP are necessary. Dome Fuji area in East Antarctica is one of the candidate areas where we may be able to find very old ice core near the bottom of the ice sheet. Japanese Antarctic Research Expedition (JARE) has conducted deep ice coring at Dome Fuji twice in the past decade. They recovered ice cores covering ages up to about 720 kyr BP. At the same time, they have accumulated radar sounding data in this area. Alfred Wegener Institute (AWI), Germany, made an extensive airborne radar survey in 2016/2017 season covering Dom Fuji with a basic survey line spacing of 10 km. In the following season of 2017/2018, JARE also made ground-based radar surveys over a distance of 2950 km with a line spacing of 5 km or less. Based on results of these surveys, we conducted a more detailed radar surveys at Dome Fuji in 2018/2019 season as a collaborative research between University of Alabama, the University of Kansas, National Institute of Polar Research under Research Organization of Information and Systems (Japan), and Norwegian Polar Institute. Norwegian Polar Institute joined also collaborating on these efforts with the European framework of Beyond EPICA - Oldest Ice (BE-OI). We used two state-of-the-art radars: A wideband radar ice sounder developed by CReSIS, University of Kansas and ultra-wideband radar developed by University of Alabama. In addition, we used a classical pulse-modulated VHF radar of JARE with high gain antennas. Using a traverse team of JARE and its snow vehicles, we investigated along 2,700 km in an area of about 1,000 km^2. Final spacing between survey lines varied between 0.5 km and 0.25 km. The surveys were completed by the end of December, 2018. We will present preliminary results from these surveys. Preliminary quick-look results indicate that we collected an excellent radar data set with very good layering information including the bottom 10% of the ice. The data will be examined to identify candidate locations to drill very old ice.

Keywords: Antarctica, ice core, ice sheet, radar, paleoclimate, climate change

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Possible cause for rapid deformation of ice from glacial periods, investigated from laboratory-based deformation experiments and microstructural observations

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1. Nagaoka University of Technology, 2. National Institute of Polar Research, 3. SOKENDAI (The Graduate University for Advaced Research)

Deformation mechanism of coarse-grained polycrystalline ice is well investigated by various experiments. However, the deformation of ice-sheet ice is complicated by various factors such as local distributions of impurities and mechanical anisotropies. Detailed analyses of ice cores have revealed that ice from glacial periods (ice-age ice) that has highly-concentrated impurities and small grains deforms rapidly compared with ice from Holocene. Although the causes of the rapid deformation in ice-age ice have been discussed in various studies, the detailed mechanism remains unclear.
The deformation rate in ice sheets is extremely slow; therefore, ice-sheet ice deforms under low dislocation density state. To replicate such deformation mechanism in laboratory experiments, we prepared fine-grained ice which has much grain boundaries. Since grain boundaries can act as sinks of dislocations, a low dislocation density state is kept during deformation like ice sheets.
To investigate the cause of rapid deformation of ice-age ice, we conducted deformation experiments and microstructural observations using artificial ice, with focusing on the influences of microparticles and grain size (grain boundaries). We made pure ice, and silica-dispersed ice with particle diameters of 0.3 μm and mass concentrations of 0.1 and 0.01 %. For the investigation of grain-size-sensitivity of deformation, various-sized ice (mean grain size with 30 μm –2 mm) was prepared.
Our experimental results revealed different trends for softening and hardening effect due to microparticles dispersion, grain-size-sensitivity, and microstructural evolutions during deformation in fine- and coarse-grained ice. Silica-dispersed ice with coarse grains indicated a hardening trend compared with pure ice, while little direct effect on the deformation in fine-grained ice. Grain-size-sensitivity was appeared only in fine-grained ice: the strain rates become larger at finer grains.
In this presentation, we discuss the possible cause for the rapid deformation of ice-age ice based on systematic deformation experiments and microstructural observations.

Keywords: ice-sheet flow, microstructure, microparticles

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-GE Geological & Soil Environment

Tue. May 28, 2019 1:45 PM - 3:15 PM JST | Tue. May 28, 2019 4:45 AM - 6:15 AM UTC | 202 2F

[A-GE30] Conservation and Restoration of Soil Environment at Terrestrial Surface

convener:Yasushi Mori(Graduate School of Environmental and Life Science, Okayama University), Chairperson:Yasushi Mori(Okayama University)

Soil is the largest store of carbon of all terrestrial media. Soils also have important functions such as water storage and plant support roles. However, at present, these characteristics do not fully function, because of mismanagement of the field or climate-change-induced heavy rainfall would wash away the organic-rich surface soils. In this session, soil environment research, from soil conservation to restoration technique for degraded soils are welcomed.

1:45 PM - 1:50 PM JST | 4:45 AM - 4:50 AM UTC

Introduction

1:50 PM - 2:05 PM JST | 4:50 AM - 5:05 AM UTC

[AGE30-01] Soil Organic Cabon Contents Estimation using Neural Network System

Ikumi Kaida[1], *Yasushi Mori[1], Takayuki Shuku[1] (1.Graduate School of Environmental and Life Science, Okayama University)

2:05 PM - 2:25 PM JST | 5:05 AM - 5:25 AM UTC

[AGE30-02] Methane emission from rice paddies and its response to climate change

★Invited Papers

*Takeshi Tokida[1] (1.Institute for Agro-Environmental Sciences, National Agriculture and Food Research Organization)

2:25 PM - 2:40 PM JST | 5:25 AM - 5:40 AM UTC

[AGE30-03] **Relationship between degradation of rice grain quality due to chalky kernels and available nutrients in soil**

*Shingo Matsumoto[1], Junko Kasuga[1] (1.Shimane University)

2:40 PM - 2:55 PM JST | 5:40 AM - 5:55 AM UTC

[AGE30-04] The effects of trenching and insertion of crop residue on infiltration and soil erosion in a farmland

*Kazutoshi Osawa[1], Yasushi Mori[2], Akira Hoshikawa (1.Utsunomiya University, 2.Graduate school of Environmental and Life Science, Okayama University)

2:55 PM - 3:15 PM JST | 5:55 AM - 6:15 AM UTC

[AGE30-05] Measuring wide-range soil water content using GPS signals

★Invited Papers

*Kosuke Noborio[1], Natsumi Naganuma[1] (1.Meiji University)

Soil Organic Cabon Contents Estimation using Neural Network System

Ikumi Kaida[1], *Yasushi Mori[1], Takayuki Shuku[1]

1. Graduate School of Environmental and Life Science, Okayama University

Dynamics of organic matter in soil greatly affects the material circulation of the outermost layer of the earth and since it has the largest storage capacity in the terrestrial area, its accumulation and disappearance attracts high attention on global warming. Previous studies showed some achievements on the estimation of soil organic matter. However, since natural process is very complicated, the parameters are extracted from the accumulation of individual research, and are not estimated while considering mutual relationships based on a sufficient amount of data. Therefore, it is going to be waste of time or not realistic to tackle the problem for relating huge sets of soil parameters without understanding functional relationship. With the development of computers in recent years, machine learning and neural networks, which are rapidly becoming to be applied to realistic tasks, read huge amounts of data and learn individual relationships while estimating the target value.

Therefore, in this study, we tried to find deeply related soil parameters using 11000 sets of 16 parameters (limited only in Europe) obtained from Harmonized World Soil Database (FAO, IIASA). Recursive Feature Elimination (RFE method) eliminated the weakly related parameters, and then the deeply related parameters are used to estimate organic carbon using neural network. Among the verifications, the neural network showed the best performance when the parameter selection was set to seven. Clay content, dry bulk density, clay CEC, total CEC, base saturation, exchangeable base, and ESP are evaluated as having high relevance. Interestingly, uncommon parameters were also included in the selection. 70% of the models constructed with these seven parameters estimated the amount of soil organic matter very well, 30% resulted in extremely bad results. In addition, although the selected parameter is deeply related to soil organic matter contents, it is not clear whether each parameter works positive or negative for estimation in the non-linear function. Since the derived relation is nonlinear and very complicated, it is difficult to understand the calculation process. But since the model function is obtained without giving a functional system from the human side, it is going to be a powerful tool in extracting necessary parameters from huge data sets which seems to have unknown relationships. In addition, the research will be more effective, and will greatly contribute to elucidation of environmental dynamics involving complex factors.

Keywords: Soil Organic Carbon, Neural Network, Global Warming

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Methane emission from rice paddies and its response to climate change

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a, b, c, d, e

Keywords: rice paddy, methane, global warming, FACE (Free-Air CO2 Enrichment)

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Relationship between degradation of rice grain quality due to chalky kernels and available nutrients in soil

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a,b,c,d,e,

Keywords: high-temperature damage to rice grain ripening, chalky grain, available silicate

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The effects of trenching and insertion of crop residue on infiltration and soil erosion in a farmland

*Kazutoshi Osawa[1], Yasushi Mori[2], Akira Hoshikawa

1. Utsunomiya University, 2. Graduate school of Environmental and Life Science, Okayama University

It has been recognized that dynamics of water and the associated materials such as sediment and nutrients are important to conserve ecosystem existing in a watershed. Among others, excess soil and nutrients transports toward the coastal zones and deposition on corals are one of the major environmental problems in Okinawa, Japan, in which agricultural area is the major source of sediment yield. In this study, we focused on effects of trenching and insertion of crop residue on infiltration and soil erosion in a sugarcane field.

In the term of fallow period, water discharge in the trenching plot was 69% smaller than that in the control plot because the rainwater was infiltrated at the trenches on the surface. However, sediment yield in the trenching plot increased 57% over that in the control prot because soil surface was distubed by subsoiler to make trenches.

In the term of cropping period, water discharge in the plot of trenching and insertion of crop residue was 39% smaller than that in the control plot. The effect of increasing infiltration was continued because trenches did not fill with soil due to insertion of crop residue. Sediment yield in the plot of trenching and insertion of crop residue decreased 64% over that in the control prot. Then, from the view of preventing soil erosion, trenching and insertion of crop residue are effective practice during cropping period.

Keywords: Soil erosion, Infiltration, Trenching, insertion of organic matter, Sugarcane, Okinawa

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Measuring wide-range soil water content using GPS signals

*Kosuke Noborio[1], Natsumi Naganuma[1]

1. Meiji University

For prediction of the amount of irrigation water during a crop growing period, estimation of groundwater recharge amount, landslide forecast, and others, measurement of a wide range of soil moisture content is indispensable. Since the introduction of TDR moisture meter by Topp et al. in 1980, measurement of soil water content at a certain point has become possible with high precision, and remote automatic data acquisition. However, when measuring a wide range of soil moisture content as conventional measurements using satellites or cosmic rays, there are concerns on resolution and measurement accuracy so that it has not been applied to routine observation. In 2008 Larson and colleagues reported that there is a significant relationship between the ground reflected wave intensity contained in the GPS signal and the soil moisture content around the GPS antenna. Since GPS satellites are operated to be observed at any location on the earth for 24 hours a day, if we could measure soil moisture content using GPS signals, applicability of this method would be immeasurable. In this report, we outline the principle and examples of wide area soil moisture content measurement using GPS signals.

Keywords: soil moisture, GPS satellite, signal noise ratio

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-GE Geological & Soil Environment

Tue. May 28, 2019 3:30 PM - 5:00 PM JST | Tue. May 28, 2019 6:30 AM - 8:00 AM UTC | 202 2F

[A-GE31] New Roles of Soil Science for Extraterrestrials

convener:Kosuke Noborio(Meiji University), Masaru Mizoguchi(Graduate school of Agricultural and Life Sciences, The University of Tokyo), Chairperson:Naoto Sato

In recent years water ice and vapor have been discovered in extraterrestrials; however, liquid and ice water behavior in such environments is still not well understood. We will share recent studies how liquid or ice water behavior in porous media in microgravity or vacuum condition.

3:30 PM - 4:00 PM JST | 6:30 AM - 7:00 AM UTC

[AGE31-01] Life search on Mars by Life Detection Microscope (LDM)

★Invited Papers

*Yoshitaka Yoshimura[1] (1.College of Agriculture, Tamagawa University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[AGE31-02] **Moisture movement in sand during evaporation under reduced pressure**

*Masaru Mizoguchi[1] (1.Graduate school of Agricultural and Life Sciences, The University of Tokyo)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[AGE31-03] Gravity effects on liquid behavior in porous media of uniform glass beads.

*Naoto Sato[1], Natsumi Naganuma[2], Kento Nogawa[2], Yuichi Maruo[2], Kosuke Noborio[1] (1.School of Agriculture, Meiji University, 2.Graduate School of Agriculture, Meiji University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[AGE31-04] Effects of changes in viscosity under low gravity on infiltration rate

*Kento Nogawa[1], Naoto Sato[2], Yuichi Maruo[1], Natsumi Naganuma[1], Kosuke Noborio[2] (1.Graduate School of Agriculture, Meiji University, 2.School of Agriculture, Meiji University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[AGE31-05] Differences in infiltration process on the planets under different gravity.

*Yasushi Mori[1] (1.Graduate School of Environmental and Life Science, Okayama University)

Life search on Mars by Life Detection Microscope (LDM)

*Yoshitaka Yoshimura[1]

1. College of Agriculture, Tamagawa University

Recent findings on Mars tend to support the possible presence of living microbes near the surface of Mars. MSL Curiosity has found organic compounds [1], the temporal increase of methane concentration in Martian atmosphere [2] and reduced sulfur compounds such as pyrite in Martian soil [3]. Methane and reduced sulfur compounds can be energy sources to support the growth of chemoautotrophic microbes [4]. The detection of hydrated salts suggested the possible presence of liquid water at Recurring Slope Lineae [5]. Although present Martian environments are hostile to life, terrestrial microorganisms inhabit a wide range of environmental conditions, suggesting some microorganisms may survive near the surface [4]. Though UV radiation is harmful, it would be shielded by thin layers (less than a millimeter) of dust or regolith [6]. A depth of several centimeters from the surface, therefore, could provide sufficient covering for microorganisms to survive.

The Viking mission in 1970’ s did not find evidence for life [7], however, the sensitivity of the GC-MS (mass spectrometer) onboard the Viking mission was found not to be very high, and it was not able to detect 10^6 microbial cells in 1 gram soil [8, 9], indicating that another life detection program is necessary.

The Life Detection Microscope (LDM) that we have proposed [6, 10] has the potential sensitivity much higher than the Viking instrument. Microscopes directly image life forms and identify their shapes, sizes, and other morphological structures and have the potential to detect a single cell in field of view. Therefore, the sensitivity can be as high as desired just by increasing the volume of sample to be scanned in a reasonable duration of experiment. LDM scans about 1 mm^3 and detects less than 10^4 cells in 1 gram soil at a spatial resolution of 1 μm [10]. LDM differentiates among organic compounds surrounded by membranes or with enzyme activity by staining the samples with fluorescent pigments. This technique is especially useful for the detection of living microorganisms.

Our investigation goals are the followings. 1) Identify cell-like structure in which organic compounds are enveloped by membrane, which may represent Martian life. 2) Search for organic compounds in Mars surface samples. The compounds include cells, other biological materials, and abiotic polycyclic aromatic hydrocarbon (PAH). 3) High-resolution characterization of regolith and dust particles. The search for living microorganisms is important not only for scientific interest but for planetary protection. Before future human missions begin, surveys investigating the presence of living microorganisms should be conducted to mitigate the risk of human contact with Martian microorganisms, which may be harmful to human health. The LDM would be also an effective tool for this purpose.

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Keywords: fluorescent microscope, extraterrestrial life

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Moisture movement in sand during evaporation under reduced pressure

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In order to investigate the mechanism of moisture transfer in the basement of Mars, experiments were conducted to measure the moisture, temperature, and salt distribution in the sand column during the vacuum evaporation process. As a result, it was found that the sample freezes at low salt concentration while it does not freeze at high concentration. In addition, we found that the salt moves to the surface layer with liquid water movement, and that the higher the salt concentration, the higher the evaporation amount. These results may relate to phenomena such as drying accompanied by evaporation under reduced pressure, freezing due to latent heat loss, crust formation due to salt concentration and freezing point depression.

Keywords: under reduced pressure, Moisture movement, evaporation

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Gravity effects on liquid behavior in porous media of uniform glass beads.

*Naoto Sato[1], Natsumi Naganuma[2], Kento Nogawa[2], Yuichi Maruo[2], Kosuke Noborio[1]

1. School of Agriculture, Meiji University, 2. Graduate School of Agriculture, Meiji University

In recent years, evidence of the existence of water has been found on the moon and Mars. The water resources on the moon or Mars are expected to be utilized as an in situ resource for future manned exploration. It is necessary to elucidate how the water exists in the porous media and how we can extract it. Under the 1G condition, water flow in porous media is expressed by Richards' equation. According to Richards' equation, water moves by a matric potential gradient and a gravity gradient. It was reported that water movement by a matric potential gradient, however, changed under microgravity. Therefore, water movement under low gravity might be different from estimation by conventional water movement theory. In this study, we observed water movement in porous media made of glass beads under microgravity and evaluated the effects of gravity on liquid behavior in porous media. We conducted infiltration experiments using porous media of 0.4 mm grass beads under microgravity conditions created by parabolic flight. The advances of the gas-liquid interface were captured by a video camera and the infiltration rate was calculated. We also conducted a horizontal infiltration experiment under 1G and compared the infiltration rate under each gravity conditions. The infiltration rate under microgravity was slightly lower than the horizontal infiltration rate under 1G. The decrease of infiltration rate, however, was smaller than the decrease in the previous study using 1.5 mm glass beads.

Keywords: Porous media, Liquid behavior, Gravity

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Effects of changes in viscosity under low gravity on infiltration rate

*Kento Nogawa[1], Naoto Sato[2], Yuichi Maruo[1], Natsumi Naganuma[1], Kosuke Noborio[2]

1. Graduate School of Agriculture, Meiji University, 2. School of Agriculture, Meiji University

It is important to clarify water behavior in the porous media to realize cultivation of crops in spacecraft, on Mars or on the Moon. However, Jones et al. (1999) revealed that infiltration rate in porous media under microgravity (μG) is lower than that under 1G. In addition, Maruo (2018) revealed that infiltration rate in the capillary tube under μG is lower than that under 1G. Infiltration in porous media under μG depends on capillary force, so that the decrease infiltration rate in the capillary tube might be a cause of the decrease in infiltration rate in the porous media under μG. It is thought that the decrease of infiltration rate in capillary tube under μG was caused by a decrease in surface tension, an increase in contact angle, and/or an increase in viscosity. Naganuma et al. (2019) reported that the surface tension of water does not vary with gravity. In addition, it was revealed that the contact angle of water droplets under μG does not change compared to under 1G (Naganuma et al., 2018). However, there are few studies that evaluated the gravitational dependence of the viscosity of water. In this research, we evaluated the gravity dependence of the viscosity of water and estimated the influence of viscosity change on infiltration rate. In this experiment, low gravity experiment using parabolic flight was carried out for 2 days using MU-300 (Diamond Air Service Inc., Nagoya, Japan) as an aircraft. The gravity condition was μG (1st day: 3 times, 2nd day: 3 times), 1/6G (1st day: 3 times, 2nd day: 6 times), 1/3G (1st day: 5 times, 2nd: 3 times), and each low gravity duration was 20 to 30 seconds. Changes in gravity were acquired from the accelerometer installed in the aircraft. For the acrylic column with an inner diameter of 64 mm and a height of 41 mm used for the experiment, water repellent treatment was performed on the upper 14 mm of the inner wall of the column, and the water level was adjusted so that the boundary between the processed part and the unprocessed part became the water surface. Degassed water was used as the sample to be filled in the column. For measurement of viscosity, a viscometer (Tuning Fork Vibro Viscometers SV-10, A & D Co., Ltd.) was used. The water temperature was measured by a temperature sensor built in the viscometer. The measurement interval of viscosity and temperature was 2 seconds on the 1st day and 1 second at the 2nd day. I photographed the state of the surface with a video camera (GoPro Hero 4, GoPro Inc.). Experimental results showed a negative correlation between viscosity and gravity in the range of 0G to 1G (Fig. 1). In the range of 1 G to 2 G, the measured values varied due to vibration, and reliable data could not be obtained. Since it is known that the surface tension and the contact angle do not change under μG, it is considered that the decrease infiltration rate in the capillary tube was brought about only by the increase in viscosity. From this, we consider the effect of increase in viscosity under μG on decrease of capillary invasion rate. Maruo (2018) defines the rate of change of infiltration rate in the capillary tube under μG compared to under 1G as a coefficient of delay α and is expressed by equation (1) (Fig. 2). Postulate that values other than viscosity do not change with 1G and μG in equation (1), it is considered that equation (2) holds. Therefore, $1/\alpha^2$ in capillary infiltration experiment by Maruo (2018) is compared with $\eta_{\mu G}/\eta_{1G}$ in this experiment. $1/\alpha^2$ is 2.49 at the capillary diameter of 0.8 mm, 2.78 at 2.37 mm, 3.19 at 5.5 mm, $\eta_{\mu G}/\eta_{1G}$ is at 2.66 on the 1st day and 2.70 on the 2nd day, $1/\alpha^2$ and $\eta_{\mu G}/\eta_{1G}$ are nearly the same value. From this, it is considered that the decrease infiltration rate in the capillary tube under μG was caused by the increase in viscosity.

Keywords: viscosity, low gravity, infiltration rate

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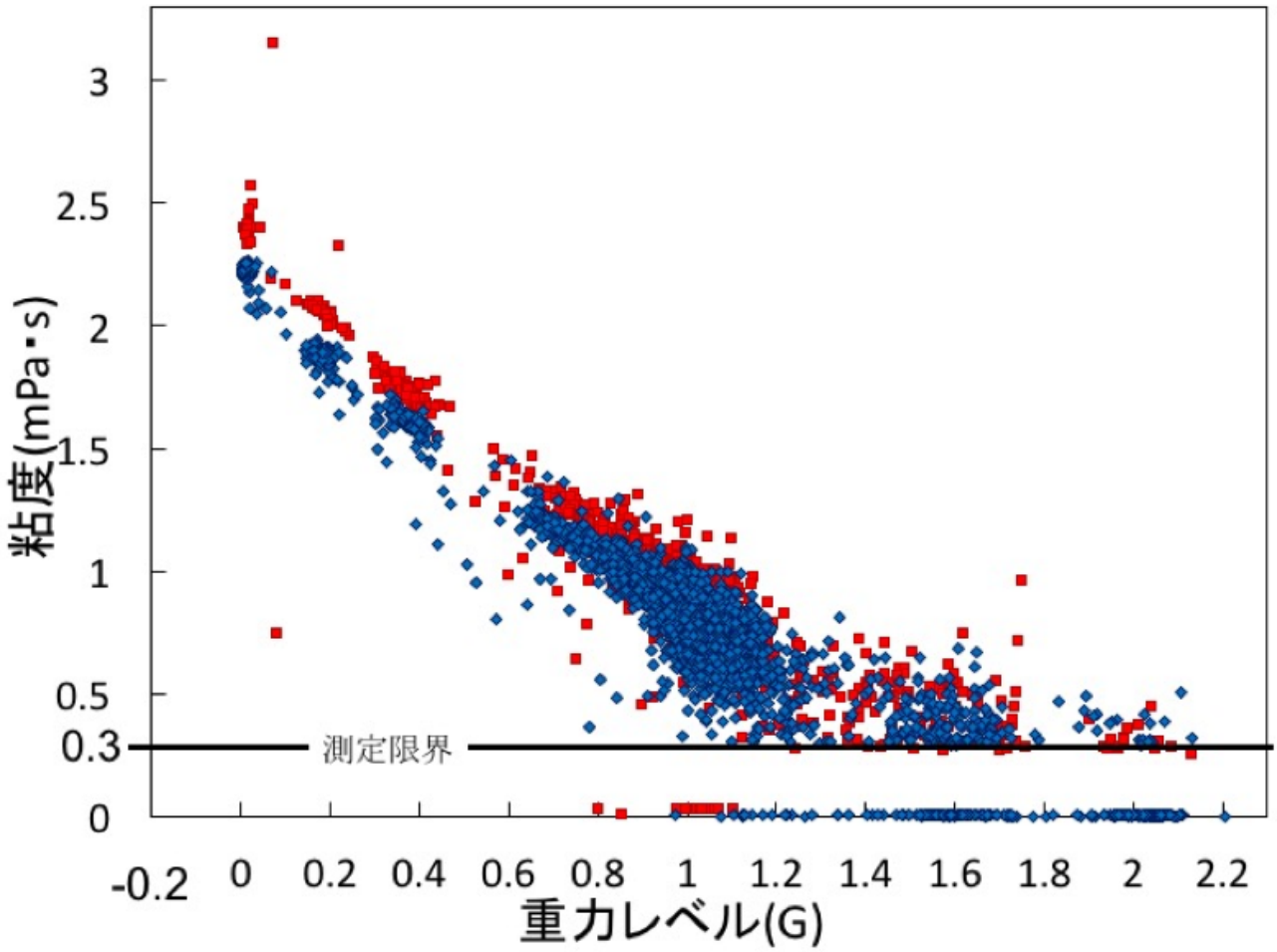


Fig. 1 粘度と重力の関係

$$\alpha = \sqrt{\frac{\sigma_{\mu G}}{\sigma_{1G}} \frac{\cos\theta_{\mu G}}{\cos\theta_{1G}} \frac{\eta_{\mu G}}{\eta_{1G}}}$$

Fig. 2 式 (1)

α ：遅延係数, σ ：表面張力 (N/m),
θ ：接触角(°), η ：粘度(Pa・s)

$$\frac{1}{2} = \frac{\eta_{\mu G}}{}$$

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Differences in infiltration process on the planets under different gravity.

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These days, we are trying to conduct the long-term stay in the space station, the various experiments under microgravity by the parabolic flight, and the research to explore the possibility of our stay on the other planets. In addition, we are exploring the existence of water and traces of living things on the other planets and satellites. If such an approach has become realistic, the next approach would be the earth, soil or regolith, where we need to consider how liquid flows and behaves. Here we consider the penetration phenomenon of solution when gravity is different. In the parabolic flight, they report that water in a vessel is sucked into noodles when it becomes zero gravity. When the influence of gravity becomes small, the influence of the capillary force by the porous body becomes relatively large, and the downward movement by the inertial force is restricted. Indeed, preliminary experiments showed that the downward reach of the solution increased as pseudo gravity increased. When we are trying to use regolith as planting on a planet with small gravity, the solution such as water might not move downward as we are estimating.

Keywords: micro-gravity, regolith, infiltration

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Tue. May 28, 2019 9:00 AM - 10:30 AM JST | Tue. May 28, 2019 12:00 AM - 1:30 AM UTC | 104 1F

[A-CG38] Multi-scale ocean-atmosphere interaction in the tropical Indo-Pacific region

convener:Ayako Seiki(Japan Agency for Marine-Earth Science and Technology), Tomoki Tozuka(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Motoki Nagura(Japan Agency for Marine-Earth Science and Technology), Youichi Kamae(Faculty of Life and Environmental Sciences, University of Tsukuba), Chairperson:Ayako Seiki(Japan Agency for Marine-Earth Science and Technology), Motoki Nagura(Japan Agency for Marine-Earth Science and Technology)

Multi-scale ocean-atmosphere interaction in the tropics exerts a significant imprint on the global climate via atmospheric teleconnection. Since the 1980s, anchored by in-situ and satellite observations, improvements in modeling and theoretical understanding, various aspects of dominant modes of interannual (e.g., ENSO and IOD), intraseasonal (e.g., MJO) variabilities and their impacts on tropical (e.g., monsoons) and extra-tropical (e.g., North America) climate variations have received wide attention. Recent satellite-based salinity measurements indicate for an active role of salinity in the tropical ocean-atmosphere interaction. While recent studies suggest a possible link between interdecadal Pacific oscillation and global warming hiatus in 2000s, changes (if any) in the tropical ocean-atmosphere interaction are yet to be understood. Due to interactions between different time scales, between different ocean basins, and with the extratropics, the tropical ocean and atmosphere play a key role in shaping climate, its variability and change. To better understand and examine these challenging issues from various perspectives, this session offers a forum to discuss recent progress in observational, modeling and theoretical studies of multi-scale tropical ocean-atmosphere interaction.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[ACG38-01] Various aspects of climate system variability associated with ENSO

★Invited Papers

*Shuhei Maeda[1] (1.Climate Prediction Division, Japan Meteorological Agency)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[ACG38-02] Influence and mechanism of the tropical Pacific variability on the Arctic and its seasonality

*Tsubasa Takigawa[1], Yu Kosaka[1], Bunmei Taguchi[1], Lea Svendsen[2] (1.Research Center for Advanced Science and Technology, University of Tokyo, 2.Bjerknes Centre for Climate Research, University of Bergen)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[ACG38-03] Subsurface nonlinear dynamical heating and ENSO asymmetry in CMIP5: Implications for anthropogenic tropical-warming uncertainties

★Invited Papers

*Michiya Hayashi[1], Fei-Fei Jin[1] (1.Department of Atmospheric Sciences, University of Hawaii at Manoa)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[ACG38-04] **Uncertainty in the projections of ENSO amplitude change under global warming: Role of the response of atmospheric circulation to SST anomalies**

*Jun Ying[1] (1.Second institute of Oceanography, Ministry of Natural Resources)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[ACG38-05] Impact of atmospheric variability on Indian Ocean Dipole mode

*Yuya Baba[1] (1.JAMSTEC Japan Agency for Marine-Earth Science and Technology)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[ACG38-06] Do salinity anomalies matter for the evolution of the IOD? –Experimental assessments using a regional ocean model-

*Shoichiro Kido[1], Tomoki Tozuka[1], Weiqing Han[2] (1.Graduate School of Science, The University of Tokyo, 2.Department of Atmospheric and Oceanic Sciences, University of Colorado Boulder)

Various aspects of climate system variability associated with ENSO

*Shuhei Maeda[1]

1. Climate Prediction Division, Japan Meteorological Agency

The El Niño-Southern Oscillation (ENSO) is the most dominant interannual climate variability in the Earth’ s climate system, and its pattern is characterized as zonal east-west see-saw of oceanic and atmospheric conditions in the tropical Pacific, and their associated teleconnections in the atmosphere to the extra-tropics. In addition, various aspects of climate system variability associated with ENSO are observed. For example, (1)vertical distribution of sea sub-surface temperature, (2)global average temperature, (3)energy budget at the top of atmosphere, (4)available potential energy in the atmosphere, (5)atmospheric meridional circulation such as Hadley and Ferrel circulations, (6) sub-tropical jet streams, (7)wave activities in the extra-tropics, and (8) polar vortex. In the presentation, I will review these aspects of climate system variability associated with ENSO, and discuss related mechanisms.

Keywords: ENSO, meridional circulation, polar vortex

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Influence and mechanism of the tropical Pacific variability on the Arctic and its seasonality

*Tsubasa Takigawa[1], Yu Kosaka[1], Bunmei Taguchi[1], Lea Svendsen[2]

1. Research Center for Advanced Science and Technology, University of Tokyo, 2. Bjerknes Centre for Climate Research, University of Bergen

Arctic temperature has increased about twice as fast as global mean surface temperature in recent decades. While anthropogenic influence on this Arctic warming is evident, potential contributions from internal climate variability remains to be examined. Svendsen et al. (2018) showed that Pacific decadal variability played a key role in the early twentieth century Arctic warming through a coupled model pacemaker experiments with historical forcing. It is still unclear, however, how much influence the Pacific internal variability induces on the Arctic and how this remote influence is conveyed.
This study investigates the relationship between Arctic climate and tropical Pacific variability (TPV) by using a pre-industrial control experiment with GFDL CM2.1, with the primary aim to quantify the effect of TPV in different timescales. The result shows that the surface temperature response at high latitudes is amplified at multi-decadal timescales compared to sub-decadal one. The Arctic temperature anomalies peak near surface and diminishes with height. Moreover, Arctic temperature and sea ice responses feature strong seasonality with peak in late winter, despite weak seasonality of the tropical SST anomalies associated with decadal TPV. These features bear similarity to radiatively induced Arctic warming, and suggest importance of local feedbacks in Arctic climate variability driven remotely by the TPV.

Keywords: ENSO, Inter-decadal Pacific Oscillation, Teleconnection

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Subsurface nonlinear dynamical heating and ENSO asymmetry in CMIP5: Implications for anthropogenic tropical-warming uncertainties

*Michiya Hayashi[1], Fei-Fei Jin[1]

1. Department of Atmospheric Sciences, University of Hawaii at Manoa

El Niño-Southern Oscillation (ENSO) is a dominant interannual tropical variability, playing a key role in worldwide climate. Most climate models participating in CMIP5 (Coupled Model Intercomparison Project phase 5) can produce ENSO amplitude close to observations, but the asymmetry between its warm and cold phases is still poorly simulated in general. Here, using 25 CMIP5 historical simulations and multiple ocean reanalysis datasets, it is shown that the model-to-model diversity of ENSO asymmetry is mostly explained by the representation of nonlinear dynamical heating (NDH) in the subsurface ocean along the equatorial Pacific thermocline. The skewness of sea-surface temperature (SST) anomalies in the Niño-3 region linearly increases with respect to the variability of the subsurface NDH among the CMIP5 models (correlation of 0.8). The NDH variability in most CMIP5 models is under-simulated due to weak Equatorial Undercurrent variability.

Using a small subset of the models having the NDH variability greater than the CMIP5 average, the influence of ENSO amplitude change in CMIP5 anthropogenic warming scenarios is further assessed. The future change in ENSO amplitude still shows a large spread even within this subset. Nevertheless, the long-term change in climatological NDH mean follows the ENSO amplitude change, which is absent in the rest of the CMIP5 models having weak NDH variability. Hence, increasing the rectification effect of the subsurface NDH that deepens the mean-state thermocline to warm the SST can enhance the so-called "El Niño-like" global-warming pattern that exhibits the faster eastern-Pacific surface warming. In contrast, suppressing the subsurface rectification effect can cause a more "La Niña-like" warming pattern. These results suggest that properly simulating ENSO asymmetry and subsurface NDH in climate models is critical on projecting future climate.

Keywords: El Niño-Southern Oscillation, anthropogenic global warming, CMIP5 climate model

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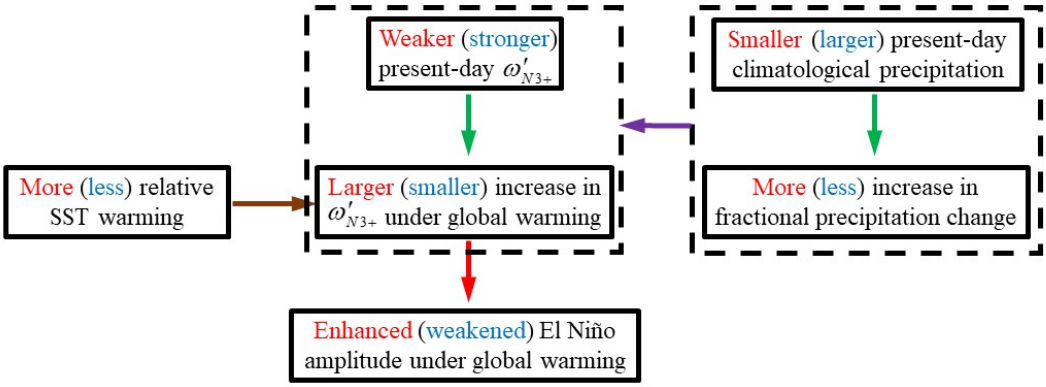
Uncertainty in the projections of ENSO amplitude change under global warming: Role of the response of atmospheric circulation to SST anomalies

*Jun Ying[1]

1. Second institute of Oceanography, Ministry of Natural Resources

The study investigates the mechanism of the large inter-model uncertainty in the change of ENSO’s amplitude under global warming, based on 31 CMIP5 models. We find that the uncertainty in ENSO’s amplitude is significantly correlated to that of the change in the response of atmospheric circulation to SST anomalies (SSTAs) in the eastern equatorial Pacific Niño3 region. This effect of the atmospheric response to SSTAs mainly influences the uncertainty in ENSO’s amplitude during El Niño (EN) phases, but not during La Niña (LN) phases, showing pronounced nonlinearity. The effect of the relative SST warming and the present-day response of atmospheric circulation to SSTAs are the two major contributors to the inter-model spread of the change in the atmospheric response to SSTAs, of which the latter is more important. On the one hand, models with a stronger (weaker) mean-state SST warming in the eastern equatorial Pacific, relative to the tropical-mean warming, favor a larger (smaller) increase in the change in the response of atmospheric circulation to SSTAs in the eastern equatorial Pacific during EN. On the other hand, models with a weaker (stronger) present-day response of atmospheric circulation to SSTAs during EN tend to exhibit a larger (smaller) increase in the change under global warming. The result implies that an improved simulation of the present-day response of atmospheric circulation to SSTAs will be effective in lowering the uncertainty in ENSO’s amplitude change under global warming.

Keywords: ENSO amplitude , Global warming, Uncertainty, relative SST warming



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Impact of atmospheric variability on Indian Ocean Dipole mode

*Yuya Baba[1]

1. JAMSTEC Japan Agency for Marine-Earth Science and Technology

Some preceding studies investigated tropical atmospheric internal variability such as Madden-Julian oscillation on the formation of Indian Ocean Dipole mode (IOD), but still number of the studies remains few, and their relationship remains unknown. In this study, we focused on the impact of atmospheric variability especially intraseasonal variability. To reveal the impact, we conducted sensitivity experiments for the IOD during 1980-2009, using an ocean general circulation model and difference atmospheric forcing data, such as (1) climatological forcing, (2) same as (1) but with yearly anomalies, (3) same as (1) but with seasonal anomalies, (4) same as (1) but with monthly anomalies, (5) 90-day low-pass filtered forcing. The simulated Dipole mode index (DMI) indicates that the sensitivity case of (1) could not reproduced realistic DMI at all, (2) and (3) reproduced decreased DMI amplitudes, and (4) and (5) reproduced similar DMI which was simulated with daily forcing data. In this presentation, possible mechanisms that caused different features of simulated IODs will be explained, focusing on the relationship between the variabilities of ocean and atmosphere.

Keywords: Indian Ocean Dipole mode, atmospheric internal variability

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Do salinity anomalies matter for the evolution of the IOD? –Experimental assessments using a regional ocean model-

*Shoichiro Kido[1], Tomoki Tozuka[1], Weiqing Han[2]

1. Graduate School of Science, The University of Tokyo, 2. Department of Atmospheric and Oceanic Sciences, University of Colorado Boulder

The Indian Ocean Dipole (IOD), which is a dominant climate mode in the tropical Indian Ocean, is accompanied by significant surface and subsurface salinity anomalies. These salinity anomalies alter density field and stratification in the upper ocean, and thereby have potentials to affect the evolution of the IOD itself. Though many previous studies have attempted to estimate the impacts of the IOD-related salinity anomalies, no comprehensive assessments have been conducted. To this end, a series of sensitivity experiments using a regional ocean model is conducted with a novel experimental strategy. Results from these sensitivity experiments show that interannual salinity anomalies associated with the positive IOD tend to suppress the cooling in the eastern equatorial Indian Ocean by about 1.0˚C. Through an on-line heat budget analysis of each experiment, it is shown that weakening of the upwelling in the eastern Indian Ocean, which originates from the upward shift of the Equatorial Undercurrent, is the primary cause of the suppressed cooling there. These changes are induced by enhanced stratification in the eastern equatorial Indian Ocean associated with negative (positive) salinity anomalies near the surface (pycnocline). Momentum budget analysis and additional sensitivity experiments using a linear continuously stratified ocean model further support these ideas. Therefore, salinity plays an active role in the evolution of the IOD, rather than being passively influenced by atmospheric anomalies.

Keywords: Indian Ocean Dipole, Salinity anomaly, Regional ocean model

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Tue. May 28, 2019 10:45 AM - 12:15 PM JST | Tue. May 28, 2019 1:45 AM - 3:15 AM UTC | 104 1F

[A-CG38] Multi-scale ocean-atmosphere interaction in the tropical Indo-Pacific region

convener:Ayako Seiki(Japan Agency for Marine-Earth Science and Technology), Tomoki Tozuka(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Motoki Nagura(Japan Agency for Marine-Earth Science and Technology), Youichi Kamae(Faculty of Life and Environmental Sciences, University of Tsukuba), Chairperson:Tomoki Tozuka(The University of Tokyo), Youichi Kamae(University of Tsukuba)

Multi-scale ocean-atmosphere interaction in the tropics exerts a significant imprint on the global climate via atmospheric teleconnection. Since the 1980s, anchored by in-situ and satellite observations, improvements in modeling and theoretical understanding, various aspects of dominant modes of interannual (e.g., ENSO and IOD), intraseasonal (e.g., MJO) variabilities and their impacts on tropical (e.g., monsoons) and extra-tropical (e.g., North America) climate variations have received wide attention. Recent satellite-based salinity measurements indicate for an active role of salinity in the tropical ocean-atmosphere interaction. While recent studies suggest a possible link between interdecadal Pacific oscillation and global warming hiatus in 2000s, changes (if any) in the tropical ocean-atmosphere interaction are yet to be understood. Due to interactions between different time scales, between different ocean basins, and with the extratropics, the tropical ocean and atmosphere play a key role in shaping climate, its variability and change. To better understand and examine these challenging issues from various perspectives, this session offers a forum to discuss recent progress in observational, modeling and theoretical studies of multi-scale tropical ocean-atmosphere interaction.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[ACG38-07] Mechanisms of future changes in equatorial upwelling: CMIP5 inter-model analysis

★Invited Papers

*Shoshiro Minobe[1,2], Mio Terada[2], Curtis Deutsch[3] (1.Earth and Planetary Sciences, Faculty of Science, Hokkaido University, 2.Graduate School of Science, Hokkaido University, 3.School of Oceanography, University of Washington)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[ACG38-08] The Indo-Pacific cross-basin interaction of the decadal climate variability under the progress of the global warming

*Yuma Miyaji[1], Youichi Tanimoto[2] (1.Hokkaido University, Graduate School of Environmental Science, 2.Hokkaido University, Faculty of Environmental Earth Science)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[ACG38-09] Air-sea flux observation by unmanned autonomous sea surface vehicle in the Tropics - Application of the Wave Glider -

★Invited Papers

*Iwao Ueki[1] (1.JAMSTEC Japan Agency for Marine-Earth Science and Technology)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[ACG38-10] **Radar-derived Fresh water flux and its possible impact to the oceanic stratification observed during the Years of the Maritime Continent (YMC)**

*Masaki Katsumata[1], Biao Geng[1], Satoru Yokoi[1], Shuichi Mori[1], Iwao Ueki[1] (1.Japan Agency for Marine-Earth Science and Technology)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[ACG38-11] **Driving Mechanism of Inter-Annual Precipitation Variability during Monsoon Season over the Northern Part of Sumatra Island, Indonesia**

*Yahya Darmawan[1,2,3], Huang-Hsiung Hsu[2] (1.Taiwan International Graduation Program, Academia Sinica, 2.Research Center for Environmental Changes, Academia Sinica, 3.Indonesian Agency for Meteorology, Climatology and Geophysics (BMKG))

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[ACG38-12] The impact of diurnal precipitation over the maritime continent on synoptic disturbances and its relation to the MJO

*Ayako Seiki[1], Satoru Yokoi[1], Masaki Katsumata[1], Kunio Yoneyama[1] (1.Japan Agency for Marine-Earth Science and Technology)

Mechanisms of future changes in equatorial upwelling: CMIP5 inter-model analysis

*Shoshiro Minobe[1,2], Mio Terada[2], Curtis Deutsch[3]

1. Earth and Planetary Sciences, Faculty of Science, Hokkaido University, 2. Graduate School of Science, Hokkaido University, 3. School of Oceanography, University of Washington

The future change in equatorial upwelling is investigated for the Pacific and Atlantic Oceans using data from 24 Coupled *Model* Intercomparison Project Phase 5 (CMIP5) models for the Representative Concentration Pathway 8.5 scenario until 2100. Three-dimensional velocity components of CMIP5 multi-models are used for the first time in an upwelling study, and allow to divide upwelling velocities into diapycnal and isopycnal velocities. This analysis, combined with inter-model regression, revealed that both the multi-model ensemble (MME) mean and the inter-model variability in the upwelling change in the eastern equatorial Pacific, where strong upwelling change occurs, are explained by two mechanisms. One is that the diapycnal upwelling decreases near the surface, which is associated with a weakened Ekman divergence. The other is that the isopycnal upwelling decreases at depths of 75–200 m around the core of the equatorial undercurrent (EUC) due to EUC flattening. Both the weakened Ekman divergence and the EUC flattening are induced by the locally weakened trade wind over the eastern Pacific basin. In the equatorial Atlantic, both the change in MME mean and the inter-model variability of upwellings are significantly related to the weakened trade wind and enhanced stratification, although these drivers are not independent. The results for the Pacific Ocean imply that future reduction in upwelling may impact the sea surface temperature and marine ecosystem by different mechanisms. The rapid warming of sea surface temperature in the eastern Pacific basin may be related to the near-surface diapycnal upwelling reduction, while the decrease in net community production, which is often measured by marine export production at a depth of 100 m, may be related to the isopycnal upwelling reduction.

Keywords: global warming , variability and mean across multiple models , ocean dynamics

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The Indo-Pacific cross-basin interaction of the decadal climate variability under the progress of the global warming

*Yuma Miyaji[1], Youichi Tanimoto[2]

1. Hokkaido University, Graduate School of Environmental Science, 2. Hokkaido University, Faculty of Environmental Earth Science

We investigate a relationship of the decadal sea surface temperature (SST) variability between over the Indian Ocean and over the tropical Pacific based on the observed data sets and the multi-model climate simulations. In the present study, by subtracting the multi-model ensemble mean rather than the observed linear trend, we attempt to retain the decadal signals without the effect of the radiative forcing, in the observed long-term records of the ocean and atmosphere.
While several observational studies indicated that the simultaneous correlation coefficient of the long-term SST variability over the two basins changed from positive before 1985 into negative after 1985, our analysis always shows the positive correlation regardless of the selected decades, indicating that the internal dynamics of the Indo-Pacific ocean-atmosphere system for this cross-basin interaction. While the decadal variations of the surface winds over the Indian Ocean are influenced by the SST variability over the tropical Pacific, the SST formation processes by those surface winds are different among the regions north and south of 10˚S, respectively. The effect of the climatological meridional gradient in the thermocline depth on the different formation processes is discussed.

Keywords: Air-sea interaction, cross-basin interaction, Decadal variability

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Air-sea flux observation by unmanned autonomous sea surface vehicle in the Tropics - Application of the Wave Glider -

*Iwao Ueki[1]

1. JAMSTEC Japan Agency for Marine-Earth Science and Technology

Air-sea fluxes of heat and momentum are fundamental variables for the ocean and atmosphere interaction, which influence weather and climate. The air-sea flux measurements; actually measurements of air temperature, humidity, sea surface temperature, winds, and radiations, are mainly conducted by research vessels, mooring buoys, and satellites. Based on these measurements, many types of global air-sea flux products are produced. However, these products still remain large biases and uncertainties in the global fields. Reducing inaccuracies in air-sea fluxes is important for improving long-term weather and climate predictions. For that purpose, we should consider about intensification of *in situ* measurements, which contribute to improve bulk algorithms, to understand mechanisms of flux variability, and to validate the products as proposed in Community White Papers of air-sea fluxes with a focus on heat and momentum in OceanObs’19. Due to the relatively high cost of research vessel and mooring buoy operations, number of in situ measurements is limited. The sparsity of the *in situ* measurement in present situation is one of obstacles to improve satellite algorithm development and product validation. Because of recent progress of unmanned autonomous ocean surface vehicles (UAVs) development, we can use these vehicles as a platform for air-sea flux observation. In this study, several field tests and evaluations of the acquired data through comparison with mooring buoys have been conducted especially in the tropical region. The present status of these activities will be introduced in the presentation.

Keywords: Air-sea flux, unmanned autonomous vehicle, Wave Glider

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Radar-derived Fresh water flux and its possible impact to the oceanic stratification observed during the Years of the Maritime Continent (YMC)

*Masaki Katsumata[1], Biao Geng[1], Satoru Yokoi[1], Shuichi Mori[1], Iwao Ueki[1]

1. Japan Agency for Marine-Earth Science and Technology

To investigate the air-land-sea interaction in the Maritime Continent (the world's largest archipelago bridging tropical Indian Ocean and tropical western Pacific), a series of the field campaign “YMC-Sumatra” was conducted as part of the project "Years of the Maritime Continent (YMC)". In “YMC-Sumatra 2017”, we deploy the research vessel "Mirai" at one station near the west coast of Sumatra Island to obtain time series.

The continuous dataset from C-band polarimetric radar is converted to the rainrate (i.e. fresh water flux) by utilizing the data from disdrometers and raingauges. The estimated fresh water flux is compared to the oceanic near-surface stratifications measured by the unmanned surface vehicle “wave glider”. The observed salinity at 0.2m and 6m depths differ under a precipitating event with weak wind (< 5 m/s). The event was followed by the strong wind (>10 m/s) precipitation. After the event, low salinity layer was captured down to 30~40 m depth for more than half days.

Keywords: fresh water flux, oceanic near-surface stratification, YMC (Years of the Maritime Continent)

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Driving Mechanism of Inter-Annual Precipitation Variability during Monsoon Season over the Northern Part of Sumatra Island, Indonesia

*Yahya Darmawan[1,2,3], Huang-Hsiung Hsu[2]

1. Taiwan International Graduation Program, Academia Sinica, 2. Research Center for Environmental Changes, Academia Sinica, 3. Indonesian Agency for Meteorology, Climatology and Geophysics (BMKG)

The precipitation variability of the Northern part of Sumatra Island in Indonesia has been driven by the complex tropical climate systems along with the local factors. The aim of this study is to investigate the driving mechanism of precipitation variability during the JJA-periods (June, July, and August) over the northern part of Sumatra. Moist Static Energy (MSE) budget analysis was used to model the source of energy which supports the precipitation anomalies. Composite analysis and statistical methods were used for confirming the result of MSE budget. By using 36 years of ERA-interim data, precipitation anomalies of JJA periods were classified into two categories, namely: wet years and dry years. Positive precipitation anomalies are found during the wet years which are supported by the upward motion of vertical velocity. During the wet years, the weaker easterly wind of Indian Summer Monsoon (ISM) associated with the westerly winds of a negative El Niño–Southern Oscillation (ENSO), a positive Indian Ocean Dipole (IOD), and a strong Western North Pacific Subtropical High (WNPSH). As a consequence, these anomalous circulations trigger a moisture flux convergence and positive precipitation anomaly. In the dry years, the downward of vertical velocity leads to negative precipitation anomaly. Generally, a stronger easterly wind of ISM was found during the dry years which is associated with a positive ENSO, a negative IOD, and a weak WNPSH. Even though the precipitation anomalies occur due to the collaboration of those winds, a new finding shows that WNSPH has a stronger impact to the precipitation anomalies than ENSO and IOD in the Northern part of Sumatra Island. In addition to those circulations, higher topography of the Barisan Mountains supports the ascending motion to moisten the lower troposphere and induces a positive precipitation anomaly in this maritime continent.

Keywords: Precipitation, MSE, ENSO, IOD, ISM, Sumatra Island

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The impact of diurnal precipitation over the maritime continent on synoptic disturbances and its relation to the MJO

*Ayako Seiki[1], Satoru Yokoi[1], Masaki Katsumata[1], Kunio Yoneyama[1]

1. Japan Agency for Marine-Earth Science and Technology

Diurnal cycle has been known to contribute to a significant amount of precipitation over the maritime continent. In this study, the impact of diurnal precipitation over Sumatra Island, the Indonesian maritime continent, on synoptic disturbances over the surrounding ocean, especially the eastern Indian Ocean, is examined using the Global Satellite Mapping of Precipitation (GSMaP) data. High precipitation area observed over Sumatra in afternoon migrates offshore during night-time and reaches 500 km off the coast in average. Synoptic disturbances represented by eddy kinetic energy are enhanced south of the equator off Sumatra when the diurnal precipitation is strong, then they migrate poleward with cyclonic structures over the eastern Indian Ocean. These results suggest that the diurnal precipitation over Sumatra can excite synoptic disturbances over the eastern Indian Ocean.

Keywords: diurnal precipitation, the maritime continent, synoptic disturbances

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Tue. May 28, 2019 9:00 AM - 10:30 AM JST | Tue. May 28, 2019 12:00 AM - 1:30 AM UTC | 301A 3F

[A-CG39] Biogeochemical cycles in Land Ecosystem

convener:Tomomichi Kato(Research Faculty of Agriculture, Hokkaido University), Kazuhito Ichii(Chiba University), Takeshi Ise(FSERC, Kyoto University), Munemasa Teramoto(National Institute for Environmental Studies), Chairperson:Tomomichi Kato(Hokkaido University)

Terrestrial ecosystem influences global climate through cycles of water, carbon, and nitrogen between land surface and atmosphere. For better understanding of those behaviors, a great effort has been paid for developing varieties of approaches and techniques such as biometric survey, eddy and chamber methods, near and satellite remote sensing, biosphere modeling and so on.
 In particular, the JapanFlux, founded in 2006 as a researchers network of CO2, H2O and other trace gas flux measurement, has promoted the multi-disciplinal studies not only for flux measurement community, but also for remote sensing and biosphere modeling communities. Moreover, the Research-Group-on-Integrated-Land-Processes, which was founded in 2006, also has contributed to build networks between Japanese researchers to better understanding of physical and biological processes on interactions between terrestrial surface and atmosphere.
 This session unites those multi-disciplinal activities, and promotes the oral and poster presentations on the role of terrestrial ecosystem in material circulations of water, carbon, nitrogen, energy and other substances by any approaches and technics. This session takes over the former session in last year: A-CG40.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[ACG39-01] Laboratory examination of combined effects of temperature rising and increased water fluctuation on CO_2 release from volcanic ash soils

*Hirohiko Nagano[1], Mariko Atarashi-Andoh[1], Jun Koarashi[1] (1.Japan Atomic Energy Agency)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[ACG39-02] Field observation of GHGs emission from pome palm oil mill effluent (POME) treatment ponds in an oil palm plantation in tropical peatland.

*Yoshiyuki Takahashi[1], Takashi Onodera[2], Ryuichi Hirata[1], Kazuya Nishina[2], Joseph Wenceslaus Waili[3], Kevin Kemudang Musin[3], Edward Baran Aeries[3], Frankie Kiew[3], Guan Xhuan Wong[3], Zufaqar Sa'adi[3], Lulie Melling[3] (1.Center for Global Environmental Research, National Institute for Environmental Studies, 2.Center for Regional Environmental Research, National Institute for Environmental Studies, 3.Sarawak Tropical Peat Research Institute)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[ACG39-03] Soil CO_2 efflux dynamics with land-use changes in Southeast Asia

*HAJIME TOMIMATSU[1], NAISHEN LIANG[1], MUNEMASA TERAMOTO[1], JIYE ZENG[1], ZHAO XIN[1] (1.National Institute for Environmental Studies)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[ACG39-04] Individual-based analyses of the carry-over effects from recent climatic conditions on the interannual variability of LAI of an evergreen conifer stand

*Akihiro Sumida[1], Tsutomu Watanabe[1], Tomiyasu Miyaura[2] (1.Institute of Low Temperature Science, Hokkaido University, 2.Faculty of Science and Technology, Ryukoku University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[ACG39-05] Carbon dioxide balance of an oil palm plantation on tropical peat

*Takashi Hirano[1], Frankie Kiew[2], Ryuichi Hirata[3], Guan Xhuan Wong[2], Edward Baran Aries[2], Kevin Kemudang[2], Joseph Wenceslaus[2], Lo Kim San[2], Lulie Melling[2] (1.Research Faculty of Agriculture, Hokkaido University, 2.Sarawak Tropical Peat Research Institute, 3.CGER, National Institute for Environmental Studies)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[ACG39-06] The effect of heat wave in the summer of 2018 on carbon and water fluxes in an open black spruce forest in an interior Alaska

*Hideki Kobayashi[1], Robert Busey[2], Yongwon Kim[2], Sigrid Dengel[3], Stephen Chan[3] (1.Japan Agency for Marine-Earch Science and Technology, 2.International Arctic Research Center, University of Alaska, Fairbanks, 3.Lawrence Berkeley National Laboratory)

Laboratory examination of combined effects of temperature rising and increased water fluctuation on CO_2 release from volcanic ash soils

*Hirohiko Nagano[1], Mariko Atarashi-Andoh[1], Jun Koarashi[1]

1. Japan Atomic Energy Agency

Global warming will alter the precipitation pattern, resulting in the increase in seasonal fluctuation of soil water conditions. Both environmental factors of soil temperature and water fundamentally affect soil CO_2 release, a major carbon flux in terrestrial ecosystems. However, our understandings of soil CO_2 release under the increased temperature and fluctuated water conditions are still insufficient to infer the feedback of terrestrial carbon cycling in future worlds. In the present study, we are conducting laboratory incubation experiments for examining the combined effects of temperature rising and soil water fluctuation on CO_2 release from volcanic ash soils. Volcanic ash soil is the major soil type in Japan and is expected to have great ability to stabilize carbon as soil organic matter. We incubated volcanic ash soils under four combinatorial conditions of two temperatures (20 and 30 ˚C) and two water conditions (a continuously constant water and a fluctuated water conditions). The rate of CO_2 release was periodically measured during the incubation. Then, the ratio of CO_2 release at 20 ˚C to that at 30 ˚C, namely Q_{10}, was expressed as the temperature sensitivity of soil CO_2 release. The fluctuated water condition was maintained with multiple dry-wet cycles to achieve an average water content of 40% of water holding capacity which was equivalent to that under the continuously constant water condition. For the incubation at 20 ˚C, soil CO_2 release under the fluctuated water condition was up to 50% greater than that under the constant water condition. The excess of soil CO_2 release under the fluctuated water condition was, however, reduced to less than 10% for the incubation at 30 ˚C. Thus, Q_{10} under the fluctuated water condition (1.3 to 1.5) was equivalent to or lower than that under the continuously constant water condition (around 1.5). These preliminary results offer the needs of modifying basal CO_2 release extent and Q_{10} value for inferring the soil CO_2 release under increased temperature and fluctuated water conditions. The experiments are still ongoing and results and further insights will be presented at the meeting.

Keywords: greenhouse gas, soil carbon dynamics, global warming

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Field observation of GHGs emission from pome palm oil mill effluent (POME) treatment ponds in an oil palm plantation in tropical peatland.

*Yoshiyuki Takahashi[1], Takashi Onodera[2], Ryuichi Hirata[1], Kazuya Nishina[2], Joseph Wenceslaus Waili[3], Kevin Kemudang Musin[3], Edward Baran Aeries[3], Frankie Kiew[3], Guan Xhuan Wong[3], Zufaqar Sa'adi[3], Lulie Melling[3]

1. Center for Global Environmental Research, National Institute for Environmental Studies, 2. Center for Regional Environmental Research, National Institute for Environmental Studies, 3. Sarawak Tropical Peat Research Institute

1. Introduction

Intense land-use change in tropical Asia has a significant influence on greenhouse gases (GHGs) budget in the region. Conversion of tropical peat swamp forest to both acacia and oil palm plantation is a typical land-use change in the region. To evaluate impact of the conversion on GHGs budget, we have to quantify many related processes, for example, enhanced decomposition of peat soil, N_2O emission from fertilization, biogas emission from palm oil mill effluent (POME) treatment ponds, etc. Oil mill facility is built adjacent to oil palm field because fresh oil palm fruit needs to be processed immediately after harvest. Oil palm plantation forms a stationary material cycle system as an integration of palm oil field and mill facility. POME treatment ponds is typical waste water treatment system in an oil palm plantation. Biogas contains high concentration of methane, because methane fermentation is an essential process in waste water purification in the ponds. Measured values of GHGs emission from POME treatment ponds is limited. We conducted field observation of GHGs emission from a POME treatment ponds in an oil palm plantation in tropical peatland as a joint research of National Institute for Environmental Studies and Sarawak Tropical Peat Research Institute.

2. Methods

We conducted field measurement of GHGs emissions from POME treatment ponds in an oil palm plantation on tropical peatland near Sibu Town, Sarawak, Malaysia. The life of the sampling equipment was assumed considerably short in POME treatment ponds due to the exposure to high concentration of corrosive hydrogen sulfide and pollution by oily scum. To quantify GHGs emission from the ponds, we had developed floating chamber system specialized to the POME ponds. The low cost and program controlled system made it possible to perform multi-point simultaneous sampling automatically in a short period of time. We collected biogas from the ponds into balloons of gas-barrier film using the chambers. We measured total amount of biogas in the balloons with modified water replacement method firstly, consequently measured concentration of gases (CH_4, CO_2, O_2, H_2, and H_2S) with portable gas monitor (BIOGAS 5000, Gastech, U.K.). We calculated gas fluxes from covered area, sampling duration, gas volume and gas concentrations. The gas fluxes measurements were conducted in eight ponds in upstream side of whole ten ponds during dry season (June 2018).

3. Results and discussions

Biogas from POME treatment ponds were mainly CO_2 and CH_4. Markedly large biogas flux was found in fourth pond from upper stream. About 65% of the biogas from the fourth pond was CH_4. This might be due to neutral pH and moderate temperature were suitable for methane fermentation in the pond. In the three upper-stream ponds, the pond water was acidic in which CO_2 dominated about 60% of biogas. Biogas flux was small in the ponds in lower-stream of the forth pond.

4. Summary

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In the POME treatment ponds, decomposition process of organic matter in POME would be different in each stage because of differences in the various environmental factors such as pH, temperature, organic matter content, etc. It was successful in the integration of data in severe environmental condition in the POME treatment ponds despite various technical challenge. Oil palm plantation is a continuous and stationary material flow system as a whole including plant field, mill facility and POME treatment ponds. To fully understand the impact of land-use change on GHGs budget, it is very important to quantify the relationship between GHGs budget and material cycle in the whole plantation system. Besides field measurements, we also do interviews on material flow in the plantation with the cooperation of business entity of the plantation.
We will introduce the result of wet season (January 2019) during this presentation.

Keywords: Climate change, Land-use change, Tropical Asia, Tropical peat, Greenhouse gases

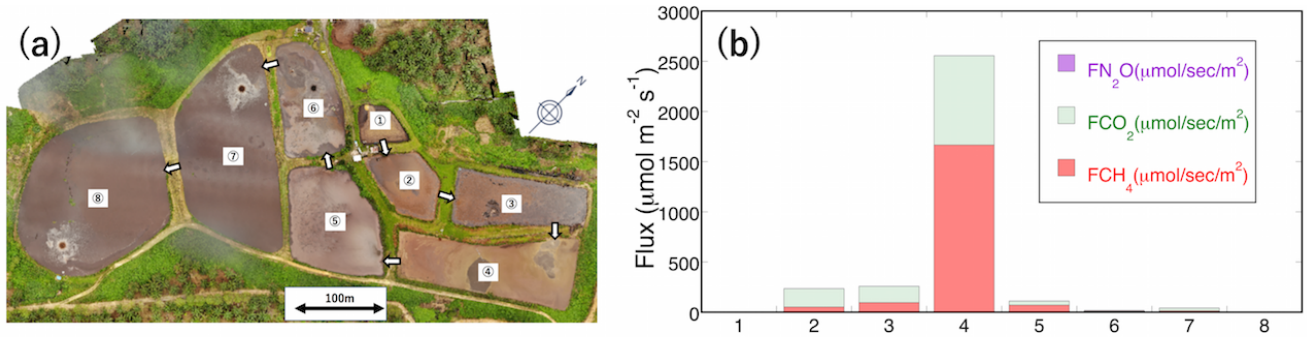


Figure. (a) Location of ponds and (b)GHGs flux from the ponds.

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Soil CO_2 efflux dynamics with land-use changes in Southeast Asia

*HAJIME TOMIMATSU[1], NAISHEN LIANG[1], MUNEMASA TERAMOTO[1], JIYE ZENG[1], ZHAO XIN[1]

1. National Institute for Environmental Studies

Land use changes greatly affect carbon cycle of forest ecosystem. Since the 1970s, about 35% of tropical primary forests were lost due to disorderly commercial logging, plantation development such as oil palm and rubber in Southeast Asia. These rapid land use changes cause serious environmental problems such as soil erosion, decrease in soil fertility, and decrease in productivity. As a result, there will be a major change in the regional biochemical cycles.

Soil is an important source of information on the global carbon budget and it is a carbon sink, and soil respiration (R_s) is one of the most important elements of the carbon cycle in terrestrial ecosystems. Land use changes influence the dynamics of R_s. However, most studies on the effects of land use change on R_s focused on the boreal, temperate and subtropical ecosystems. In Southeast Asia, we have addressed the response of R_s to the land use changes, but mostly it is a short period with little spatial or temporal repetition, especially there are few long-term observations in lowland rainforests with no seasonal changes in temperature.

To examine the long-term response of R_s to land use change in Southeast Asia, we selected 4 research sites of different land use type, primary forest (PF), secondary forest (SF), oil palm plantation (OP), and rubber plantation (RP). In 2010, we installed total 30 soil collars (diameter 32 cm) in each site. The 30 collars were distributed in two rows, each with 15 collars and at 5 m intervals. R_s was measured every two weeks using a portable automatic opening and closing chamber system developed by the National Institute for Environmental Studies.

R_s showed synchronicity seasonal change among all sites, suggesting that it is controlled by both soil temperature and moisture. The apparent temperature sensitivity of R_s (Q_{10}) decreased from 4.86 in NF to 2.09 in SF, 2.14 in OP, 3.79 in GP. In addition, the annual average soil respiration rate decreased about 38% in SF, about 33% in OP and about 40% in GP compared with NF. Our results indicate that logging and/or conversions of primary forests to plantations lead severe soil degradation.

Keywords: Land use change, Plantation, Soil respiration

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Individual-based analyses of the carry-over effects from recent climatic conditions on the interannual variability of LAI of an evergreen conifer stand

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1. Institute of Low Temperature Science, Hokkaido University, 2. Faculty of Science and Technology, Ryukoku University

The leaf area index (LAI) of a forest stand has been known to remain within a specific range after a peak at relatively young stand ages. For evergreen stands, however, little has been known about interannual variability of LAI and its effects on biomass increase. In this paper we introduce a series of studies ([1], [2]) in which interannual variability of the LAI and the growth rates of stem biomass were investigated with biological and climatic factors affecting them in an evergreen hinoki cypress (*Chamaecyparis obtusa*) stand between 21 and 40 years of stand age. In this long-term investigation, the stem diameter at the crown base (D_{CB}) was recorded for all living trees each year. This allowed us to estimate the leaf area of a tree (tree LA) using an allometric equation, which is known to be little affected by the difference in stand ages. Given the tapered shape of a tree stem within the crown, a rapid rise of the crown base height can lead to a decrease in D_{CB}, or a decrease in the tree LA. The other measurements also allowed us to estimate the stem dry mass for each tree in each year, and then the stand LAI and the stand stem biomass. The prediction intervals of LAI and stand stem biomass were evaluated for each year by propagating errors of those individual-based estimates. Monthly meteorological data were obtained using the climatic measurements recorded at the nearest weather station (AMeDAS).

The LAI varied between 7.1–8.8, with a relatively long fluctuation cycles over the observation period. This LAI range was maintained such that the gradual increase in the LA of the largest trees counterbalanced the gradual loss in LA of the smallest trees. The decrease in LA of the smallest trees resulted in their gradual death. Just before their death year, their tree LA had decreased to ~1% of the LAI of that year. Hence their death did not affect the LAI. These smallest trees were able to survive for many years even as their LA was decreasing, which would be important for LAI to be maintained without a sudden decrease. The total basal area decreased twice during the 20 years, whereas the stand stem biomass never decreased despite the death of trees. This was because the portion of the stem within the crown maintained a certain level of radial growth even in the trees with almost no stem radial growth at breast height.

There was a weak but significant positive relationship (r=0.40) between the LAI and the current-year mean summer temperature (July and August). This indicates that LAI tended to increase in the year with warm summer during which new leaves are produced. Further, we found that the moving average of the summer temperatures of 6 years (the current year and the previous 5 years) indicated a much stronger relationship (r=0.93) with the current-year LAI. According to a previous study in the same forest, the mean turnover time of the canopy leaves was estimated to be 4.3–6.3 years, suggesting that the summer temperature of the past years when the leaves in the current-year canopy accumulated was strongly influential in the LAI of the current year.

As canopy photosynthesis would generally be proportional to LAI, we had expected that the annual stem biomass increase rate (dB_{STEM}) would be greater in a year with a high LAI. However, the relationship

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between them was not significant (r=0.09). Instead, dB_{STEM} had a positive significant relationship with the sum of precipitation of early summer (May-July) of the current year. Preceding studies of tree physiology have pointed out that a considerable portion of non-structural carbohydrates (NSC) from photosynthesis are used for purposes other than growth (e.g., maintenance of physiological homeostasis), and that the priority of the NSC to be allotted to growth would be lower than any other uses. This partly explains why dB_{STEM} was not correlated with LAI.

[1] Sumida et al. (2013) Tree Physiology 33, 106–118; [2] Sumida et al. (2018) Scientific Reports 8, 13950.

Keywords: evergreen conifer forest, leaf area index, carry-over effects from recent climatic conditions, biomass growth, competition among individuals, interannual variability

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Carbon dioxide balance of an oil palm plantation on tropical peat

*Takashi Hirano[1], Frankie Kiew[2], Ryuichi Hirata[3], Guan Xhuan Wong[2], Edward Baran Aries[2], Kevin Kemudang[2], Joseph Wenceslaus[2], Lo Kim San[2], Lulie Melling[2]

1. Research Faculty of Agriculture, Hokkaido University, 2. Sarawak Tropical Peat Research Institute, 3. CGER, National Institute for Environmental Studies

Oil palm plantations have been expanding rapidly over recent decades especially in Indonesia and Malaysia, the two largest oil palm producers in the world. The greatest concern associated with such expansion is its environmental impact. Carbon rich tropical peat swamp forest is also not excluded from such expansion, because it is accessible for developers. Carbon dioxide (CO_2) release through accelerated oxidative peat decomposition is one of the main environmental concerns in the land conversion from peat swamp forest into oil palm plantations, which were drained and compacted to increase yield. Changes in aboveground biomass also might significantly alter the CO_2 exchange dynamics of the ecosystems. Despite the possible significant changes in the CO_2 balance through the land conversion, there is still no study on the ecosystem-scale CO_2 balance of oil palm plantations established on tropical peat. Thus, we have monitored CO_2 flux above an oil palm plantation established on tropical peatland in Sarawak, Malaysia by the eddy covariance technique since 2011. We quantify the annual CO_2 balance of the oil palm plantation and compare it with that of a secondary peat swamp forest in the same region.

Keywords: CO2 flux, Eddy covariance technique, Tropical peat swamp forest, Deforestation, Drainage

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The effect of heat wave in the summer of 2018 on carbon and water fluxes in an open black spruce forest in an interior Alaska

*Hideki Kobayashi[1], Robert Busey[2], Yongwon Kim[2], Sigrid Dengel[3], Stephen Chan[3]

1. Japan Agency for Marine-Earch Science and Technology, 2. International Arctic Research Center, University of Alaska, Fairbanks, 3. Lawrence Berkeley National Laboratory

Temperatures have been increasing at higher rate in the northern high latitudes than any other regions of the globe, especially over the land areas, and are projected to continue to do so during this century. In interior Alaska, where the majority of landscape is covered with evergreen needleleaf forest, an exceptionally hot dry summer heat wave was observed in July 2018. In this study, we investigated the eddy covariance carbon and water fluxes under the hot dry period in July 2018. The study was performed in an open black spruce forest site located in the Poker Flat Research Range in interior Alaska. Three eddy covariance systems (two enclosed path and one open path eddy covariance systems) were utilized in the study period. We found the significant down regulation of net ecosystem exchanges (NEE) during a high temperature period during DOY 201-206, 2018. We will introduce the results from the carbon and water fluxes with meteorological and spectral measurements in order to understand how the environmental conditions regulated the carbon and water fluxes and how these fluxes are related with the continuous spectral measurements.

Keywords: eddy Covariance, heat wave, boreal forest

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Tue. May 28, 2019 10:45 AM - 12:15 PM JST | Tue. May 28, 2019 1:45 AM - 3:15 AM UTC | 301A 3F

[A-CG39] Biogeochemical cycles in Land Ecosystem

convener:Tomomichi Kato(Research Faculty of Agriculture, Hokkaido University), Kazuhito Ichii(Chiba University), Takeshi Ise(FSERC, Kyoto University), Munemasa Teramoto(National Institute for Environmental Studies), Chairperson:Tomomichi Kato(Hokkaido University)

Terrestrial ecosystem influences global climate through cycles of water, carbon, and nitrogen between land surface and atmosphere. For better understanding of those behaviors, a great effort has been paid for developing varieties of approaches and techniques such as biometric survey, eddy and chamber methods, near and satellite remote sensing, biosphere modeling and so on.
 In particular, the JapanFlux, founded in 2006 as a researchers network of CO2, H2O and other trace gas flux measurement, has promoted the multi-disciplinal studies not only for flux measurement community, but also for remote sensing and biosphere modeling communities. Moreover, the Research-Group-on-Integrated-Land-Processes, which was founded in 2006, also has contributed to build networks between Japanese researchers to better understanding of physical and biological processes on interactions between terrestrial surface and atmosphere.
 This session unites those multi-disciplinal activities, and promotes the oral and poster presentations on the role of terrestrial ecosystem in material circulations of water, carbon, nitrogen, energy and other substances by any approaches and technics. This session takes over the former session in last year: A-CG40.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[ACG39-07] Evaluation of feasibility of continental vegetation monitoring using Himawari-8.

*Kodai Hayashi[1], Kazuhito Ichii[1], Hiroki Yoshioka[2], Kazutaka Murakami[3], Reiko Ide[3], Kenlo Nasahara[4], Tomoko Akitsu[4], Tomoaki Miura[5] (1.Chiba Univ., 2.Aichi Prefectural Univ., 3.NIES, 4.Tsukuba Univ., 5.Univ. Hawaii)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[ACG39-08] Estimation of global carbon dioxide emissions by fires

*Tomohiro Shiraishi[1], Ryuichi Hirata[1] (1.National Institute for Environmental Studies)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[ACG39-09] Interactions between topography, permafrost, and vegetation in Siberian larch forest: a simulation study

*Hisashi Sato[1] (1.Institute of Arctic Climate and Environment Research, Japan Agency for Marine-Earth Science and Technology (JAMSTEC))

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[ACG39-10] Data assimilation experiments with MODIS LAI observation and the dynamic global vegetation model SEIB-DGVM in Japan

*Hazuki Arakida[1], Shunji Kotsuki[1], Shigenori Otsuka[1], Takemasa Miyoshi[1] (1.RIKEN Center for Computational Science)

11:45 AM - 12:15 PM JST | 2:45 AM - 3:15 AM UTC

[ACG39-11] Studying ecosystem dynamics with deep neural networks

★Invited Papers

*Takeshi Ise[1], Masanori Onishi[2] (1.FSERC, Kyoto University, 2.Grad. School of Agriculture, Kyoto University)

Evaluation of feasibility of continental vegetation monitoring using Himawari-8.

*Kodai Hayashi[1], Kazuhito Ichii[1], Hiroki Yoshioka[2], Kazutaka Murakami[3], Reiko Ide[3], Kenlo Nasahara[4], Tomoko Akitsu[4], Tomoaki Miura[5]

1. Chiba Univ., 2. Aichi Prefectural Univ., 3. NIES, 4. Tsukuba Univ., 5. Univ. Hawaii

A new generation geostationary meteorological satellite, Himawari-8, began operation in July 2015. Due to newly attached multiple bands in the visible and near infrared wavelength ranges and improved observation frequency of onboard sensor, AHI (Advanced Himawari Imager), application to terrestrial monitoring is expected.
Himawari-8/AHI data are provided as the radiance or the reflectance at the top of atmosphere (TOA) level. In order to monitor terrestrial vegetation, conversion to surface reflectance (TOC: Top of canopy reflectance) is necessary. However, the methods to estimate and verify TOC reflectance of Himawari-8/AHI data has not yet been established. Furthermore, the TOC reflectance data of Himawari-8/AHI requires careful interpretation due to observational geometric conditions unique to geostationary orbit.
In order to understand the feature of the TOC reflectance and the normalized index by Himawari-8/AHI data and to evaluate the usefulness for terrestrial vegetation monitoring, first, we estimated the TOC reflectance from Himawari-8/AHI data with 6SV. The estimated TOC reflectance from Himawari-8/AHI was further evaluated using independent observations such as Terra, Aqua MODIS data and ground observations (HemiSpherical Spectro-Radiometer (HSSR) at Phenological Eyes Network (PEN) sites).
We compared the Himawari-8 TOA/TOC reflectances with the MODIS TOA/TOC reflectances from Terra and Aqua. In particular, in the shorter wavelengths such as blue and green, the R^2 was greatly improved by atmospheric correction. Furthermore, if we selected data only with similar illumination and geometric condition of AHI and MODIS, both TOC reflectances were very close to each other in all wavelength bands. Then, we checked the monthly variation in the TOC reflectances of AHI, MODIS, and HSSR. We found that the three TOC reflectances are similar in the first half of the year (spring and summer). However, after summer, the TOC reflectances of AHI were higher than those of MODIS and HSSR. It can be explained by the dominant backward scattering component in AHI in Japan. In particular, the difference in intensity between the backward scattering and the forward scattering increases toward winter seasons. Meanwhile normalized index such as NDVI could effectively reduce the anisotropic effect on the TOC reflectance and it can capture vegetation phenology similar to MODIS. As a result of cross-validation, Himawri-8 TOC reflectance estimated in this study was generally consistent with other data. However it is necessary to consider the observation conditions of the Himawari-8 TOC reflectance. In the next step, we will demonstrate how the high temporal resolution of Himawari-8 improve our understandings of terrestrial vegetation dynamics.

Keywords: Himawari-8, atmospheric correction, PEN, MODIS, vegetation monitoring, 6SV

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Estimation of global carbon dioxide emissions by fires

*Tomohiro Shiraishi[1], Ryuichi Hirata[1]

1. National Institute for Environmental Studies

Global warming accelerates snow melting and drying which cause forest fires. The forest fire gives positive feedback in global warming because large greenhouse gases are emitted into the atmosphere by the forest fire. The purpose of this study is to estimate carbon emissions caused by forest fire with high spatial and temporal resolution, which are 500 m and daily base.
In this study, we used several satellite observation data to estimate global carbon dioxide emissions by fires from 2001 to 2018. We used MODIS MOD14A 1 product for fire detection, MODIS MCD12Q1 product as land cover classification map, and above ground biomass map created by (Avitabile et al., 2016) in Wageningen university. Carbon dioxide emissions were estimated from burned area, biomass densities, burning efficiencies and emission factors for each land cover categories. The estimated carbon dioxide emissions through 18 years were 6159.77 [Tg/year] on yearly average and 607.26 [Tg/year] on standard deviation. These results underestimated to approximately 11% for GFED4.1s and FINN1.0, 8%, 36% for GFAS 1.0 and G-G (Shi et al., 2015), respectively.

Keywords: Carbon dioxide emissions

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Interactions between topography, permafrost, and vegetation in Siberian larch forest: a simulation study

*Hisashi Sato[1]

1. Institute of Arctic Climate and Environment Research, Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

In eastern Siberia, larches (Larix spp.) often exist in pure stands, constructing the world's largest coniferous forest, of which changes can significantly affect the earth's albedo and the global carbon balance. Siberian larch area locates on the environmental edge of existence of forest ecosystem, and hence small difference in environmental condition alters existence of larch trees.

Indeed, there is a quantitative pattern that topographic properties controls the abundance of larch forest via both drought and flooding stresses in this region; larch abundance appears to be controlled by drought stress in mountainous regions, while controlled by flooding stresses in plain areas (Sato& Kobayashi 2018). Besides, this region is underlaid by permafrost, vegetation productivity is constraint by depth of active layer; plant productivity becomes lower for shallower active layer by reducing liquid-state-water holding capacity (Beers et al. 2007). At the same time, active layer depth is a function of soil wetness, because wetland soil has larger ice content in active layer, which facilitates downward heat conduction to the permafrost, resulting in shallow thaw for the active layers (Woo & Xia 1996).

To reconstruct such complicated interactions between topography, permafrost, and vegetation in Siberian larch forest, the TOPMODEL, which is a physically based streamflow and water-table-depth computation scheme was implemented to a dynamic vegetation model SEIB-DGVM (Sato et al. 2016), which works with a thermohydrology model. In this presentation, I will talk how this integrated model reasonably works, and how it can be employed for future projection of environmental conditions of the Siberian larch region.

Citations

Beer, C., et al. (2007). "Effects of soil freezing and thawing on vegetation carbon density in Siberia: A modeling analysis with the Lund-Potsdam-Jena Dynamic Global Vegetation Model (LPJ-DGVM)." Global Biogeochemical Cycles 21(1).

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Woo, M. K. and Z. J. Xia (1996). "Effects of hydrology on the thermal conditions of the active layer." Nordic Hydrology 27(1-2): 129-142.

Keywords: Permafrost, Dynamic Global Vegetation Models, Larch, TOPMODEL

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Data assimilation experiments with MODIS LAI observation and the dynamic global vegetation model SEIB-DGVM in Japan

*Hazuki Arakida[1], Shunji Kotsuki[1], Shigenori Otsuka[1], Takemasa Miyoshi[1]

1. RIKEN Center for Computational Science

In the previous study, Arakida et al. (2017) developed a data assimilation system with the SEIB-DGVM (Spatially Explicit Individual-Based Dynamic Global Vegetation Model), and assimilated satellite-observed Leaf Area Index (LAI) successfully over Siberia. In this study, we extend the experiment to a Japanese forest at the Takayama flux site and investigate the performance of the data assimilation system. We estimate the vegetation functions and structures, and model parameters related to the phenology of the deciduous broad-leaved tree and the undergrowth. For the climate forcing data, we used the global reanalysis dataset known as the ERA5. The original data assimilation system developed for Siberia turned out not to be suitable for the Japanese forest because of different LAI variabilities between Siberia and Japan. Namely, LAI stays at the saturated level for an extended period in Japan, while in Siberia, the LAI starts to drop soon after it reaches to the maximum value. Therefore, a model parameter which controls the saturated LAI level was considered for additional parameter estimation. In addition, the undergrowth was changed from deciduous to evergreen. The results show that the DA system performs generally well in Japan with the additional parameter estimation and the modification to the undergrowth.

Arakida, H., T. Miyoshi, T. Ise, S.-I. Shima, and S. Kotsuki (2017), Non-Gaussian data assimilation of satellite-based leaf area index observations with an individual-based dynamic global vegetation model, Nonlinear Proc. Geoph., 24, 553-567, doi:10.5194/npg-24-553-2017.

Keywords: data assimilation, vegetation model, satellite data

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Studying ecosystem dynamics with deep neural networks

*Takeshi Ise[1], Masanori Onishi[2]

1. FSERC, Kyoto University, 2. Grad. School of Agriculture, Kyoto University

Obtaining ecological data by field observation has been labor intensive. In this study, we present several approaches to obtain ecological bid data, using information technology. First, introduction to data-driven science and big-data science will be presented. As an example of these new approaches, deep learning with neural networks has various applications in ecological studies. In fact, digital images from satellite, UAV, or even smartphone can be the big data. We show how these big data are used to identify specific features of organisms and vegetation. Moreover, deep neural networks can be applied to analyze time-series data and project the future conditions.

Keywords: deep learning, neural networks, remote sensing

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Tue. May 28, 2019 9:00 AM - 10:30 AM JST | Tue. May 28, 2019 12:00 AM - 1:30 AM UTC | 102 1F

[A-CG40] Coastal Ecosystems - 1. Water Cycle and Land-Ocean Interactions

convener:Masahiko Fujii(Faculty of Environmental Earth Science), Makoto Yamada(Faculty of Economics, Ryukoku University), Jun Shoji(The University of Tokyo), Ryo Sugimoto(Faculty of Marine Biosciences, Fukui Prefectural University), Chairperson:Masahiko Fujii, Makoto Yamada

Substances from land which are brought by river and/or submarine groundwater discharge are important for the process of biological production in coastal areas. This session focuses on land-ocean interactions through water cycle. The aim of this session is to create interdisciplinary discussions on the research of connectivity of ecosystems, water cycles in terrestrial and coastal areas, fishery resources and biodiversity. Comprehensive discussion on the mechanisms that promote productivity and biodiversity in coastal ecosystems will be made from the viewpoint of land-ocean interactions. Presentations on water-material cycle in terrestrial and coastal areas, fishery resources, biodiversity and connectivity of the ecosystems are encouraged.
A companion session proposed as "Coastal Ecosystems - 2. Coral reefs, seagrass meadows, and mangroves" focuses on benthic communities in shallow-water ecosystems such as coral reefs, seagrass meadows and mangroves and is dedicated to promote researches on comprehensive assessment and monitoring of ecosystem functions and development of effective means for conservation and restoration. Main focuses of these two sessions are different. However, there are much of information that covers both sessions. Scientists who work on the related field will be able to obtain information and share them with other scientists if they attend to both of these sessions.

9:00 AM - 9:05 AM JST | 12:00 AM - 12:05 AM UTC

Introduction

9:05 AM - 9:20 AM JST | 12:05 AM - 12:20 AM UTC

[ACG40-01] Submarine groundwater discharge from Mt. Fuji in Suruga Bay(VI)

*Yasuhide Muranaka[1], Takafumi Kamitani[1], Noriaki Fushimi[1], Tomoya Oka[1], Masahiko Ono[2], Atsunao Marui[2] (1.Shizuoka Institute of Environment and Hygiene, 2.National Institute of Advanced Industrial Science and Technology)

9:20 AM - 9:35 AM JST | 12:20 AM - 12:35 AM UTC

[ACG40-02] Relationship between the distribution of freshwater groundwater under the seabed at Obama Bay and the surrounding terrain of the land

*Makoto Yamada[1], Ryo Sugimoto[2], Toshimi Nakajima[3] (1.Faculty of Economics, Ryukoku University, 2.Fuculty of Marine Biosciences, Fukui Prefectural University, 3.Fukui Prefectural University)

9:35 AM - 9:50 AM JST | 12:35 AM - 12:50 AM UTC

[ACG40-03] Influence of recirculated submarine groundwater discharge on phytoplankton dynamics in Moune Bay, Kesennuma

*Toshimi Nakajima[1], Takahiro Kusunoki[1], Yoshitake Takao[1], Ryo Sugimoto[1] (1.Fukui Prefectural University)

9:50 AM - 10:05 AM JST | 12:50 AM - 1:05 AM UTC

[ACG40-04] Estimation of contribution rate of Submarine Groundwater Discharge to *Ulva pertusa* using nitrogen stable isotope ratio analysis

*Tatsuhiro Ishida[1], Masaru Takeuchi[1], Toshimi Nakajima[1], Ryo Sugimoto[1], Shiho Kobayashi[2], Keisuke Koba[3], Keitaro Fukushima[3], Osamu Tominaga[1] (1.Fukui Prefectural University, 2.Kyoto University, 3.Center for Ecological Research,Kyoto Univrsity)

10:05 AM - 10:20 AM JST | 1:05 AM - 1:20 AM UTC

[ACG40-05] Evaluation of the environmental condition of Submarine Groundwater Discharge (SGD) using carbon and oxygen stable isotope ratio of the sessile bivalve *Crassostrea nippona*

shell

*Osamu Tominaga[1], Takeuchi Masaru[1], Ryo Sugimoto[1], Ishida Tatsuhiro[1], Takeru Hirai[1], Toshimi Nakajima[1], Jun Shoji[2], Hisami Honda[4], Makoto Taniguchi[3] (1.Fukui Prefectural University, 2.Tokyo Univ. AORI, 3.RIHN, 4.Fukui Pref Gov)

10:20 AM - 10:30 AM JST | 1:20 AM - 1:30 AM UTC

Discussion

Submarine groundwater discharge from Mt. Fuji in Suruga Bay(VI)

*Yasuhide Muranaka[1], Takafumi Kamitani[1], Noriaki Fushimi[1], Tomoya Oka[1], Masahiko Ono[2], Atsunao Marui[2]

1. Shizuoka Institute of Environment and Hygiene, 2. National Institute of Advanced Industrial Science and Technology

Around the foot of Mt. Fuji, the main flow passages of groundwater are thought to be in the Younger Fuji volcano, which consists of the pervious basaltic lavas in new volcanic stage. Most of rainfall and melted snow have been considered to be percolating into underground, turning to groundwater, flowing down in the layers of the Younger Fuji volcano and partly discharging from seabed in Suruga Bay. Especially, the Fujikawa-kako fault zone, which stretches south to north in the southwestern side of Mt. Fuji, has a potentially effect on the local groundwater flow system into Suruga Bay. Therefore, precipitation at Mt. Fuji have been considered to be discharging partly from seabed in Suruga Bayand making a impact on the biological production at the coastal sea area.

For the purpose of contribution to make sense of the rich coastal ecosystem in Suruga Bay, we conducted a survey for submarine groundwater discharge (SGD) in Oku-Suruga Bay: from the mouth of the Fuji River, at which the fault is found, to Tagonoura, where the lavas of the Younger Fuji volcano are distributed from 100 to 200 m below sea level. We detected SGD in the top of the cliff in the west of Tagonoura usinga remotelyoperatedvehicle(ROV), sampled seawater containing a high percentage of sea bottom spring water and conducted water quality analyses. In this presentation, we introduce our works noted above.

Keywords: submarine groundwater discharge (SGD), Mt. Fuji, remotely operated vehicle (ROV), water sampling method

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Relationship between the distribution of freshwater groundwater under the seabed at Obama Bay and the surrounding terrain of the land

*Makoto Yamada[1], Ryo Sugimoto[2], Toshimi Nakajima[3]

1. Faculty of Economics, Ryukoku University, 2. Fuculty of Marine Biosciences, Fukui Prefectural University, 3. Fukui Prefectural University

In Obama bay at north side of Obama City, Fukui Prefecture, research on submarine groundwater discharge (SGD) has been actively carried out so far, and it is clear that the SGD are discharging in Obama Bay. However, there are still many unclear points about the situation of SGD, that is, the distribution of freshwater groundwater under the seabed. Therefore, in this research, in order to clarify the distribution of freshwater groundwater under the seabed, we conducted the survey of resistivity distribution under the seabed by using a towing electric exploration system (SuperSting: Advanced Geosciences, Inc.). We discussed about relationship between the distribution of freshwater groundwater under the seabed and the surrounding terrain of the land from the results and the surrounding land topography.

The range indicated by the resistivity value under the seabed was approximately 0.1 to 6.2 Ohm-m. The place where the relatively high resistivity value of 1 Ohm-m or more was seen was mainly the place close to the land of the alluvial fan. At the north survey area, Observation towards the offshore direction revealed that the high resistivity area extended towards the offshore area. However, further offshore there was no place of high resistivity. These facts suggest that there is a possibility that freshwater groundwater is present in the high resistivity area extending about 500 m from the shoreline to the offshore.

At the estuary of the Kita-river in the south survey area, a high resistivity area was found at a distance of 1 km from the shoreline, suggesting the possibility that freshwater groundwater is present there. According to the bathymetric chart of Obama bay, the slope of the seabed at the offshore of Kita-river is gentle from estuary towards the ocean, which is considered to be covered with sediments derived from Kita-river. The place where high resistivity was observed corresponds to that part. In other words, it is considered that freshwater groundwater is present in the fan-shaped sediment. The above suggests that the groundwater flowing through the basement of the fan in land area may flow through the alluvial fan sediment under the seabed and supply freshwater groundwater under the seabed.
As a result, it was suggested that the distribution of freshwater groundwater under the seabed in Obama Bay was influenced by the spread of the alluvial sediment at the seabed and related to the shape of the alluvial fan in land area.

Keywords: Submarine Groundwater Discharge, Alluvial fan, Obama Bay

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Influence of recirculated submarine groundwater discharge on phytoplankton dynamics in Moune Bay, Kesennuma

*Toshimi Nakajima[1], Takahiro Kusunoki[1], Yoshitake Takao[1], Ryo Sugimoto[1]

1. Fukui Prefectural University

Riverine inputs are often considered as the main terrestrial source of dissolved inorganic nitrogen (DIN), phosphorus (DIP), and silicon (DSi) in coastal seas. However, the fluxes of nutrients through submarine groundwater discharge (SGD) often exceed riverine inputs in different local and regional scale settings. Although the combined effects of riverine and SGD-derived nutrient inputs are crucial for sustaining marine productivity, a difference of nutrient composition in each source may result in a different response of phytoplankton dynamics in coastal seas. In this study, we evaluated the influence of each nutrient source on phytoplankton dynamics in the head of Kesennuma Bay in June, September and November 2018. Using the short-lived radium and radon isotopes, we quantified the contribution rates of four nutrient sources (river water, fresh SGD, recirculated SGD and offshore waters) on surface waters. Simultaneously, we evaluated productivity, biomass, apparent growth rates and species composition of phytoplankton. In brief results, DIP-enriched recirculated SGD affect significant impacts on phytoplankton dynamics. In the presentation, we will discuss more detailed results.

Keywords: Recirculated submarine groundwater discharge, Phytoplankton, Radium isotopes

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Estimation of contribution rate of Submarine Groundwater Discharge to *Ulva pertusa* using nitrogen stable isotope ratio analysis

*Tatsuhiro Ishida[1], Masaru Takeuchi[1], Toshimi Nakajima[1], Ryo Sugimoto[1], Shiho Kobayashi[2], Keisuke Koba[3], Keitaro Fukushima[3], Osamu Tominaga[1]

1. Fukui Prefectural University, 2. Kyoto University, 3. Center for Ecological Research,Kyoto Univrsity

In recent years, the influence of Submarine groundwater discharge (SGD) has attracted attention as a source of nutrient that supports biological production in the coastal area. However, the information about the direct influence of SGD on biological production is poor. In this study, in order to examine how much the groundwater contributes to primary production, we collected the primary producer *Ulva pertusa* in Yuza, Yamagata Prefecture, where the groundwater is abundant. On August 27, 2018, we collected sea water, ground water and ambient water around *Ulva* at five sites in the Yuza Coast and simultaneously measured salinity, water temperature, ^{222}Rn concentration which is the indicator of undergroundwater. We also analyzed the nutrient concentration, of sampled water and of *Ulva*. Finally, we estimated the contribution of groundwater to Ulva using two source Bayesian Mixing model. The value of nitrate nitrogen derived from SGD was low. In the high SGD sites (^{222}Rn concentration 427 ~ 22000 Bq/m^3) and the low SGD sites (^{222}Rn concentration 38.1 to 210.6 Bq/m^3), the of *Ulva* was 2.1 to 3.6 and 5.4 to 6.9, respectively. It was suggested that nutrient derived from SGD contributed to the production of *Ulva* in Yuza.

Keywords: Submarine Groundwater Discharge, Biological production, δ 15N

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Evaluation of the environmental condition of Submarine Groundwater Discharge (SGD) using carbon and oxygen stable isotope ratio of the sessile bivalve *Crassostrea nippona* shell

*Osamu Tominaga[1], Takeuchi Masaru[1], Ryo Sugimoto[1], Ishida Tatsuhiro[1], Takeru Hirai[1], Toshimi Nakajima[1], Jun Shoji[2], Hisami Honda[4], Makoto Taniguchi[3]

1. Fukui Prefectural University, 2. Tokyo Univ. AORI, 3. RIHN, 4. Fukui Pref Gov

Submarine Groundwater Discharge (SGD) results in various biogeochemical changes in the coastal environments, such as coastal primary production, eutrophication, and benthic production. The SGD condition of 6 sites along volcanic mountain coast in northern Japan was evaluated by using carbon and oxygen stable isotope ratio ($\delta^{13}C$ and $\delta^{18}O$) in the shell of sessile bivalves *Crassostrea nippona*. In order to estimate the proportion of fresh water flow rate in SGD (FR) from the respective $\delta^{13}C$ and $\delta^{18}O$ of *C. nippona* shell, we used the three end member (sea water, riverine water and fresh underground water) bayesian stable isotope mixing model. The significant positive correlation was found between $\delta^{13}C$ and $\delta^{18}O$ of the shell and those of ambient water, respectively. FRs estimated from three source model were 3.1 -8.6% at low ^{222}Rn sites and 21.9-28.5% at high ^{222}Rn sites. At the site (Nishihama) of river mouth, the $\delta^{13}C$ and $\delta^{18}O$ of the shell collected were low (estimated FR 10.6-25.0%) and ^{222}Rn concentration was also low. The contribution of DIC in SGD and riverine water for shell formation was estimated to be 19.8 % and 7.8%, respectively. In the present study, we demonstrated the effectiveness of $\delta^{13}C$ and $\delta^{18}O$ of *C. nippona* shell as the tool for estimating FR.

Keywords: Submarine Groundwater Discharge, carbon stable isotope, oxygen stable isotope, rock oyster shell, bayesian stable isotope mixing model

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Tue. May 28, 2019 10:45 AM - 12:15 PM JST | Tue. May 28, 2019 1:45 AM - 3:15 AM UTC | 102 1F

[A-CG40] Coastal Ecosystems - 1. Water Cycle and Land-Ocean Interactions

convener:Masahiko Fujii(Faculty of Environmental Earth Science), Makoto Yamada(Faculty of Economics, Ryukoku University), Jun Shoji(The University of Tokyo), Ryo Sugimoto(Faculty of Marine Biosciences, Fukui Prefectural University), Chairperson:Masahiko Fujii, Makoto Yamada

Substances from land which are brought by river and/or submarine groundwater discharge are important for the process of biological production in coastal areas. This session focuses on land-ocean interactions through water cycle. The aim of this session is to create interdisciplinary discussions on the research of connectivity of ecosystems, water cycles in terrestrial and coastal areas, fishery resources and biodiversity. Comprehensive discussion on the mechanisms that promote productivity and biodiversity in coastal ecosystems will be made from the viewpoint of land-ocean interactions. Presentations on water-material cycle in terrestrial and coastal areas, fishery resources, biodiversity and connectivity of the ecosystems are encouraged.
A companion session proposed as "Coastal Ecosystems - 2. Coral reefs, seagrass meadows, and mangroves" focuses on benthic communities in shallow-water ecosystems such as coral reefs, seagrass meadows and mangroves and is dedicated to promote researches on comprehensive assessment and monitoring of ecosystem functions and development of effective means for conservation and restoration. Main focuses of these two sessions are different. However, there are much of information that covers both sessions. Scientists who work on the related field will be able to obtain information and share them with other scientists if they attend to both of these sessions.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[ACG40-06] Influence of climate change on river and submarine groundwater discharge for three decades and the change of nutrient fluxes from the land to the coastal area

*Saki KATAZAKAI[1], Jing ZHANG[2], Kota NOJIMA[3] (1.Graduate School of Science and Engineer, University of Toyama, 2.Graduate School of Science and Engineering for Science, University of Toyama, 3.University of Toyama)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[ACG40-07] The assessment of human impacts on the distribution patterns of mangroves: a comparative study between the Rewa and Ba delta, Fiji

*Masahiko Fujii[1], Jone Ravuci Sassen[2] (1.Faculty of Environmental Earth Science, 2.Graduate School of Environmental Science)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[ACG40-08] Landscape factors affect persistence and accumulation of organic carbon in sediment of secondary mangrove forests: A preliminary study

*Toshihiro Miyajima[1], Rempei Suwa[2], Keith Limuel C. Bejasa[3], Rene N. Rollon[3], Maria Lourdes San Diego-McGlone[3], Caroline M.B. Jaraula[3], Fernando P. Siringan[3], Kenji Ono[4], Yasmin H. Primavera Tirol[5], Yosuke Miyairi[1], Yusuke Yokoyama[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Japan International Research Center for Agricultural Sciences, 3.Marine Science Institute, University of the Philippines, 4.Forestry and Forest Products Research Institute, 5.Aklan State University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[ACG40-09] Multiple benefits of blue carbon ecosystems in promoting blue economy and reinforcing resilience in coastal communities

*Atsushi Watanabe[1] (1.The ocean policy research institute, The Sasakawa peace foundation)

11:45 AM - 12:05 PM JST | 2:45 AM - 3:05 AM UTC

[ACG40-10] Significant storage of organic carbon in mineral matrix in both land and ocean and the role of Fe

★Invited Papers

*Rota Wagai[1] (1.NARO, Institute for Agro-Environmental Sciences)

12:05 PM - 12:15 PM JST | 3:05 AM - 3:15 AM UTC

Discussion

Influence of climate change on river and submarine groundwater discharge for three decades and the change of nutrient fluxes from the land to the coastal area

*Saki KATAZAKAI[1], Jing ZHANG[2], Kota NOJIMA[3]

1. Graduate School of Science and Engineer, University of Toyama, 2. Graduate School of Science and Engineering for Science, University of Toyama, 3. University of Toyama

In Toyama prefecture, 10 billion tons of river and submarine groundwater discharge annually flows in to Toyama Bay containing nutrients (Hatta et al., 2005) . Urasawa et al. (2016) shows that 20-40% of nitrate originated on land contributes to the coastal ecosystems. So it is important to evaluate the state of nutrient transport of from the land to the coastal area. However, global warming has caused an increase in rainfall and a decrease in snowfall in Hokuriku area and it is possible that the states of water and material fluxes has changed over the past years. The aim of this study is to clarify the change of nutrient fluxes via river and submarine groundwater discharge into the coastal area, analyzing hydrogen and oxygen stable isotopes as well as chemical composition.
Results of my analysis, should be, data in my study show that the stable isotopes decreased due to increasing rainfall and decreasing snowfall for three decades. Nitrate and phosphate fluxes are shown to have dramatically decreased as forest and paddy field decreased and the water treatment facilities increased over the years.
These results suggest that nutrient fluxes from the land to coastal zone in this region may continue to decrease due to ongoing climate change and the impact of human activities.

Keywords: climate change, nutrients, river , submarine groundwater discharge

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The assessment of human impacts on the distribution patterns of mangroves: a comparative study between the Rewa and Ba delta, Fiji

*Masahiko Fujii[1], Jone Ravuci Sassen[2]

1. Faculty of Environmental Earth Science, 2. Graduate School of Environmental Science

Mangrove ecosystems are among the most productive ecosystems on this planet. They are sources of livelihood to many people, the first walls of protection from storm waves, and nursery grounds for some marine organisms. Unfortunately, mangroves in Fiji are observed to have decreased over the years due to human (induced) activities. Moreover, apart from human impacts, there are several other natural impacts like tropical cyclones that may influence the distribution patterns of mangroves. The aims of this study are: (1) to elucidate changes of the distribution patterns of mangroves and the causes, and based on the results, and (2) to provide practical suggestions for sustainable use of mangroves and saving the ecosystems in Fiji.

To estimate changes in the area of mangroves, satellite imagery data from Landsat 7 and 8 were acquired and analyzed by using Geographic Information System (GIS) to produce land use classification maps for the Rewa delta (in 2002, 2005, 2016 and 2017) and Ba delta (in 2004, 2007, 2010 and 2017) in Fiji. A total of five land cover classes, i.e. mangrove, non-mangrove, urban, barren land, and water were used to classify the land cover. To elucidate causes of the changes in the area of mangroves, social survey was conducted in three villages of Kiuva, Muana I ra and Kinoya in the Rewa delta and three villages of Natutu, Nawaqarua and Votua of the Ba delta, respectively.

The trend in distribution patterns of mangroves was different between the study sites. In the Rewa delta, the area of mangroves has increased from 2002 to 2016 and decreased by 5 km² from 2016 to 2017. In Ba delta, on the other hand, the area decreased from 2004 to 2007, increased from 2007 to 2010, and again decreased from 2010 to 2017. The difference is considered to be caused by the difference in the dependency of people on mangrove ecosystems in the two sites, i.e. higher dependency on mangrove ecosystems for livelihood in the Ba delta with less access to urban centers than in the Rewa delta. Impacts of tropical cyclones and subsequent floods to mangrove ecosystems were also examined as possible climate change stressors, but the impacts were not found clearly in this study.

This study suggests that anthropogenic factors have continuously been major causes of mangrove degradation in Fiji. Mangrove protection in Fiji can be improved firstly by raising people’s awareness on the importance of mangroves to their lives. Secondly, amendment of current legislation might administer the protection of mangrove ecosystems by broadening its scope to monitor the domestic use as well as the commercial use of mangroves. Furthermore, mangrove areas are also required to be designated as “protected areas”, which can be an effective way to guard mangrove ecosystems from human impacts.

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Landscape factors affect persistence and accumulation of organic carbon in sediment of secondary mangrove forests: A preliminary study

*Toshihiro Miyajima[1], Rempei Suwa[2], Keith Limuel C. Bejasa[3], Rene N. Rollon[3], Maria Lourdes San Diego-McGlone[3], Caroline M.B. Jaraula[3], Fernando P. Siringan[3], Kenji Ono[4], Yasmin H. Primavera Tirol[5], Yosuke Miyairi[1], Yusuke Yokoyama[1]

1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. Japan International Research Center for Agricultural Sciences, 3. Marine Science Institute, University of the Philippines, 4. Forestry and Forest Products Research Institute, 5. Aklan State University

Mangroves are swamp forest ecosystem that predominates in low-energy brackish environment of subtropical and tropical coastal systems. Mangroves have a remarkable capacity to capture CO_2 by primary production and sequester organic carbon (OC) in the sediment, thereby contributing to climate change mitigation. Typical carbon sequestration rate and OC stock in top 1 m of mangrove sediment have been estimated to be 1030 kg C ha^{-1} $year^{-1}$ and 723 Mg C ha^{-1}, respectively (median values of available data; Alongi 2018). Mangroves have been vastly degraded by human activities and reclaimed and/or converted to aquacultures and agricultural fields for past a few centuries. Current global loss rate of mangroves has been estimated to be up to 2% per year, which corresponds to an emission of 0.27 to 0.59 Pg CO_2 $year^{-1}$ at the maximum, if OC in top 1 m of sediment is assumed to be entirely reoxidized after reclamation and conversion (Alongi 2018, Atwood et al. 2017). However, the degree to which and the rate at which sediment OC is returned to the atmosphere as CO_2 after degradation of mangroves are still uncertain, and presumably depend on land use pattern and hydrodynamic conditions after conversion. Some part of sediment OC may be reoxidized shortly after conversion, while other parts may remain unoxidized in the soil for long term or be flushed out to the ocean by tidal exchange. To estimate the rate of OC loss after degradation and conversion of mangroves and evaluate how the sediment OC stock may be recovered by reforestation, we are now conducting a multidisciplinary research project in coastal areas of Panay Island, Philippines, where various types of habitats typical to once degraded and converted mangroves are found, such as naturally recovered secondary mangroves, artificially reforested mangroves, artificial mangroves planted on originally seagrass-dominated habitats, and tidal marshes and shrubs growing on abandoned aquaculture plots. Here, we introduce first preliminary results on OC characteristics in sediment cores collected from a naturally-recovered secondary mangrove in an estuarine delta (Ibajay) and a replanted mangrove in a well-protected embayment (Batan Bay). Estimated OC stocks in top 1 m of sediment ranged from 40 Mg C ha^{-1} in lower estuary of Ibajay to 420 Mg C ha^{-1} in Batan Bay, which are significantly lower than the world-median OC stock for natural mangroves mentioned above. Radiocarbon dating showed that the cores from the lower estuarine secondary mangrove were predominated by modern carbon down to a depth of 1 m, which suggests that old OC originally stored in the primary mangrove had been reoxidized and/or washed out to the sea soon after the conversion. In contrast, sediment OC in the upper estuarine secondary mangrove showed a radiocarbon age of 400 –1200 yBP throughout the cores, suggesting that old OC stored in original mangroves persisted at least partially through conversion and subsequent regrowth of the forest. The OC loading, i.e. the amount of OC per unit surface area of sediment grains, seemed to be constrained by the hydrodynamic stability of sediment. This implies that detrital particles derived from mangrove litter was stored at the higher concentrations in sediment of the more protected environment. The curvilinear correlation of stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotope ratios to the OC loading suggests that

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mangrove-derived detritus typically exhibits the $\delta^{13}C$ of −28‰ vs. VPDB and the $\delta^{15}N$ of +0.5‰ vs. atmospheric N_2. The other endmember of sediment OC, putatively marine seston, is represented by the $\delta^{13}C$ of around −25‰ and the $\delta^{15}N$ of +3‰ and tended to decrease with increasing sediment depth. Our results overall showed that both the persistence of old sediment OC and the accumulation of newly supplied detrital OC in secondary mangroves are strongly constrained by the hydrodynamic setting of habitat.

Keywords: carbon sequestration function, mangroves, reforestation

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Multiple benefits of blue carbon ecosystems in promoting blue economy and reinforcing resilience in coastal communities

*Atsushi Watanabe[1]

1. The ocean policy research institute, The Sasakawa peace foundation

Blue carbon ecosystems (hereafter BCEs) such as seagrass beds and mangrove forests have recently been paid international attention due to their capability in effectively absorbing and storing carbon dioxide and thus mitigating climate change impacts when they are managed properly. BCEs could also be beneficial to the coastal communities in terms of preventing or minimizing climate change impacts, offering better environmental settings for aquaculture and fisheries, and in turn reinforcing their resilience. For instance ecosystem-based disaster risk reduction (Eco-DRR), sustainable food production through fisheries and aquacultures, and sustainable tourism could enhance adaptation capacity of the coastal community to climate change. The properly managed coastal ecosystems are thus the basis for the secure, safe, and circular coastal society, which is one of the main targets of the sustainable blue economy.
In this presentation, the definition and characteristics of BCEs such as mangrove forests, seagrass beds, coral reefs, and their interlinkages will be introduced first. Then some good examples and lessons learned from coastal communities in Japan as well as Palau will be introduced. Restoration of seagrass beds and coral reefs has involved multi-stakeholders and strengthened socioecological systems in Japanese coastal communities with some innovative ideas or continuing efforts of locals. In Palau, beautiful, unique marine ecosystems have attracted tourists from overseas and environmental fees paid by these tourists have contributed to the conservation and monitoring of these ecosystems in return. Through cataloguing and networking of these good examples from world coastal areas with similar natural or socioeconomic backgrounds, sustainable use of BCEs could be mainstreamed for promoting the blue economy and combating loss of these important ecosystems globally.

Keywords: Blue economy, Blue carbon, Seagrass beds, Coral reefs

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Significant storage of organic carbon in mineral matrix in both land and ocean and the role of Fe

*Rota Wagai[1]

1. NARO, Institute for Agro-Environmental Sciences

Land-ocean linkage is one of the least understood aspects in biogeochemistry and carbon (C) cycle, which presumably results from insufficient collaboration between land and ocean scientists as well as the inherent complexity of land-to-ocean processes. At a global scale, the largest C reservoir on land is soil (1500-2400 Pg C) in which major portions of C is stored as organic C (OC) in association with soil mineral particles. In ocean, sediment holds similar amounts of OC. Thus, OC stability and reactivity in soils and sediments have been a great concern as their strong impacts on global C cycle and climate change.

In this talk, I focus on the interaction of organic C with minerals (e.g., aluminosilicate clays, hydrous iron oxides) and discuss the similarity and difference in their interaction between soil and sediment based on my own studies and the literature. I also discuss mechanistic reasons why OC is stabilized in mineral matrix in both systems. An emphasis is given to iron-C interaction due to their high reactivity and ecological importance in both terrestrial and aquatic systems. For instance, OC cycle is linked to N and P cycling as many organic compounds contain N and P. Iron can control P cycle due to strong sorption of phosphate to Fe oxides.

I plan to end my talk by emphasizing that basic understanding of soil formation and biogeochemistry would greatly help when tackling C and nutrient-related questions in river and coastal water.

Keywords: iron, organic matter, soil and sediment, soil carbon, carbon cycle

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Tue. May 28, 2019 3:30 PM - 5:00 PM JST | Tue. May 28, 2019 6:30 AM - 8:00 AM UTC | 201B 2F

[A-CG41] Promotion of Application and Utilization of Aircrafts for Earth sciences

convener:Nobuhiro Takahashi(Institute for Space-Earth Environmental Research, Nagoya University), Makoto Koike(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Toshinobu Machida(National Institute for Environmental Studies), Taro Shinoda(Institute for Space-Earth Environmental Research, Nagoya University), Chairperson:Nobuhiro Takahashi(Institute for Space-Earth Environmental Research, Nagoya University)

The problem of global environmental change such as global warming is a problem throughout the Earth and planetary sciences. To confront this problem, progresses of the observations that are dedicated for the monitoring Earth and for the process studies as well as the progresses of numerical prediction models. Aircraft observation has the great advantages of immediate and direct (in-situ) observations which cannot be achieved by Earth observing satellites or ground-based observations. Recently, the importance of aircraft observation is increasing in "in-situ measurements" such as concentration of greenhouse gases, aerosol and cloud particle size distribution, and chemical composition, and "remote sensing" such as three dimensional typhoon observation and observation on forests and vegetation. In addition, the application of aircraft observation to geodesy, study on earthquakes and volcanos are also progressing. However, steady and extensive aircraft observations to fulfill the requirements in Japan are not realized at the present time. Meanwhile, it is also a fact that the aircraft observations which have been carried out has cited the world leading results. In order to realize the effective research by using aircraft, it is necessary to have a close collaborations among researchers to promote aircraft observations, and it is also necessary to carry out as the master plan of national academic council of Japan. In this session, we will discuss the future aircraft observation through the latest research results with aircraft observations.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[ACG41-01] In situ observation of typhoon central pressure using dropsondes

*Kazuhisa Tsuboki[1], Hiroyuki Yamada[2], Yukihiro Takahashi[3], Taro Shinoda[1], Tadayasu Ohigashi[4], Munehiko Yamaguchi[5], Hisayuki Kubota[3], Tetsuo Nakazawa[5], Norio Nagahama[6], Kensaku Shimizu[6], Masaya Kato[1], Sachie Kanada[1], Mayumi Yoshioka[1], Nobuhiro Takahashi[1] (1. Institute for Space-Earth Environmental Research, Nagoya University, 2.University of the Ryukyus, 3.Hokkaido University, 4.National Research Institute for Earth Science and Disaster Resilience, 5.Meteorological Research Institute, Japan Meteorological Agency, 6.Meisei Electric Co. Ltd.)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[ACG41-02] New observation strategies for typhoon intensity over the western North Pacific

*Hiroyuki Yamada[1], Kazuhisa Tsuboki[2], Taro Shinoda[2], Hisayuki Kubota[3], Yukihiro Takahashi[3], Norio Nagahama[4], Kensaku Shimizu[4], Tadayasu Ohigashi[5], Kosuke Ito[1], Munehiko Yamaguchi[6], Tetsuo Nakazawa[6] (1.University of the Ryukyus, 2.Nagoya University, 3.Hokkaido University, 4.Meisei Electric, 5.National Research Institute for Earth Science and Disaster Resilience, 6.Meteorological Research Institute, Japan Meteorological Agency)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[ACG41-03] Observing System Experiment for Typhoon Trami (2018) using T-PARCII dropsondes and JMA Global Forecasting System

*Munehiko Yamaguchi[1], Toshiyuki Ishibashi[1], Tetsuo Nakazawa[1], Kosuke Ito[2], Hiroyuki Yamada[2], Tadayasu Ohigashi[3], Norio Nagahama[4], Kensaku Shimizu[4], Hisayuki Kubota[5], Yukihiro Takahashi[5], Masaya Kato[6], Sachie Kanada[6], Mayumi Yoshioka[6], Taro Shinoda[6], Nobuhiro Takahashi[6], Kazuhisa Tsuboki[6] (1.Meteorological Research Institute, Japan Meteorological Agency, 2.Faculty of Science, University of the Ryukyus, 3.National Research Institute for Earth Science and Disaster Resilience, 4.Meisei Electric, 5.Graduate School of Science, Hokkaido University, 6.Institute for Space-Earth Environmental Research, Nagoya University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[ACG41-04] Fundamental characteristics of black carbon and iron oxide aerosols in the troposphere revealed from the aircraft measurements

*Nobuhiro Moteki[1], Makoto Koike[1], Sho Ohata[2], Yutaka Kondo[3], Nobuyuki Takegawa[5], Kouji Adachi[4], Naga Oshima[4], Hitoshi Matsui[2], Kazuyuki Kita[6], Tatsuhiro Mori[7], Atsushi Yoshida[1] (1.The Univerisity of Tokyo, 2.Nagoya University, 3.National Institute for Polar Research, 4.Meteorological Research Institute, 5.Tokyo Metropolitan University, 6.Ibaraki University, 7.Tokyo University of Science)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[ACG41-05] Aerosol measurements around the ridge of East Antarctica using a Rogallo wing UAV

*Ryohei Haraguchi[1], Masahiko Hayashi[1], Keiichiro Hara[1], Naohiko Hirasawa[2], Koki Nakata[3], Kei-ichi Ozuka[4,1] (1.Fukuoka University, 2.National Institute of Polar Research, 3.kkt Inovate Co., Ltd, 4.Nippon Tungsten Co., Ltd)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[ACG41-06] Wind Mesurements Based on In-situ Data -Direct Vector Calculation and Hodograph Analyses-

*Masahiko Hayashi[1], Tomoyuki Onohara[1], Ryohei Haraguchi[1,3], Kei-ichi Ozuka[2,4], Kazuo Okabe[3] (1.Faculty of Science, Fukuoka University, 2.Nippon Tungsten Co.,Ltd, 3.SkyRemote Co.,Ltd, 4.FIT-EH, Fukuoka University)

In situ observation of typhoon central pressure using dropsondes

*Kazuhisa Tsuboki[1], Hiroyuki Yamada[2], Yukihiro Takahashi[3], Taro Shinoda[1], Tadayasu Ohigashi[4], Munehiko Yamaguchi[5], Hisayuki Kubota[3], Tetsuo Nakazawa[5], Norio Nagahama[6], Kensaku Shimizu[6], Masaya Kato[1], Sachie Kanada[1], Mayumi Yoshioka[1], Nobuhiro Takahashi[1]

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After the US aircraft reconnaissance in the western North Pacific was terminated in 1987, typhoon intensity is estimated by the Dvorak technique using satellite cloud pattern. Consequently, uncertainty of intensity estimation became large for very intense typhoons. Accurate intensity estimations are essential for prevention and mitigation of typhoon disaster. They are also important information for a study of long-term change of typhoon with the climate change. To improve this problem, the T-PARCII (Tropical cyclone-Pacific Asian Research Campaign for Improvement of Intensity estimations/forecasts) project performs an in situ observation of typhoons. In this project, Nagoya University and Meisei Electric Co., Ltd developed a new dropsonde and a four-channel dropsonde receiver. Using these systems on a jet aircraft, the T-PARCII project performed aircraft observations of very intense typhoons in 2017 and 2018. Typhoon Lan (2017) was the most intense typhoon in 2017 and was categorized as a supertyphoon by JTWC. It moved northeastward in the east of the Okinawa main island at 23 N on 21 October and at 28 N on October 22, 2017. In these two days, we made dropsonde observations inside of the eye and in the surrounding area of the eyewall. The T-PARCII team also made aircraft observations of Typhoon Trami (2018) during the period from 25 to 28 September 2018 in collaboration with the SATREPS ULAT group as well as Taiwan DOTSTAR. The observed dropsonde data were transmitted to GTS (Global Telecommunication System) in real time and were used for typhoon forecasts in 2018.

Because the height of dropsonde is derived from GPS, error of height data becomes large just before the dropsonde reaches to the sea surface. As a result, the sea level pressure is uncertain. Typhoon intensity is represented by the central sea level pressure. Accurate estimation of sea level pressure is necessary for a typhoon intensity information. We, therefore, developed two schemes to estimate the sea level pressure from dropsonde data. Temperature, humidity and pressure are measured by sensors of dropsonde. We assume that the accuracy of these data is sufficiently high and height is also accurate above ~500 m in height. In the scheme I, the sea level pressure is calculated by a pressure correction method from 50~100 observed points in 900~750 hPa. The final result is the average of these calculated sea level pressure values. In the scheme II, heights of observed pressure levels below 800 hPa are calculated by the hydrostatic equation using virtual temperature. The sea level pressure is corrected from the lowest grid point.

These schemes were examined by special observations around Minami-Daitojima comparing dropsonde observations with balloon sonde observations launched from Minami-Daitojima Island as well as the JMA surface observation. The maximum difference of sea level pressure is less than 3 hPa. The central sea level pressures of typhoons Lan and Trami were calculated by the schemes I and II. The results by these two schemes agreed well each other. We consider that the sea level pressures were estimated with a sufficient accuracy. They were compared with the JMA best track data. The difference of central pressure of typhoon Trami was about 5 hPa on September 25 when the typhoon was most intense. It was about 10 hPa on September 28 when the typhoon was weakened in the south of the Okinawa main island.

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Keywords: typhoon, dropsonde, central pressure

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New observation strategies for typhoon intensity over the western North Pacific

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Recent activities on typhoon intensity observation/estimation using aircraft reconnaissance and ground-based Doppler radars in the western North Pacific are introduced. Since aircraft reconnaissance by the US military was ceased in 1987, new techniques of intensity estimation using microwave radiometer and a geostationary satellite are used in this basin without enough verification. The major obstacle of aircraft reconnaissance is the difficulty of having a specially-designed propeller aircraft that withstands strong turbulence. Since wind speed in a typhoon is stronger in the lower troposphere, it takes a great deal of labor and expense to measure the center position and the central pressure of a typhoon through low-altitude flight with slow speed. On the other hand, since the winds become weaker in the upper troposphere, it is possible to fly into the typhoon center if the risks of heavy icing and severe turbulence in a convective burst can be avoided by using an airborne weather radar. During T-PARCII (Tropical Cyclone-Pacific Asian Research Campaign for Improvement of Intensity Estimations / Forecasts), we succeeded in observing the central pressure of two intense typhoons, Lan (2017) and Trami (2018), by using a commercial jet aircraft (Gulfstream-II) with a newly-developed GPS dropsonde system. These flight missions were made in the upper troposphere (43,000ft, approximately 13.7 km) and were marked by very weak turbulence during eyewall penetration. These flights demonstrated a possibility of typhoon intensity observation using a civil aircraft. In the Pacific coast of Japan and Philippines, Doppler radars became available in this decade. The combination of aircraft reconnaissance off the coast with the ground-based velocity track display (GBVTD) analysis near the coast will provide accurate information on typhoon intensity.

Acknowledgements: This work was supported by JSPS KAKENHI Grant Numbers JP16H06311, JP16H04053, JP18H03805, and the Science and Technology Research Partnership for Sustainable Development (SATREPS) Understanding Lightning and Thunderstorm (ULAT) project.

Keywords: aircraft reconnaissance, tropical cyclone, western North Pacific

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Observing System Experiment for Typhoon Trami (2018) using T-PARCII dropsondes and JMA Global Forecasting System

*Munehiko Yamaguchi[1], Toshiyuki Ishibashi[1], Tetsuo Nakazawa[1], Kosuke Ito[2], Hiroyuki Yamada[2], Tadayasu Ohigashi[3], Norio Nagahama[4], Kensaku Shimizu[4], Hisayuki Kubota[5], Yukihiro Takahashi[5], Masaya Kato[6], Sachie Kanada[6], Mayumi Yoshioka[6], Taro Shinoda[6], Nobuhiro Takahashi[6], Kazuhisa Tsuboki[6]

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Airborne typhoon observations were conducted for Typhoon Trami (2018) under Tropical cyclones-Pacific Asian Research Campaign for Improvement of Intensity estimations/forecasts (T-PARCII). Using the dropsonde data (zonal and meridional winds, temperature, and relative humidity) and the Japan Meteorological Agency Global Spectral Model (JMA/GSM, TL959L100) and 4 Dimensional Variational data assimilation (4DVAR, TL319L100), we performed Observing System Experiment (OSE) to see the impact of the newly available observational date on the track/intensity predictions by the JMA/GSM.

Three sets of numerical experiments, CNTL, EXP1 and EXP2, were performed. All the T-PARCII dropsonde and typhoon bogus data were used in the data assimilation in CNTL while T-PARCII dropsonde (typhoon bogus) data only were assimilated in the 4DVAR in EXP1 (EXP2). The period of the experiments is from 2018.09.25 00UTC to 2018.09.28 18UTC with a 6-hour data assimilation and forecasting cycle.

The error of the track predictions of EXP1 and EXP2 is smaller than that of CNTL. For example, the 3-day track prediction error of CNTL, EXP1 and EXP2 is 232, 201 and 218 km, respectively. A possible reason of the degradation of the track predictions by CNTL is that some dropsonde data were assimilated at the almost same locations as typhoon bogus data, which might deteriorate the initial structure of the typhoon.

In the operational configuration of the 4DVAR, all dropsonde data were assimilated irrespective of the existence of the typhoon bogus data. The results of a series of these numerical experiments may lead to improvement in the operational setting of dropsonde assimilation.

Keywords: Airborne observation, Typhoon, Weather Prediction

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Fundamental characteristics of black carbon and iron oxide aerosols in the troposphere revealed from the aircraft measurements

*Nobuhiro Moteki[1], Makoto Koike[1], Sho Ohata[2], Yutaka Kondo[3], Nobuyuki Takegawa[5], Kouji Adachi[4], Naga Oshima[4], Hitoshi Matsui[2], Kazuyuki Kita[6], Tatsuhiro Mori[7], Atsushi Yoshida[1]

1. The Univerisity of Tokyo, 2. Nagoya University, 3. National Institute for Polar Research, 4. Meteorological Research Institute, 5. Tokyo Metropolitan University, 6. Ibaraki University, 7. Tokyo University of Science

In this presentation, we will talk about the basic behaviors, microphysical and associated optical properties, and transport-and-removal processes of the tropospheric black carbon and iron oxide aerosol which have been elucidated mostly from aircraft measurements. We will clarify the scientific significance and contribution of these findings in the context of the related international research activities on atmospheric aerosols and climate change. In addition, we will suggest some related open problems which need to be investigated through in-situ aircraft measurements in future research.

Keywords: aerosol, aircraft measurement, black carbon, iron oxide, atmospheric chemical composition

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Aerosol measurements around the ridge of East Antarctica using a Rogallo wing UAV

*Ryohei Haraguchi[1], Masahiko Hayashi[1], Keiichiro Hara[1], Naohiko Hirasawa[2], Koki Nakata[3], Kei-ichi Ozuka[4,1]

1. Fukuoka University, 2. National Institute of Polar Research, 3. kkt Inovate Co., Ltd, 4. Nippon Tungsten Co., Ltd

Meteorological observations using a UAV in the Antarctica have been carried out at S17 Air Base (69° 02’ S, 40° 06’ E, 606m a.s.l.), near Syowa Base by the 48th, 54th, and 56th Japanese Antarctic Research Expedition, (JARE). The JARE 58th planned to perform meteorological observations including snow, water vapor and aerosols budgets at S17 during December 22nd, 2016 and February 4th, 2017. One of main mission of the observation focused on aerosol processes using automated UAVs with a Rogallo wing, called Kite Planes. Two types of Kite Planes were used for different type observations. One is engine powered Kite Plane for horizontal observations with a condensation particle counter, an optical particle counter, and an aerosol sampler for SEM/EDX analyses. Another is a glider KitePlane supported by electric motor with an optical particle counter for vertical distribution observations. 22 flights were successfully carried out during the campaign of JARE 58th and obtained following results.

1. Uniformity in CN and Mie particle concentrations is very high during January in 2017.
2. Low CN concentrations were sometimes observed near surface.
3. High CN event with low Mie particle concentration from free troposphere was observed on January 23rd, suggesting caused by new particle formation.
4. High CN event with high Mie particle concentration from ocean area was observed on January 27th, 2017, suggesting hygroscopic growth of aerosols from marin boundary layer.

Keywords: Aerosol, UAV, Antarctica, new particle formation

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Wind Mesurements Based on In-situ Data -Direct Vector Calculation and Hodograph Analyses-

*Masahiko Hayashi[1], Tomoyuki Onohara[1], Ryohei Haraguchi[1,3], Kei-ichi Ozuka[2,4], Kazuo Okabe[3]

1. Faculty of Science, Fukuoka University, 2. Nippon Tungsten Co.,Ltd, 3. SkyRemote Co.,Ltd, 4. FIT-EH, Fukuoka University

Un-manned Aerial Vehicles have been developing rapidly and performance as observation platform are increasing. Our group have used Rogallo wing UAV, called KitePlane for aerosol measurement about 20 years ago. In-situ wind measurements have tested, becuase of importance for meteorological analyses and technical requirements for safety flight operations. There are two typical methods for atmospheric wind measurements based on in-situ data by in-flight airplane. One is direct calculation method by difference between gound speed and true air speed. The other is that drift of center of hodograph circle for ground speed coinsident with wind vector during flight.
Time and spatial resolutions for the direct calculations are around 1 second and 10 m respectively, and require high accuracy for true wind vectors. On the other hand, those for the hodograph methods are around 1 minuite and several hundreds meters, respectively, however the method only require position and time for calculations.
It will be presented based on actual flight by KitePlane that accuracies of wind speeds and directions are around 0.1m/sec and several degrees for both methods with recently developed small and precision sensors.

Keywords: wind mesurements, UAV, meteorology

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Tue. May 28, 2019 1:45 PM - 3:15 PM JST | Tue. May 28, 2019 4:45 AM - 6:15 AM UTC | 102 1F

[A-CG44] Coastal Ecosystems 2 Coral reefs, seagrass and macroalgal beds, and mangrove

convener:Yu Umezawa(Tokyo University of Agriculture and Technology), Toshihiro Miyajima(Marine Biogeochemistry Group, Division of Ocean-Earth System Science, Atmosphere and Ocean Research Institute, The University of Tokyo), Atsushi Watanabe(The ocean policy research institute, The Sasakawa peace foundation), Tomihiko Higuchi(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Yu Umezawa(Tokyo University of Agriculture and Technology), Toshihiro Miyajima(The University of Tokyo), Tomihiko Higuchi(Atmosphere and Ocean Research Institute, The University of Tokyo), Atsushi Watanabe(Tokyo Institute of Technology)

Coastal marine ecosystems are complex open system interacting with surrounding watersheds, outer ocean, and the atmosphere, providing a wealth of various ecosystem services to human life. Simultaneously, they are also influenced strongly and often negatively by human activities. This session, together with a companion session dedicated for the water cycle and land-ocean interactions, aims to provide a platform for interdisciplinary discussion covering various aspects of frontiers in coastal ecosystem sciences. This session particularly focuses shallow-water benthic communities ranging from temperate to tropical regions, such as coral reefs, seagrass and macroalgal beds, and mangroves. All these communities are characterized by intrinsically high primary production, active material cycling, and biodiversity hot spots. However, increasing human demand for coastal marine resources and industrial development concentrating on coastal regions incur the risk of rapid degradation and diminishment. Comprehensive assessment and monitoring of ecosystem functions and development of effective means for conservation and restoration are urgently needed for such communities. This session is dedicated to organizing and promoting such research and management activities by sharing state-of-the-art science and technology among ecologists, geologists, geochemists, biogeographers, etc. Field-based and modeling studies concerning the following topics are especially welcome: material cycling and ecosystem functions; community connectivity; environmental changes such as global warming, ocean acidification, and sea-level rise; ecosystem services such as carbon sequestration, nutrient regulation, and fisheries production; broad-scale comparison; long-term ecological researches.

1:45 PM - 1:50 PM JST | 4:45 AM - 4:50 AM UTC

Introduction

1:50 PM - 2:10 PM JST | 4:50 AM - 5:10 AM UTC

[ACG44-01] Evaluation of mangrove ecosystems as a dissolved iron supplying system to tropical coastal waters

★Invited Papers

*Yasuhiro Nakanishi[1], Ko Hinokidani[1] (1.Tokyo University of Agriculture)

2:10 PM - 2:25 PM JST | 5:10 AM - 5:25 AM UTC

[ACG44-02] Dissolved organic carbon and optical properties in tropical and subtropical mangrove environments

*Raghab Ray[1], Toshihiro Miyajima[1], Charissa M Ferrera[2], Chia-Jung Lu[1], M.L San Diego-McGlone[2], Hiroshi Ogawa[1], Kazuo Nadaoka[3] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Marine Science Institute, University of the Philippines, Diliman, 3.School of Environment and Society, Tokyo Institute of Technology)

2:25 PM - 2:45 PM JST | 5:25 AM - 5:45 AM UTC

[ACG44-03] Modeling coral polyp-scale bleaching phenomenon and upscaling to reef-scale

★Invited Papers

*Takashi Nakamura[1], Tomihiko Higuchi[2], Toshihiro Miyajima[2], Lawrence Patrick Cases Bernardo[1], Kazuo Nadaoka[1], Atsushi Watanabe[1,3], Hiroyuki Fujimura[4] (1.School of Environment and Society, Tokyo Institute of Technology, 2.AORI, The University of Tokyo, 3.The ocean policy research institute, The Sasakawa peace foundation, 4.University of the Ryukyus)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[ACG44-04] Reversal of surface ocean acidification and recovery potential of calcification: ecology of proton concentration control

*Kazuhiko Ichikawa[1] (1.(post) Graduate School of Environmental Earth Science, Hokkaido University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[ACG44-05] Revisit of massive *Porites* coral growth under the outbreak of crown-of-thorns starfish and thermal stress in Sekisei Lagoon, Japan

*Kohki Sowa[1] (1.Japan Agency for Marine-Earth Science and Technology)

Evaluation of mangrove ecosystems as a dissolved iron supplying system to tropical coastal waters

*Yasuhiro Nakanishi[1], Ko Hinokidani[1]

1. Tokyo University of Agriculture

Iron, one of the essential micro elements for plants, is normally contained in the insoluble forms in sea water, content of the dissolved forms greatly affects propagations of marine phytoplankton which are origins of the marine food chain and absorb CO_2 in sea water.

As one of the studies on natural systems for dissolved forms of iron from land to sea, we focused on mangrove ecosystems located at boundary between the land and sea in the tropical regions. To clarify the dissolved iron supplying systems, we have conducted studies on polyphenols content in leaves of some mangrove species and elution of dissolved iron generated in reactions between the polyphenols and mangrove floor soils. Additionally, we surveyed dissolved iron elution from the floor soils mixed with fecal materials of benthos, such as *Neosarmatium smith* and *Telebralia palustris* which feed on mangrove leaves.

Keywords: Mangrove, Ecosystem, Dissolved iron, Benthos, Polyphenole

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Dissolved organic carbon and optical properties in tropical and subtropical mangrove environments

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1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. Marine Science Institute, University of the Philippines, Diliman, 3. School of Environment and Society, Tokyo Institute of Technology

Among different wetland habitats, mangroves are key source of dissolved organic matter (DOM) for the estuarine and coastal waters. However, the quantity and quality of DOM from both natural and rehabilitated mangroves sustained under contrasting hydro-climatological settings of tropical and subtropical regions have not been examined comprehensively. The present study was carried out in areas of such regions in the tropics (Panay and Palawan, Philippines) and sub-tropics (Ishigaki and Iriomote, Japan). Surface water sampling was performed along the salinity gradient of mangrove dominated rivers and estuaries in 2018, aiming to investigate the distribution, mixing and fate of dissolved organic carbon (DOC), δ^{13}C-DOC and optical properties such as chromophoric dissolved organic matter (as CDOM). Preliminary results showed that mean DOC concentration was ~2-fold higher in Ishigaki and Iriomote than Panay and Palawan mangroves (225±111 μM and 103±52 μM, respectively) due to dilution effect by increased rain water flux from the typhoon event during sampling in Panay and Palawan. Strong correlation between DOC and CDOM absorption coefficient at 412 nm was only evident for the Ishigaki and Iriomote mangroves, indicative of dominance of predominantly allochthonous DOM. In the Philippines, there were no significant variations of DOM properties observed between natural (Palawan) and rehabilitated (Panay) mangroves but their mixing pattern along the salinity transect differed significantly. Property-salinity relationship revealed regions of non-linear mixing of DOC for both sites demonstrating dynamic source-sink reaction processes within the river estuaries. During the course of transport to the sea, DOC was added to the waters in Palawan in contrast to the recruited mangroves of Panay reflecting higher mangrove material input for the former site. Other optical descriptors (like spectra slope between 275 nm and 295 nm, and slope ratio in the ranges of 275-295 nm and 350-400 nm) confirmed the shift in DOM origin from terrigenous to marine sources along the salinity transects of the river estuaries. The linear decreasing trend of specific UV absorption at 254 nm ($SUVA_{254}$) further indicated the loss of DOM aromaticity downstream to the sea. Further attempt will be made to better characterize the DOM molecular compositions and fluorescence properties from the same tropical and sub-tropical mangrove sites.

Keywords: Dissolved organic matter, CDOM, Mangrove, Philippines

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Modeling coral polyp-scale bleaching phenomenon and upscaling to reef-scale

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1. School of Environment and Society, Tokyo Institute of Technology, 2. AORI, The University of Tokyo, 3. The ocean policy research institute, The Sasakawa peace foundation, 4. University of the Ryukyus

To elucidate the mechanism responsible for coral bleaching and to project the status of coral communities in the near future, a coral bleaching model was developed based on a reef-scale three-dimensional hydrodynamic–biogeochemical model coupled with a polyp-scale coral bleaching model.

The polyp-scale bleaching model was developed by incorporating the dynamics of photoinhibition, reactive oxygen species (ROS), and zooxanthella abundance based on a previously developed coral polyp model by Nakamura et al. (2013). The polyp-scale model assumes that ROS are produced by zooxanthellae and that corals expel zooxanthellae when the concentration of ROS in their tissues exceeds tolerable levels. When temperature increases, corals release more zooxanthellae because the ROS production rate per zooxanthella cell increases with increasing temperature. This mechanism accounts for coral bleaching at high temperatures. The model assumes that ROS are produced from excess electrons transferred from photosystem II (PSII) that are not used in the downstream photosynthetic process. Photoinhibition, which is a key factor in the transfer of electrons from PSII, was included in the model, and the temperature dependence of Rubisco activity was introduced as a blocking factor in the downstream photosynthetic process. The ROS dynamics include detoxification of ROS by antioxidant substances, and the zooxanthella population dynamics include reproduction, mortality, and the rate of zooxanthellae release, which depends on the ROS damage of the coral cell. Results of simulated incubation experiments under different temperature conditions by the bleaching model reproduced the temperature dependence of the coral bleaching phenomenon. Moreover, recovery process after bleaching was also reproduced, and the ability of the model to describe the recovery process is a unique feature. The model also reproduced the phenomenon that coral bleaching is effectively reduced by light shading. A comparison between photoinhibition and its absence revealed that photoinhibition effectively reduced electron transport from PSII and consequently reduced the production of excess electrons that form ROS. Photoinhibition therefore protects the photosystem and tissues from oxidative damage by ROS. A temperature-dependent repair delay from photoinhibition also reduces ROS production and thereby prevents coral bleaching. The delay may be strategically controlled by zooxanthellae.

The polyp-scale bleaching model was coupled with reef-scale hydrodynamic-biogeochemical model based on the model framework by Nakamura et al. (2018). The model was applied to both the Shiraho coral reef based on Nakamura et al. (2018), and Sekisei Lagoon based on Bernardo et al. (2017). The results of the model simulation confirmed that the model accurately reproduced the spatiotemporal variations of bottom water temperatures on the reef. In particular, the temperatures during the daytime were significantly higher on the reef crest and in shallow nearshore areas than in the offshore seawater. The model confirmed that the spatial pattern of zooxanthella density coincided with the spatial pattern of water temperature on the reef. The model can use the internal condition of the corals to output the parameters that characterize coral population dynamics, such as coral growth rates and mortality rates. The coupled model therefore has the potential to simulate long-term spatiotemporal changes in coral

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coverage. Although the model still needs some improvement, incorporation of additional modules and improvement of the model will make it a useful tool for evaluating how corals respond to multiple environmental stresses on the reef-scale.

Keywords: coral bleaching, numerical simulation, zooxanthellae, ROS

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Reversal of surface ocean acidification and recovery potential of calcification: ecology of proton concentration control

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1. (post) Graduate School of Environmental Earth Science, Hokkaido University

Surface ocean ecology is open system under anthropogenic effect on atmosphere. Coral reefs and individual coral polyps are interacting with surrounding watersheds. They are influenced strongly and often negatively by human activities. All the coordinates pointed out by atmospheric PCO2 and surface ocean pH were irregularly scattered at PCO2 > 290ppm under anthropogenic effect on surface ocean. The calcifying organism habitats of surface ocean are controlled by the proton dynamics and chemical physics of comprehensive global-environment. The surface oceans of calcifying organism habitats showed the proper base of ~8.0 < pH < ~8.3 at ~200ppm < P_{CO2} < ~290ppm under no anthropogenic effect on P_{CO2}. The calcifying organism habitats of surface ocean are controlled by the proton dynamics and chemical physics of comprehensive global-environment.Surface ocean ecology is open system under anthropogenic effect on atmosphere. Coral reefs and individual coral polyps are interacting with surrounding watersheds. They are influenced strongly and often negatively by human activities. All the coordinates pointed out by atmospheric PCO2 and surface ocean pH were irregularly scattered at PCO2 > 290ppm under anthropogenic effect on surface ocean. The calcifying organism habitats of surface ocean are controlled by the proton dynamics and chemical physics of comprehensive global-environment. The surface oceans of calcifying organism habitats showed the proper base of ~8.0 < pH < ~8.3 at ~200ppm < P_{CO2} < ~290ppm under no anthropogenic effect on P_{CO2}. The calcifying organism habitats of surface ocean are controlled by the proton dynamics and chemical physics of comprehensive global-environment.

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Revisit of massive *Porites* coral growth under the outbreak of crown-of-thorns starfish and thermal stress in Sekisei Lagoon, Japan

*Kohki Sowa[1]

1. Japan Agency for Marine-Earth Science and Technology

Recently, shallow water coral reefs have come under high pressure because of the changes in climate due to global warming and water quality due to pollution. Coral reefs, which are distributed from the tropical to the temperate areas, consist of calcareous biotas such as scleractinian corals. As the coral skeletal growth is one of the candidate proxies for representing the whole coral reef health, it can provide vital information for developing effective conservation strategies for coral reefs. However, there are only a few studies on the long-term and *in-situ* verification of the relationships among coral skeletal growth, and changes in coral ecology and climate information.

Sekisei area is located between the Yaeyama Islands and the largest coral reef lagoon in Japan (approximately 400 km^2). Continual monitoring of coral and crown-of-thorns starfish (COTS) started in 1983, and the results revealed the negative effects of the outbreak of COTS and the thermal stress-induced severe damage to coral reef ecology. Massive *Porites* coral is one of the key species in the framework of coral reefs in North-West Pacific. The coral continuously precipitates carbonate skeleton over its previous frame, which provides us an opportunity to hindcast the skeletal growth for the long term. Therefore, massive *Porites* coral skeleton in Sekisei Lagoon offers an opportunity to verify whether their skeletal growth is an indicator of coral reef health.

This study shows the revisit of long-term massive *Porites* coral growth (extension rate) estimated from the coral cores in Sekisei Lagoon from 1965 to 2000 reported by Omata *et al.* (2002). Eighty-two coral cores were collected from 12 areas, including reef fronts and patch reefs in Sekisei Lagoon. This study then selected seventy-four coral cores. The average growth anomaly decreased from the 1980s to 1990, which corresponded to decreasing coral coverage. The results imply that the growth of *Porites* coral would be an indicator of the changes in coral coverage by biodisturbance in this area. On the contrary, there were several reductions in extension anomaly, but it did not entirely correspond to the coral bleaching events in 1983 and 1998. These results imply that the growth of *Porites* coral does not represent the coral bleaching events in this area.

References

Omata *et al.* (2002) Skeletal growth history of modern corals in Sekisei Lagoon as a bio-indicator. *JAMSTEC-R* 45, 17-30.

Keywords: Coral, Skeleton , Hindcast, COTS, Thermal stress, Sekisei lagoon

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Tue. May 28, 2019 3:30 PM - 5:00 PM JST | Tue. May 28, 2019 6:30 AM - 8:00 AM UTC | 102 1F

[A-CG44] Coastal Ecosystems 2 Coral reefs, seagrass and macroalgal beds, and mangrove

convener:Yu Umezawa(Tokyo University of Agriculture and Technology), Toshihiro Miyajima(Marine Biogeochemistry Group, Division of Ocean-Earth System Science, Atmosphere and Ocean Research Institute, The University of Tokyo), Atsushi Watanabe(The ocean policy research institute, The Sasakawa peace foundation), Tomihiko Higuchi(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Yu Umezawa(Tokyo University of Agriculture and Technology), Toshihiro Miyajima(The University of Tokyo), Atsushi Watanabe(Tokyo Institute of Technology), Tomihiko Higuchi(Atmosphere and Ocean Research Institute, The University of Tokyo)

Coastal marine ecosystems are complex open system interacting with surrounding watersheds, outer ocean, and the atmosphere, providing a wealth of various ecosystem services to human life. Simultaneously, they are also influenced strongly and often negatively by human activities. This session, together with a companion session dedicated for the water cycle and land-ocean interactions, aims to provide a platform for interdisciplinary discussion covering various aspects of frontiers in coastal ecosystem sciences. This session particularly focuses shallow-water benthic communities ranging from temperate to tropical regions, such as coral reefs, seagrass and macroalgal beds, and mangroves. All these communities are characterized by intrinsically high primary production, active material cycling, and biodiversity hot spots. However, increasing human demand for coastal marine resources and industrial development concentrating on coastal regions incur the risk of rapid degradation and diminishment. Comprehensive assessment and monitoring of ecosystem functions and development of effective means for conservation and restoration are urgently needed for such communities. This session is dedicated to organizing and promoting such research and management activities by sharing state-of-the-art science and technology among ecologists, geologists, geochemists, biogeographers, etc. Field-based and modeling studies concerning the following topics are especially welcome: material cycling and ecosystem functions; community connectivity; environmental changes such as global warming, ocean acidification, and sea-level rise; ecosystem services such as carbon sequestration, nutrient regulation, and fisheries production; broad-scale comparison; long-term ecological researches.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[ACG44-06] Reconstructing sedimentation process of lagoon sediment in the Eastern Kume Island, Ryukyus

*Wataru Sano[1], Shoko Hirabayashi[2], Yusuke Yokoyama[3], Yosuke Miyairi[3], Kazuhiko Fujita[4], Hironobu Kan[2], Lauren T. Toth[5], Richard B. Aronson[6] (1.Graduate School of Integrated Sciences for Global Society, Kyushu University, 2.Graduate School of Social and Cultural Studies, Kyushu University, 3.Atmosphere and Ocean Research Institute, University of Tokyo, 4.Department of Physics and Earth Sciences, University of the Ryukyus, 5.United States Geological Survey, 6.Florida Institute of Technology)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[ACG44-07] Addressing challenges in long-term coral reef monitoring: Statistical tools to address the effect of new methods

*Iwao Fujii[1,2], Jennifer Selgrath[3,2], Amanda Vincent[2] (1.The Ocean Policy Research Institute of the Sasakawa Peace Foundation, 2.Project Seahorse, Institute of the Oceans and Fisheries, The University of British Columbia, 3.Hopkins Marine Station, Stanford University)

4:00 PM - 4:20 PM JST | 7:00 AM - 7:20 AM UTC

[ACG44-08] Ocean currents and herbivory drive macroalgae-to-coral community shift under climate warming

★Invited Papers

*Naoki H. Kumagai[1], Jorge García Molinos[2], Hiroya Yamano[1], Shintaro Takao[1], Masahiko Fujii[2], Yasuhiro Yamanaka[2] (1.National Institute for Environmental Studies, 2.Hokkaido University)

4:20 PM - 4:35 PM JST | 7:20 AM - 7:35 AM UTC

[ACG44-09] Estimation of temperature of seaweed bed vegetation boundary in the Western Seto Inland Sea using satellite SST

*Naoki Yoshie[1], Anri Kabe[1], Hiromori Shimabukuro[2], Goro Yoshida[2] (1.Center for Marine Environmental Studies, Ehime University, 2.Japan Fisheries Research and Education Agency)

4:35 PM - 4:55 PM JST | 7:35 AM - 7:55 AM UTC

[ACG44-10] Fate of macroalgal organic matter and its effects on in and outside of algal bed

★Invited Papers

*Shigeki Wada[1], Yuko Omori[1], Takeo Hama[1,2] (1.University of Tsukuba, 2.Dokkyo University)

4:55 PM - 5:00 PM JST | 7:55 AM - 8:00 AM UTC

Discussion

Reconstructing sedimentation process of lagoon sediment in the Eastern Kume Island, Ryukyus

*Wataru Sano[1], Shoko Hirabayashi[2], Yusuke Yokoyama[3], Yosuke Miyairi[3], Kazuhiko Fujita[4], Hironobu Kan[2], Lauren T. Toth[5], Richard B. Aronson[6]

1. Graduate School of Integrated Sciences for Global Society, Kyushu University, 2. Graduate School of Social and Cultural Studies, Kyushu University, 3. Atmosphere and Ocean Research Institute, University of Tokyo, 4. Department of Physics and Earth Sciences, University of the Ryukyus, 5. United States Geological Survey, 6. Florida Institute of Technology

This study aims to reveal the sedimentation process of the barrier reef lagoon in the Eastern Kume Island. We drilled at two sites (the south of Ooha island and the east of Eef beach)in Kume Island and obtained 4 cores. The penetration depth of cores were from 2.4 to 4.2 m. Unlithified sediments in coral reef lagoons in Kume Island were mainly composed of bioclast such as branching coral pebbles, foraminifera, shell, algae and lime mud.
We measured radiocarbon dating of 28 samples (18 coral pebbles and 10 foraminifera) in the cores and estimated their sedimentation rates. The results showed that the sedimentation rate was slow at the south of Ooha Island, but rapid at Eef beach. The timing of rapid sediment accumulation at Ooha Island coincided with the timing of relative sea-level rise around 6.7 ka and reached its highest level at Tonaki Island (Kan et al.,1997) locating next to Kume Island. The sediment accumulation at Eef Beach was from 4.1 to 3.2 ka and it lagged behind Ooha Island. It may be because the coastal plain was developed with three beach ridges behind Eef Beach (Kawana,1990) and the coring sites were located at the front of the coastal plain formation.
This study was supported by JSPS and the U.S. National Science Foundation.

Keywords: Coral reef, Sea-level change, Geomorphological development, Holocene, Ryukyu Islands

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Addressing challenges in long-term coral reef monitoring: Statistical tools to address the effect of new methods

*Iwao Fujii[1,2], Jennifer Selgrath[3,2], Amanda Vincent[2]

1. The Ocean Policy Research Institute of the Sasakawa Peace Foundation, 2. Project Seahorse, Institute of the Oceans and Fisheries, The University of British Columbia, 3. Hopkins Marine Station, Stanford University

Tracking how coral responds to marine protected areas (MPA) is critical for the effective coral reef management. Ideally, one method would be employed consistently throughout monitoring, but such longitudinal sampling can pose problems of methodology. Some possible reasons include a possibility of a current method found inappropriate in the course of monitoring or development of new preferred approaches over time. What happens when procedures are suboptimal and must be changed? Our project evaluated how data from two reef survey methods, line intercept transect (LIT) and photoquadrat (PQ), estimated coral cover. We then explored a way of combining data from different sources as one time-series dataset.

Data used in this study were collected in a three-year period of 18-year monitoring, where both LIT and PQ were executed. Monitoring surveys were conducted between 1998 and 2016 in dry and wet seasons (March ~ April, and September ~ October, respectively) at eight MPAs. LIT was used in the first half of monitoring (1998 ~ 2010) and PQ in the later half (2008 ~ 2016). Both methods were used between 2008 and 2010 as a transition period. In LIT, two 20 m transects were set up as fixed transects in each MPA; however, this method was replaced with PQ due to difficulties in maintaining the transects as fixed. In PQ, ten 23 m transects were placed haphazardly at each MPA. The surveys were conducted at the depth shallower than 5 m. LIT data were also sampled from areas between 5 and 10 m, but data from the deep areas were not included in this study.

In a comparison of data from the transition period, LIT showed higher mean percent coral cover than PQ (LIT mean: 40.5 %, PQ mean: 31.1 %). However, a difference between the two methods became insignificant after increasing sample sizes of LIT data by resampling (LIT mean after resampling: 39.0 %). In resampling, two 20 m LIT transects were subsetted by 1 m and thus, 40 samples were generated. In an analysis of coral cover change over time, PQ showed significant results (5.8 % decrease / year) whereas LIT exhibited insignificant results (1.8 % increase / year). This difference can be attributed to characteristics of PQ, where larger sample sizes were collected from wider areas. Although temporal patterns of LIT did not significantly change even after resampling, a comparability between the two methods can increase by adding deep LIT data, given there is no depth effect. These results confirmed that a difference in sample sizes and areas need to be carefully considered when data form different sources are analyzed. In addition, they indicated that resampling can be effective to improve comparability of different datasets. The results from this study can help improve the quality of monitoring data and thus, contributed to more powerful coral reef conservation.

Keywords: Coral reef, Marine protected area, Long-term monitoring , Marine Conservation

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Ocean currents and herbivory drive macroalgae-to-coral community shift under climate warming

*Naoki H. Kumagai[1], Jorge García Molinos[2], Hiroya Yamano[1], Shintaro Takao[1], Masahiko Fujii[2], Yasuhiro Yamanaka[2]

1. National Institute for Environmental Studies, 2. Hokkaido University

Range shifts in foundation species induced by global warming are likely to have ecosystem-wide implications for biodiversity, ecological functioning, biogeochemical cycling and resources used by humans. Corals and macroalgae are habitat-forming species in coastal ecosystems that co-occur and compete for space, and thus global degradation of coral reefs and macroalgal beds can have ecosystem-wide implications. However, recent studies in warm temperate zones have documented community shifts from macroalgae to corals, signaling a potential mechanism for coral conservation under climate warming at the expense of macroalgae under climate warming. Although such community shifts are expanding geographically, our understanding of the driving processes is still limited. Here, we reconstruct long-term climate-driven range shifts in 30 species of macroalgae (8 kelp and 22 fucoid species), 12 species of corals and three species of herbivorous fishes (records of overgrazing) from over 60 years records (mainly 1950–2015) stretching across 3,000 km of the Japanese archipelago from tropical to subarctic zones.

The direction and rate of the observed range shifts calculated for each species and coast during the study period showed considerable variation in both distribution centroids and range edges. Expansions were scarcer than contractions in macroalgae, whereas fishes and corals experienced expansions much more frequently than contractions. Expansions were fastest in fishes, followed by corals, fucoids and kelps, whereas macroalgae contracted their range faster than corals and fishes. Based on a revised coastal version of climate velocity trajectories and a Bayesian inference, we found that prediction models combining the effects of climate and ocean currents consistently explained observed community shifts significantly better than those relying on climate alone. Corals and herbivorous fishes performed better at exploiting opportunities offered by this interaction.

The contrasting range dynamics for these taxa suggest that ocean warming is promoting macroalgal-to-coral shifts both directly by increased competition from the expansion of tropical corals into the contracting temperate macroalgae, and indirectly via deforestation by the expansion of tropical herbivorous fish. Beyond individual species' effects, our results provide novel evidence on the important role that the interaction between climate warming and external forces conditioning the dispersal of organisms, such as ocean currents, can have in shaping community-level responses, with concomitant changes to ecosystem structure and functioning. Further, we found that community shifts from macroalgae to corals might accelerate with future climate warming, highlighting the complexity of managing these evolving communities under future climate change. Nevertheless, and although expansion rates are faster than contraction rates overall, we found that not only macroalgae but even corals might be unable to keep pace with climate change. This may suggest that the apparent expansion in overall range might be a transient effect potentially masking risk of metapopulation collapse with decreasing connectivity among local populations and future range collapses. Thus, future conservation of these communities might require of a more proactive management towards climate adaptation including abundance control of herbivorous fishes, artificial assistance for thermal adaptation through selection of thermal-tolerant lineages, or relocation and translocation into cooler areas.

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(Kumagai, N. H., J. García Molinos, H. Yamano, S. Takao, M. Fujii, and Y. Yamanaka 2018. Proceedings of the National Academy of Sciences of the United States of America 115: 8990–8995; doi: 10.1073/pnas.1716826115)

Keywords: climate velocity, coastal tropicalization, community phase shifts, range shifts

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Estimation of temperature of seaweed bed vegetation boundary in the Western Seto Inland Sea using satellite SST

*Naoki Yoshie[1], Anri Kabe[1], Hiromori Shimabukuro[2], Goro Yoshida[2]

1. Center for Marine Environmental Studies, Ehime University, 2. Japan Fisheries Research and Education Agency

Seaweed bed is algal community in the coastal region, and important for the coastal fishing. It provides various ecosystem services to human society. However, it has been changing seriously, especially in the species and composition and habitat. Therefore, vegetation and distribution of seaweed in the near future is regarded as uneasiness by fisher men. Although several studies had reported the changes associated with the warming of sea surface temperature due to the climate change, they have some problems, such as low spatial-temporal resolution for the coastal region. Moreover, the boundary temperatures of the seaweed vegetation are not clear. In this study, I investigated the boundary temperature of seaweed vegetation in the Bungo Channel by using a satellite sea surface temperature data set (NOAA/AVHRR Pathfinder version5.3 level 3 collated global 4km sea surface temperature) which had enough resolution for the coastal region. The Bungo Channel has large gradient of sea surface temperature and various seaweed vegetation. First, I analyzed the accuracy of the satellite temperature in this region by comparing with ship board observation. The result shows that the accuracy of the satellite temperature in winter is enough high (RMSE<0.74℃), while the accuracy in summer is relative low (RMSE<1.25℃) compared with those in winter. Secondly, I analyzed the time series of the temperatures of three boundaries of seaweed vegetation both winter and summer. One is the restrictive temperature of the southern limit of temperate kelps habitat. Second is the restrictive temperature of the southern limit of the other temperate seaweeds habitat. Third is the restrictive temperature of the southern limit of the transition region between temperate and subtropical seaweeds (i.e., the northern limit of subtropical seaweeds). I found that the restrictive temperatures in winter were 14.5℃, 15.0℃, 16.0℃, and also the restrictive temperatures in summer were 26.0℃, 26.5℃, 27.0℃, respectively. The restrictive temperature of the southern limit of temperate kelps moved northward from 1989 when the winter temperature have been over 14.5℃. It was also affected by warm summer temperature changing in the 2000s. The restrictive temperature of the southern limit of the other temperate seaweed habitat was considered to be strongly affected by the warm winter temperature over 15.0℃ after the 1990s. Invasion of the subtropical seaweed seemed to be related with the disappearance of the temperate seaweed which lived in there after the 1990s.

Keywords: Seaweed bed, climate change, vegetation boundary, remote sensing

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Fate of macroalgal organic matter and its effects on in and outside of algal bed

*Shigeki Wada[1], Yuko Omori[1], Takeo Hama[1,2]

1. University of Tsukuba, 2. Dokkyo University

Macroalgal bed is known as one of the most productive biome on the earth’ s surface. Their habitat is limited to shallow coastal region, but the coastal environments are linked with the open oceans. A part of organic matter derived from macroalgae would be exported, and it contributes to ecosystem outside of algal bed. Dislodgement of algal body from their base provide drifting algae which would be partly utilized by organisms in offshore. Another fate of organic matter which is exported would be dissolved organic matter (DOM). DOM is exuded to body surface of macroalgae, and transported with mixing of water mass. Based on quantitative estimates of these fate of macroalgal products, we have tried to evaluate the ecological roles of macroalgae in large special scale.

Dislodgement of macroalgae

Dislodgement of macroalgal body would often happen due to wave action. In order to quantitatively estimate the amount of dislodgement, we labeled the body of *Ecklonia cava* which is dominant species in kelp forest around Shimoda, Izu Peninsula, Shizuoka, Japan. A part of labels was disappeared due to dislodgement, and it accounted for about 20-30% of fixed carbon by *E. cava*. In addition, we collected benthic organisms in offshore region with/without drifting algae, showing settlement of drifting algae increases species diversity of fauna on the seafloor.

Macroalgal DOM

Release rate of DOM is estimated by covering bag on blades of *E. cava*, and approximately 40% of fixed carbon is released as DOM. Horizontal distribution of DOM across algal bed to offshore showed a gradient of macroalgal DOM, being consistent with the fact that *E. cava* releases large amount of DOM in coastal region. We additionally examined the microbial and photochemical decomposition processes of the macroalgal DOM. Macroalgal DOM has a resistance for bacterial mineralization, while it was degraded by exposure to sunlight. Therefore, macroalgal DOM would be exported with mixing of water mass, and it is partly decomposed in surface layer. On the other hand, the fraction transported to deeper layer has resistance for bacterial decomposition, and contributes to carbon sequestration.

Keywords: Macroalgae, Dislodgement, Dissolved Organic Matter, Decomposition

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Tue. May 28, 2019 9:00 AM - 10:30 AM JST | Tue. May 28, 2019 12:00 AM - 1:30 AM UTC | 103 1F

[A-CG45] Visible Remote Sensing of Hydrospheric Science and Its Application

convener:Joji Ishizaka(Institute for Space-Earth Environmental Research, Nagoya University), Mitsuhiro Toratani(School of Engineering, Tokai University), Yuji Sakuno(Graduate School of Engineering, Hiroshima University), Toru Hirawake(Faculty of Fisheries Sciences, Hokkaido University), Chairperson:Yuji Sakuno(広島大学大学院工学研究科)

Variety of visible remote sensing data for hydrospheric science is now available. For example, it is known that 20 years of long time series of 1 km resolution ocean color data from OCTS-SeaWiFS-MODIS is available. At the end of 2017, 250 m resolution SGLI (Shikisai) was launched by JAXA, and with 300 m resolution European OLSI it became possible to use high resolution and high frequency data. Furthermore, geostationary satellite data from Korean GOCI is also useful. Not only the satellite variety, diversity of products is also increasing from just phytoplankton pigment, chlorophyll-a, to primary production, phytoplankton community structure and even non-phytoplankton materials and optical properties. Those ocean color satellite data should be useful for various fields of hydrospheric science, combining with higher resolution LANDSAT as well as high frequency Himawari data. In this section, we will discuss the variety of new observations and applications of visible remote sensing in hydrospheric science.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[ACG45-01] Further information in the coastal areas from 250-m resolution multiple bands of GCOM-C “SHIKISAI”

★Invited Papers

*Hiroshi Murakami[1], Manabu Shimizu[2], Goh Onizuka[3] (1.Earth Observation Research Center, Japan Aerospace Exploration Agency, 2.Japan Fisheries Research and Education Agency, 3.National Research Institute of Fisheries and Environment of Inland Sea, Japan Fisheries Research and Education Agency)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[ACG45-02] Features of GCOM-C/SGLI standard atmospheric correction scheme and its processing results

*Mitsuhiro Toratani[1], Kazunori Ogata[2], Hajime Fukushima[3] (1.School of Engineering, Tokai University, 2.Japan Aerospace Exploration Agency/Earth Observation Research Center, 3.Tokai University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[ACG45-03] Verification of GCOM-C/SGLI-derived chlorophyll *a* data in the western North Pacific during May 2018 aboard the R/V *Shinsei Maru*

*Koji Suzuki[1], Stanford B. Hooker[2], Tomonori Isada[1], Kazunori Ogata[3], Mitsuhiro Toratani[4], Hiroshi Murakami[3] (1.Hokkaido University, 2.NASA, 3.JAXA, 4.Tokai University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[ACG45-04] Toward a global retrieval of in-water optical properties using Deep Neural Network

*Salem Ibrahim Salem[1], Hiroto Higa[2], Kazuo Oki[1], Taikan Oki[1] (1.The University of Tokyo, 2.Yokohama National University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[ACG45-05] Development of atmosphere and in-water combining algorithm using GCOM-C/SGLI in Tokyo Bay

*Taiga Nakayama[1], HIROTO HIGA[1], Kazuki Ogata[2] (1.Yokohama National University, 2.Japan Aerospace eXploration Agency)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[ACG45-06] Analysis of the uncertainty of backscattering coefficient by radiative transfer simulation in coastal areas and lakes

*Hidehito Taki[1], Hiroto Higa[1], Yoshiyuki Nakamura[1], Takayuki Suzuki[1] (1.Graduate School of Urban Innovation, Yokohama National University)

Further information in the coastal areas from 250-m resolution multiple bands of GCOM-C “SHIKISAI”

*Hiroshi Murakami[1], Manabu Shimizu[2], Goh Onizuka[3]

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Generally, since the optical characteristics of a coastal area is more complicated than an open ocean, it is necessary to take into consideration the regionality of the in-water optical properties (absorption and scattering, and their spectral characteristics) in order to estimate biological variables like a chlorophyll-a concentration from satellite observations. On the other hand, the optical properties may be useful as new environment information if they can be derived correctly.

The Second-generation Global Imager (SGLI) boarded on Global Change Observation Mission - Climate (GCOM-C) has launched in Dec. 2017. Since SGLI has 19 observation channels with 250-m spatial resolution in the visible - infrared wavelengths, applications near the coastal areas are expected to be improved. The SGLI channels (380, 412, 443, 490, 530, 565, 672, and 867 nm) include a near-ultraviolet band (380 nm) and a pair of an absorption and a baseline in comparatively longer wavelengths (530 nm and 565 nm) which can improve estimate of high chlorophyll-a concentration since the absorption is not saturated with the high concentration in the wavelengths.

GCOM-C captured patches where water-leaving reflectance (r_w) of 565-nm, which is derived by the atmospheric radiative transfer code, Pstar-4 (Ota et al., 2010), were especially higher compared with r_w at 530 nm in the central part of the Seto Inland Sea on August 1, 5, and 13 2018. High a_ph/(a_ph+a_dg) ratio areas were captured (Fig. 1) through the in-water optical property model (Lyon and Hoge, 2006; Murakami, 2018) using average spectra of a_ph or a_dg in NOMAD dataset (Werdell, and Bailey, 2005). Generally, difference between absorption coefficients of phytoplankton at 530 nm and 565 nm (a_ph(530nm) - a_ph(565nm)) is larger than difference between absorption coefficient of CDOM + detritus at 530 nm and 565 nm (a_dg(530nm) - a_dg(565nm)). It may correspond to the redtide which has been reported around the area by Fisheries Agency (Fisheries Agency, 2018).

We will continue to make more precise water-leaving spectra to be used for useful information of coastal environment through improvement of correction aerosol absorption and so on.

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Keywords: GCOM-C, SHIKISAI, SGLI , ocean color, remote sensing

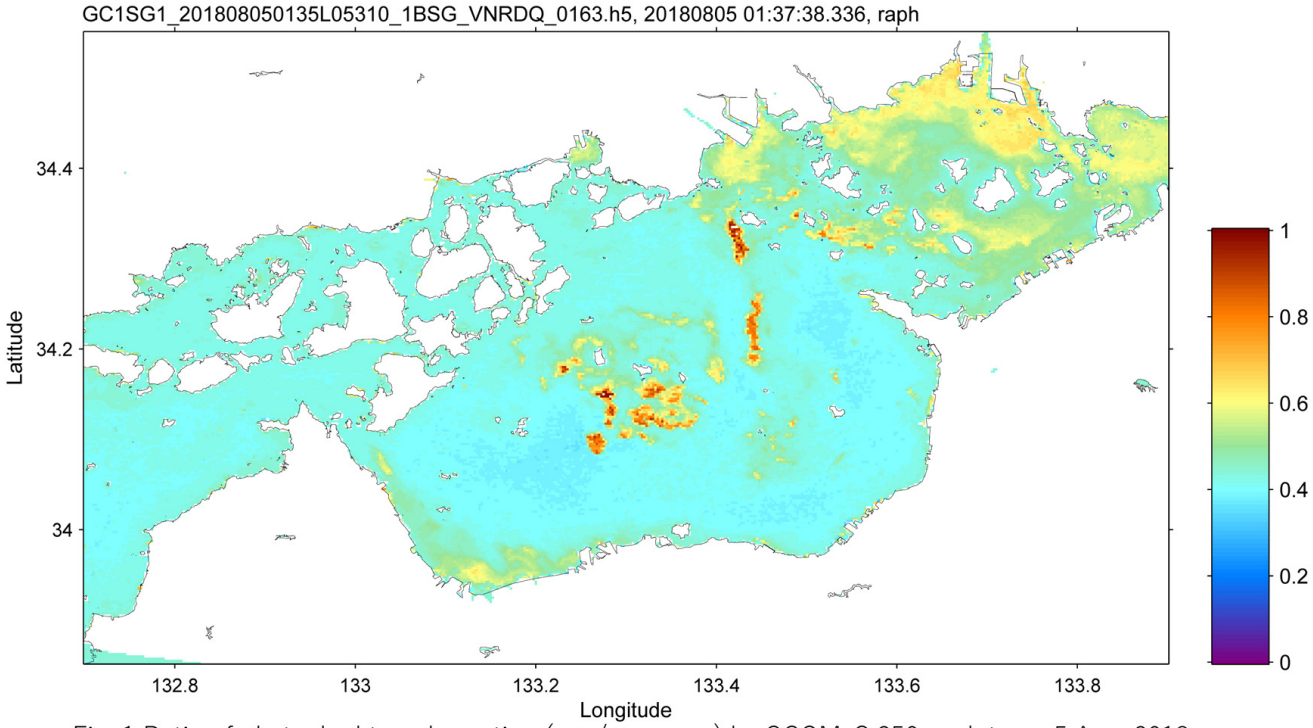


Fig. 1 Ratio of phytoplankton absorption (a_{ph} / a_{ph} + a_{dg}) by GCOM-C 250-m data on 5 Aug. 2018

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Features of GCOM-C/SGLI standard atmospheric correction scheme and its processing results

*Mitsuhiro Toratani[1], Kazunori Ogata[2], Hajime Fukushima[3]

1. School of Engineering, Tokai University, 2. Japan Aerospace Exploration Agency/Earth Observation Research Center, 3. Tokai University

On December 23, 2017, the Second-generation Global Imager (SGLI) aboard the Global Climate Observation Mission-C (GCOM-C) satellite "Shikisai" was launched. SGLI has 11 observation bands in the visible and near-infrared region (380-870 nm), designed to detect slight change in water color (spectral water reflectance) with 250m spatial resolution. In order to retrieve accurate water reflectance, the correction of atmospheric absorption and scattering effects (atmospheric correction) is of vital importance. One feature of the JAXA standard atmospheric correction for SGLI is to combined use of the conventional atmospheric correction method for open ocean with the method that utilize the short wavelength infrared bands for coastal high suspended matter concentration waters. We demonstrate the processing results in comparison with MODIS results, and discuss the remaining issues.

Keywords: ocean color remote sensing, atmospheric correction

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Verification of GCOM-C/SGLI-derived chlorophyll *a* data in the western North Pacific during May 2018 aboard the R/V *Shinsei Maru*

*Koji Suzuki[1], Stanford B. Hooker[2], Tomonori Isada[1], Kazunori Ogata[3], Mitsuhiro Toratani[4], Hiroshi Murakami[3]

1. Hokkaido University, 2. NASA, 3. JAXA, 4. Tokai University

The Second-generation Global Imager (SGLI) aboard the JAXA GCOM-C satellite was successfully launched on 23 December 2017. We conducted the first GCOM-C field campaign for the western North Pacific during 20–30 May 2018 aboard the R/V *Shinsei Maru*. During this expedition, in situ apparent optical property (AOP) measurements were made using a Compact-Optical Profiling System (C-OPS, Biospherical Instruments Inc.) in order to match up with SGLI data. Also, phytoplankton pigment samples were concomitantly collected from surface waters. A significant linear correlation (R^2 = 0.99, n = 6) was found between ultra-high performance liquid chromatography (UHPLC)-determined chlorophyll (Chl) *a* levels and those derived from C-OPS with the in-water algorithm OC3M6. However, the C-OPS values were underestimated by 32% as compared with the UHPLC data. This could be partly due to the higher pigment extraction efficiency of *N*,*N*-dimethylformamide (DMF) than other organic solvents such as methanol and acetone which are generally used in the world. During the field campaign, SGLI data were successfully matched up with in situ data at a station off Iwate Prefecture, Japan on 21 May. The SGLI-, C-OPS-, UHPLC- and Turner fluorometry-determined surface Chl *a* values were 0.546, 0.709, 0.847 and 1.21 mg m^{-3}, respectively. Other results obtained from the GCOM-C field campaign will also be shown in our presentation.

Keywords: GCOM-C/SGLI, ocean color, satellite remote sensing

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Toward a global retrieval of in-water optical properties using Deep Neural Network

*Salem Ibrahim Salem[1], Hiroto Higa[2], Kazuo Oki[1], Taikan Oki[1]

1. The University of Tokyo, 2. Yokohama National University

Reflected sunlight from water bodies, which records by ocean color sensors, contains information of optical properties of water bodies (e.g., chlorophyll-a concentrations, absorption and backscattering coefficients). During the last few decades, researches have been proposed many approaches for monitoring water bodies by retrieving their optical properties. These approaches include bands ratio, semi-analytical algorithms, and spectrum matching. However, there is no accurate continuous monitoring on a global scale, particularly over inland lakes and coastal regions. This is mainly due to the nonlinear complexity of water environment. In additions, there are a few studies that used the synthetic simulated reflectance to train artificial neural network (ANN) models to be applied on a global scale. However, the recent revaluation of these ANN models over the Japanese and European lakes revealed their limitation to provide accurate monitoring of these water bodies. These results could be attributed to two main reasons; (1) inappropriate ANN architecture with one hidden layer which could not be suitable to represent the complex situation of water bodies. (2) the limitation of the synthetic simulated reflectance that used to train these models. The deep neural network (DNN) with multiple hidden layers could provide a promising approach to overcome these complexities. Up to 2006, there is no way to accurately train a DNN due to a Vanishing gradient problem. the recent advances of DNN enable researchers to efficiently use the DNN models with low cost. During the current research, the performance of a DNN model with three-, five- and seven-hidden layers under different architecture conditions will be presented. These conditions include different activation functions (i.e., sigmoid, Relu and TanH), different optimization technique (i.e, Adam optimizer and stochastic gradient descent) and with/without applying dropout technique. The DNN model was designed to receive water leaving reflectance of several ocean color satellites (e.g., Global Change Observation Mission –Climate (GCOM-C)). Nine water quality parameters are generating from the DNN model. Two independent simulated datasets comprising 100,000 water leaving reflectance spectra each were generated for training and testing the DNN models. The two simulated datasets cover wide ranges of Chla (0.01–250 $mg{\cdot}m^{-3}$), NAP (0.01–250 $g{\cdot}m^{-3}$), and CDOM (0.001–10 m^{-1}) concentrations, representing the open ocean, coastal areas, and inland lakes. The proposed technique was also validated using in-situ datasets (e.g., NOMAD dataset, and many Japanese lakes and coastal bodies) that represent various trophic statuses. The results reveal the ability of proposed technique to provide accurate retrieval of in-water optical properties as will be discussed.

Keywords: deep neural network, water quality, optical properties, Lakes

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Toward a global retrieval of in-water optical properties using Deep Neural Network

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Reflected sunlight from water bodies, which records by ocean color sensors, contains information of optical properties of water bodies (e.g., chlorophyll-a concentrations, absorption and backscattering coefficients). During the last few decades, researches have been proposed many approaches for monitoring water bodies by retrieving their optical properties. These approaches include bands ratio, semi-analytical algorithms, and spectrum matching. However, there is no accurate continuous monitoring on a global scale, particularly over inland lakes and coastal regions. This is mainly due to the nonlinear complexity of water environment. In additions, there are a few studies that used the synthetic simulated reflectance to train artificial neural network (ANN) models to be applied on a global scale. However, the recent revaluation of these ANN models over the Japanese and European lakes revealed their limitation to provide accurate monitoring of these water bodies. These results could be attributed to two main reasons; (1) inappropriate ANN architecture with one hidden layer which could not be suitable to represent the complex situation of water bodies. (2) the limitation of the synthetic simulated reflectance that used to train these models. The deep neural network (DNN) with multiple hidden layers could provide a promising approach to overcome these complexities. Up to 2006, there is no way to accurately train a DNN due to a Vanishing gradient problem. the recent advances of DNN enable researchers to efficiently use the DNN models with low cost. During the current research, the performance of a DNN model with three-, five- and seven-hidden layers under different architecture conditions will be presented. These conditions include different activation functions (i.e., sigmoid, Relu and TanH), different optimization technique (i.e, Adam optimizer and stochastic gradient descent) and with/without applying dropout technique. The DNN model was designed to receive water leaving reflectance of several ocean color satellites (e.g., Global Change Observation Mission – Climate (GCOM-C)). Nine water quality parameters are generating from the DNN model. Two independent simulated datasets comprising 100,000 water leaving reflectance spectra each were generated for training and testing the DNN models. The two simulated datasets cover wide ranges of Chla (0.01–250 $mg \cdot m^{-3}$), NAP (0.01–250 $g \cdot m^{-3}$), and CDOM (0.001–10 m^{-1}) concentrations, representing the open ocean, coastal areas, and inland lakes. The proposed technique was also validated using in-situ datasets (e.g., NOMAD dataset, and many Japanese lakes and coastal bodies) that represent various trophic statuses. The results reveal the ability of proposed technique to provide accurate retrieval of in-water optical properties as will be discussed.

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Development of atmosphere and in-water combining algorithm using GCOM-C/SGLI in Tokyo Bay

*Taiga Nakayama[1], HIROTO HIGA[1], Kazuki Ogata[2]

1. Yokohama National University, 2. Japan Aerospace eXploration Agency

GCOM-C / SGLI launched at the end of December 2017, has an excellent spatiotemporal resolution such as one time observation every two or three days at a resolution of 250 m on coastal area, is expected to monitor coastal areas where water environment change is siginificantly large and water area is comparatively small. However, high accuracy of water estimation is exceedingly difficult because coastal light environment in water changes complexly. In the traditional ocean color atmospheric correction algorithm, it is assumed that the water leaving radiance in the near infrared region is 0 and radiance due to air in the visible region is calcuration after estimating the radiance of atmospheric scattering. However, as in the coastal region, in the case of organic matter and inorganic matter increasing significantly, the water leaving radiance in the near infrared region increases and the assumption does not hold. Because of this, an aerosol reflectance is over estimated and an error occurs in the estimation of the water leaving reflectance in the visible region band. To improve this, there is a method of estimating aerosol reflectance while estimating water leaving reflectance in the near infrared region by the iterative method, and if the in-water model is suitable for the water area, highly accurate water leaving reflectance estimation Is possible. SGLI uses this iterative method in a low turbidity water such as the case1 water, and estimates atmospheric reflectance from a short-wavelength infrared channel without using an in-water model in a coastal area or other high turbidity water area, However, its accuracy is not as good as the high turbidity area.

In this study, we tried to develop a combination algorithm of atmospheric correction model, and in-water model which is adequate for coastal areas as a target of Tokyo Bay where organic matter is dominant. This is a modification of the in-water model used at the atmospheric correction stage to the Bio-Optical model created based on the measured SIOPs(Specific inherent optical properties) in Tokyo Bay, an selection aerosol model and estimation of reflectance at each wavelength are conducted by iterative calculation based on three parameters of Chl-a(Chlorophyll-a), CDOM(Color dissolvedorganic matter) and NAP(Non-algal particles). As a result, the suggested model became possible to estimate Chl-a and Rrs with high accuracy compared to normal SGLI atmospheric correction.

Keywords: atmospheric correction, SGLI, TokyoBay

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Analysis of the uncertainty of backscattering coefficient by radiative transfer simulation in coastal areas and lakes

*Hidehito Taki[1], Hiroto Higa[1], Yoshiyuki Nakamura[1], Takayuki Suzuki[1]

1. Graduate School of Urban Innovation, Yokohama National University

In coastal areas and lakes, the ocean color change is greatly complicated because of various substances which are derived from terrestrial and internal production coexist in the water. Therefore, in radiative transfer simulation in the water, the inherent optical properties per substance concentration, which is the basic parameter change greatly in spatiotemporal, resulting in errors in calculation accuracy. In particular, it has been pointed out that the uncertainty of the backscattering coefficient is one of the major error factors in radiative transfer simulation. (Lain et al., (2017)). In this study, we have conducted field observations to measure water quality, apparent optical properties and inherent optical properties which are basic parameters in radiative transfer simulation in coastal areas and lakes having different optical characteristics such as Tokyo Bay, Kasumigaura Lake, Thailand Bay, and Seto Inland Sea respectively. Furthermore, we tried to conduct radiative transfer simulation by using Hydrolight 4.1 (Mobley et al., (2000)) based on in-situ specific light absorption coefficient and specific backscattering coefficient in each water areas. As a result, it was found that the simulated remote sensing reflectance: R_{rs} (/str) is remarkably variable due to the fluctuation of backscattering probability expressing the particle scattering form in the water.
It was suggested that this result is because of not considering properly the variations of scattering form related to particle characteristics.

Keywords: Ocean color remote sensing, Coastal areas and lakes, Radiative transfer simulation, Inherent optical properties, Backscattering probability

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Tue. May 28, 2019 10:45 AM - 12:15 PM JST | Tue. May 28, 2019 1:45 AM - 3:15 AM UTC | 103 1F

[A-CG45] Visible Remote Sensing of Hydrospheric Science and Its Application

convener:Joji Ishizaka(Institute for Space-Earth Environmental Research, Nagoya University), Mitsuhiro Toratani(School of Engineering, Tokai University), Yuji Sakuno(Graduate School of Engineering, Hiroshima University), Toru Hirawake(Faculty of Fisheries Sciences, Hokkaido University), Chairperson:Joji Ishizaka(名古屋大学宇宙地球環境研究所)

Variety of visible remote sensing data for hydrospheric science is now available. For example, it is known that 20 years of long time series of 1 km resolution ocean color data from OCTS-SeaWiFS-MODIS is available. At the end of 2017, 250 m resolution SGLI (Shikisai) was launched by JAXA, and with 300 m resolution European OLSI it became possible to use high resolution and high frequency data. Furthermore, geostationary satellite data from Korean GOCI is also useful. Not only the satellite variety, diversity of products is also increasing from just phytoplankton pigment, chlorophyll-a, to primary production, phytoplankton community structure and even non-phytoplankton materials and optical properties. Those ocean color satellite data should be useful for various fields of hydrospheric science, combining with higher resolution LANDSAT as well as high frequency Himawari data. In this section, we will discuss the variety of new observations and applications of visible remote sensing in hydrospheric science.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[ACG45-07] Development of a blue tide estimation method based on the optical properties of sulfur colloid particles by geostationary ocean color satellite

*HIROTO HIGA[1], WATARU NAKAMURA[1] (1.Yokohama National University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[ACG45-08] Characteristics of water quality and red tide distribution in the Seto Inland Sea immediately after heavy rain in the western Japan by GCOM-C SGLI data

*Yuji Sakuno[1], Hiroto Higa[2], Hiroshi Kobayashi[3], Mitsuhiro Toratani[4] (1.Hiroshima University, 2.Yokohama National University, 3.Yamanashi University, 4.Tokai University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[ACG45-09] Application of Satellite Remote Sensing to Monitor Eutrophication Status of Inland Lakes

*Wei Yang[1], Bunkei Matsushita[2] (1.Chiba University, 2.University of Tsukuba)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[ACG45-10] **Exploring the Potentials of Google Earth Engine for Global Assessment of Coastal Eutrophication Based on Chlorophyll-*a* concentration**

*Eligio de Raus Maure[1], Genki Terauchi[1], Joji Ishizaka[2] (1.Northwest Pacific Region Environmental Cooperation Center, 2.Institute for Space-Earth Environmental Research, Nagoya University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[ACG45-11] Seasonal and interannual variability of seagrass distribution detected by Landsat TM, ETM+ and OLI images in western Nanao Bay

*Genki Terauchi[1] (1.Northwest Pacific Region Environmental Cooperation Center)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

Discussion

Development of a blue tide estimation method based on the optical properties of sulfur colloid particles by geostationary ocean color satellite

*HIROTO HIGA[1], WATARU NAKAMURA[1]

1. Yokohama National University

Blue tides occurs every year from the summer to the fall in Tokyo Bay or Mikawa Bay, Japan. The blue tides occurs by upwelling sulfur colloid particles, which is generated by reacting oxygen with hydrogen sulfide in the hypoxic water at the bottom. The sulfur colloid particles scatter the light strongly at the surface and the ocean color changes to blue-white, therefore, it is called blue tide. When the magnitude of the blue tide is huge, mass mortality of shell and fish occurs and sometimes it is connected to damage of fisheries. Hence, the blue tides are recognized as an important water environment problem. Because the blue tide is short time scale phenomenon, it is difficult to monitor the spatial behavior adequately. Hence, the blue tide monitoring is expected by using geostationary ocean color satellite which spatio-temporal resolution is superior.
In the previous study, simple method of sulfur estimation method based on simple band of Rrs(Remote sensing reflectance) at 660 nm have been suggested(Higa et al., (2017)). However, it is impossible to separate the backscattering of sulfur and other detritus, respectively. In this study, we developed a bio-optical model, which is specialized in blue tide, based on the measured IOPs(Inherent optical properties) of Sulfur colloid particles. Furthermore, a sulfur estimation method was developed to separate the backscattering of sulfur and other detritus based on the QAA(Quasi-Analytical Algorithm).

Keywords: Blue tide, Geostationary Ocean Color Satellite

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Characteristics of water quality and red tide distribution in the Seto Inland Sea immediately after heavy rain in the western Japan by GCOM-C SGLI data

*Yuji Sakuno[1], Hiroto Higa[2], Hiroshi Kobayashi[3], Mitsuhiro Toratani[4]

1. Hiroshima University, 2. Yokohama National University, 3. Yamanashi University, 4. Tokai University

The heavy rain in western Japan disaster occurred in early July 2018. After this heavy rain, a large amount of sediment discharge from the river and damage of red tide occurred in the Seto Inland Sea. Meanwhile, Chla (Chlorophyll-a), TSM (Total Suspended Matter), CDOM (Color Dissolved Organic Matter), SST (Sea Surface Temperature), Rrs (Remote Sensing Reflectance) of GCOM-C SGLI launched at the end of December 2017 Standard product data with 250 m spatial resolution will be provided once every 2-3 days from JAXA (The Japan Aerospace Exploration Agency). In this research, the results of accuracy verification of these product data (Level 2) officially released in December 2018 will be reported. Secondly, a method for estimating the distribution of harmful red tides (mainly *Chattonella* and *Karenia*) occurred in the Seto Inland Sea from Rrs products will be examined. The study period is mainly from June to August 2018. As a result, the SGLI product satisfies the target accuracy even in this water area, and the characteristics of the water quality and red tide distributions in the Seto Inland Sea about one month after the heavy rainfall became clear.

Keywords: red tide, heavy rain, satellite

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Application of Satellite Remote Sensing to Monitor Eutrophication Status of Inland Lakes

*Wei Yang[1], Bunkei Matsushita[2]

1. Chiba University, 2. University of Tsukuba

Eutrophication of inland lakes is becoming a severe environmental issue all over the world. Routine monitoring of eutrophication status of inland lakes is essential for guaranteeing sustainable development of freshwater resources. The coupled spatial and temporal heterogeneity of water bodies often result in inadequate monitoring and characterization of water quality by using conventional sampling methods. On contrast, satellite remote sensing is quite flexible for monitoring the eutrophication status of inland lakes in terms of being able to cover large spatial areas at very frequent intervals. However, remote sensing of inland lakes has been far less successful than that of open oceans, due mainly to the complex interactions among optically active substances in the lake waters, as well as the difficulties in atmospheric correction. In this presentation, we will introduce our state-of-the-art remote sensing algorithms for estimating Chlorophyll-a concentrations (Chl-*a*) and Secchi disk depth (SDD), which have been widely used to evaluate the eutrophication status of lakes. These algorithms have been extensively validated using extensive in situ collected data sets, yielding satisfactory performances in overcoming the difficulties in remote sensing of turbid inland lakes. Application studies on satellite-based operational monitoring of Chl-*a* and SDD in several lakes of Japan will also be presented. Assessment results demonstrated that the proposed algorithms have the potential of being applied to operationally monitor water quality of inland lakes.

Keywords: inland lake, satellite remote sensing, water quality

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Exploring the Potentials of Google Earth Engine for Global Assessment of Coastal Eutrophication Based on Chlorophyll-*a* concentration

*Eligio de Raus Maure[1], Genki Terauchi[1], Joji Ishizaka[2]

1. Northwest Pacific Region Environmental Cooperation Center, 2. Institute for Space-Earth Environmental Research, Nagoya University

Eutrophication is either emerging or growing environmental issue in many parts of the global marine systems in the ocean. This deterioration in water quality in the coastal regions may at times result in the appearance of harmful algal blooms or hypoxic conditions that affects large spatial and temporal scales with serious damages to the environment and economy, and the marine ecosystem itself. To assess the coastal eutrophication the Special Monitoring and Coastal Environment Assessment Regional Activity Centre (of the Action Plan for the Protection, Management and Development of the Marine and Coastal Environment of the Northwest Pacific Region of the United Nations Environmental Programme) developed a screening procedure to detect symptoms of eutrophication based on satellite observations of chlorophyll-a concentration. The methodology was originally developed for the Toyama Bay, Japan and later applied to the whole Northwest Pacific region. In this presentation, we introduced the method and its applicability to the global ocean. Furthermore, we also introduce the potentials of the Google Earth Engine (GEE)—a cloud-based tool with planetary-scale analysis capability—for future coastal eutrophication assessment based on recent higher resolution ocean colour sensors such as SGLI on GCOM-C with 250 m or Sentinel-3 with 300 m spatial resolutions. Once the GEE is proven useful, it will be an important tool in providing rapid assessment of the status of marine systems in many regions where the information on the status and extent of coastal eutrophication is very limited.

Keywords: coastal eutrophication, assessment, satellite, chlorophyll-a concentration, google earth engine

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Seasonal and interannual variability of seagrass distribution detected by Landsat TM, ETM+ and OLI images in western Nanao Bay

*Genki Terauchi[1]

1. Northwest Pacific Region Environmental Cooperation Center

Western Nanao Bay is known for being a home to massive seagrass beds. A massive die-off of seagrass was reported in 2012 in this area, possibly due to high water temperature in summer. Archive images of Landsat Thematic Mapper (TM), Enhanced Thematic Mapper Plus (ETM+) and Operational Land Imager (OLI) were obtained from USGS to detect seasonal and interannual variability of seagrass distribution. Ground truthing survey with an underwater video camera were carried out from a small boat to study sea floor substrates on June 1, 2 and 16 in 2016. Still photos were also taken from a Stand Up Paddleboard on June 1, 2016 to study seagrass species in a very shallow (< 1m) water area. Information of sea floor substrates obtained from the field survey was then used to classify sea floor types. Six classes of training data were then prepared for classifying the Landsat OLI image observed on June 1, 2016 namely: (1) dense seagrass, (2) dense seagrass with *Sargassum*, (3) *Sargassum*, (4) sandy bottom, (5) mud and (6) exposed sand. Supervised classification of the bottom substrates was carried out by the maximum likelihood method using bands of Red, Green and Blue or ratios of Green/Blue, Green/Red, Blue/Red and Green/Coastal bands corrected with the Depth Invariant Index (DII) method. Accuracy assessment showed better results in the DII corrected band ratios: overall accuracy of 0.73 and tau coefficient of 0.66.

To study seasonal and interannual variability for seagrass, past Landsat archive images were analyzed to detect seagrass distribution. Since past field data of seagrass distribution were not sufficient, the K means unsupervised classification technique with the six classes was applied for mapping the seagrass distribution from past Landsat archive images. The classification result of the Landsat OLI image on June 1, 2015 was used as a reference to determine seagrass distributions as it had a good compliance with the ground truth data. Since two out of the six classes obtained from the unsupervised classification corresponded to a distribution pattern of (1) the dense seagrass and (2) the dense seagrass with *Sargassum* classes from the June 1, 2015, these two classes were merged into one class to represent seagrass distribution in Western Nanao Bay. A comparison of seasonal patterns of seagrass distribution estimated by the unsupervised classification of the Landsat archive data from November 22, 1991 to June 1, 1992 and from November 21, 2014 to June 1, 2015 showed consistent similar seasonal pattern; indicating seagrass recovery between late fall to early summer, which corresponds to seagrass seed germination periods. The Landsat archive data during the seagrass seed germination periods were also obtained to study interannual variability of seagrass distribution. The obtained results showed that there are fewer seagrass years (1994, 1996 and 1999) and more seagrass years (2000, 2004, 2007 and 2008) during the seagrass seed germination periods, indicating the survival rate of seagrass varied depending on the year.

Keywords: seagrass, landsat, remote sensing, mapping, Nanao Bay

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[J] Oral | H (Human Geosciences)：H-DS Disaster geosciences

Tue. May 28, 2019 3:30 PM - 5:00 PM JST | Tue. May 28, 2019 6:30 AM - 8:00 AM UTC | Convention Hall B 2F

[H-DS13] Tsunami and Tsunami Forecast

convener:Naotaka YAMAMOTO CHIKASADA(National Research Institute for Earth Science and Disaster Resilience), Hiroaki Tsushima(Japan Meteorological Agency), Tatsuya Kubota(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Osamu Sandanbata, Tatsuya Kubota

This session discusses issues related to improving real-time and long-term prediction accuracy of tsunami from earthquakes, landslides, and volcanoes, which include such as a better understanding of tsunami dynamics, new real-time tsunami observing systems deployed in the open ocean and coastal waters, methodologies of more rapid and accurate prediction during tsunami emergencies, more extensive and accurate inundation maps, and long-term tsunami potential forecast.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[HDS13-01] Sensibility analysis for the inundation tsunami height due to 2018 Sulawesi earthquake and tsunami

★Invited Papers

*Taro Arikawa[1], Abdul Muhari[3], Shota Takeda[1], Anawat Suppasri[2], Fumihiko Imamura[2] (1.Chuo University, 2.IRIDES, Tohoku University, 3.Ministry of Marine Affairs and Fisheries, Indonesia)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[HDS13-02] Tsunami Source of the 2018 Sulawesi Earthquake Estimated from Tsunami and InSAR Data

*Tungcheng Ho[1], Kenji Satake[1], Shingo Watada[1], Ray Y Chuang[2], Chih-Heng Lu[2] (1.Earthquake Research Institute,The University of Tokyo, 2.Department of Geography, National Taiwan University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[HDS13-03] Source Models of the Two September and December 2018 Indonesia Tsunamis Based on Spectral Analyses and Numerical Modeling

*Mohammad Heidarzadeh[1], Abdul Muhari[2], Tomoya HARADA[3], Takeo Ishibe[4], Antonius Wijanarto[5] (1.Brunel University London, 2.Ministry of Marine Affairs and Fisheries, Jakarta 10110, Indonesia, 3.Earthquake Research Institute, The University of Tokyo, Japan, 4.Association for the Development of Earthquake Prediction, Tokyo, 101-0064, Japan, 5.Badan Informasi Geospasial, Cibinong, Indonesia)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[HDS13-04] Abrupt Large Uplift Caused by Volcanic Tsunami Earthquakes near the Kermadec Islands, New Zealand

*Osamu Sandanbata[1], Shingo Watada[1], Kenji Satake[1] (1.Earthquake Research Institute, the University of Tokyo)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[HDS13-05] Adaptive tsunami waveform inversion for estimating coseismic vertical displacements and slip distribution

*Iyan E. Mulia[1], Aditya Riadi Gusman[2], M. Jakir Hossen[3], Kenji Satake[1] (1.Earthquake Research Institute, The University of Tokyo, 2.GNS Science, 3.BRAC University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[HDS13-06] Real-time tsunami prediction in a coastal zone, using a superposition of Green's function

*Seiji Tsuno[1], Norihiko Hashimoto[2] (1.Railway Technical Research Institute, 2.ITOCHU Techno-Solutions Corporation)

Sensibility analysis for the inundation tsunami height due to 2018 Sulawesi earthquake and tsunami

*Taro Arikawa[1], Abdul Muhari[3], Shota Takeda[1], Anawat Suppasri[2], Fumihiko Imamura[2]

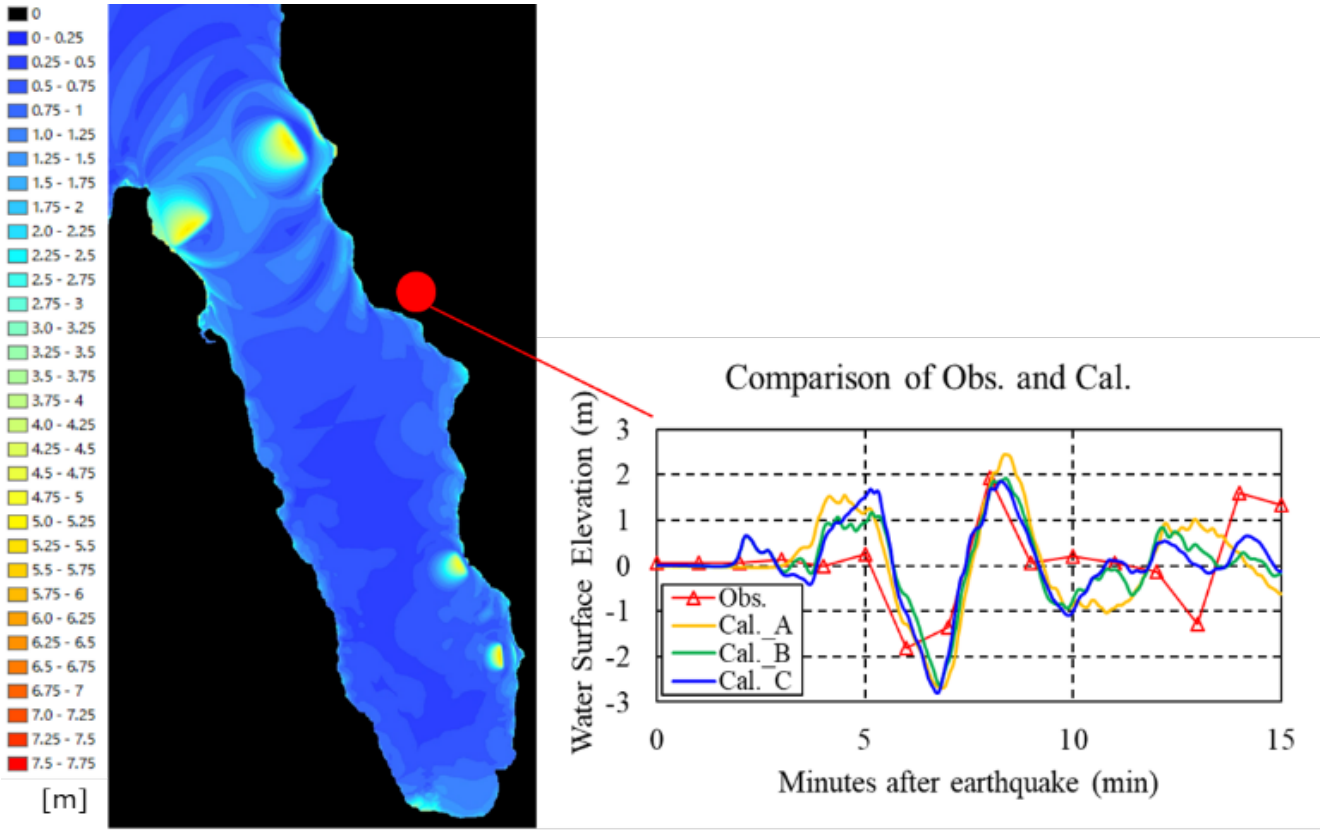
1. Chuo University, 2. IRIDES, Tohoku University, 3. Ministry of Marine Affairs and Fisheries, Indonesia

Today’s Japan has conducted immediate, wide-area tsunami forecasts using the quantitative tsunami forecasting system that databases results of numerous preliminary tsunami simulations. In the future, in order to conduct more accurate tsunami forecasts, it is necessary to verify the accuracy of the tsunami run-up calculation. However, there were few studies about the variation of run-up tsunami force by calculating on-site. In this study, we conducted the on-site tsunami run-up calculation using the two-dimensional simulator and analyzed the variation of run-up tsunami force.

We focused on the earthquake near Palu, Indonesia on September 28, 2018. We set some tsunami sources based on the results of the field study, (by Arikawa *et al.*) and conducted the 300 cases of two-dimensional tsunami run-up simulations by changing the fault parameters. Next, we investigated statistically the variation of the maximum inundation depth and Froude number at the maximum inundation depth. Using the calculation results of all cases we conducted, we made groups every 0.2m from the small inundation depth and made histograms of the maximum inundation depth and Froude number for each group.
As a result, the average of Froude number increased monotonically as the maximum inundation depth increased, and the variance of Froude number tended to increase about 4 times as the maximum inundation depth increased. This corresponds to a value of Froude number of 1.5 to 2.0 times. This indicates that even if the inundation depth is the same, there is a possibility that there is a difference in tsunami force, so it is necessary to investigate the variance of the Tsunami force in the area where the inundation depth is large. In addition, it is also necessary to further study the variance of the flow velocity in numerical calculation.

Keywords: 2018 Sulawesi earthquake and tsunami, Landslide tsuanmi, Inundation simulation

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Tsunami Source of the 2018 Sulawesi Earthquake Estimated from Tsunami and InSAR Data

*Tungcheng Ho[1], Kenji Satake[1], Shingo Watada[1], Ray Y Chuang[2], Chih-Heng Lu[2]

1. Earthquake Research Institute,The University of Tokyo, 2. Department of Geography, National Taiwan University

An unexpected destructive tsunami struck Palu Bay after the Mw 7.5 strike-slip faulting earthquake in Sulawesi, Indonesia, on 28 September 2018. This tsunami impacted Palu city with 5 m to 10 m runup. The combined effects of the earthquake and tsunami caused a few thousand casualties. The tsunami waves were observed by two tide gauges in Sulawesi. One tide gauge at Pantoloan port in the bay recorded tsunami waves starting at about 5 minutes after the earthquake with amplitudes of up to 2 m. The other tide gauge at Mamuju port recorded tsunami waves after about 20 minutes with peaks of about 10 cm. To understand the mechanism of this unusual tsunami, we jointly utilized the tsunami records and InSAR data to analyze the source of this earthquake. The InSAR data observed by Sentinel-1 well resolved the offset of horizontal ground movement in the direction of the orbit azimuth along the fault strike. The data show a strike of about 358˚ in the north of the bay and about 352˚ in the south of the bay. The magnitude of the offsets varied from about 1 m in the north to up to 5 m in the south. Our simple modeling result suggests a slip of about 5 m at the north and a slip up to 8 m at the south to reproduce the observed tsunami waveform at Pantoloan. The southern asperity extended about 40 km from the bay with a width of about 16 km. Tsunami travel time analysis showed that the main tsunami arrived at the Mamuju station after about 45 minutes which means the first tsunami wave at this station was triggered by another source.

Keywords: Palu, tsunami, InSAR, Sulawesi Earthquake, source inversion

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Source Models of the Two September and December 2018 Indonesia Tsunamis Based on Spectral Analyses and Numerical Modeling

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Indonesia was struck by two tsunamis in September and December 2018 in Sulawesi and Sunda strait, respectively. The combined fatalities from the two events were ~2500 people which made 2018 as one of the deadliest year for Indonesia in terms of natural disasters. The 2018 twin tsunamis were unique because both events were not generated by typical earthquake-generated seafloor deformation. The Sulawesi tsunami in September 2018 was most likely associated with a large submarine landslide (Heidarzadeh et al., 2018, Pure & Appl. Geophys. 176) and the Sunda event was of volcanic origin. Therefore, there have been intense speculations in the scientific community about the origins and mechanisms of these twin tsunamis without any clear clues about the source mechanisms so far (February 2019). Our methodology here to address the puzzle of the 2018 twin tsunamis is analyzing the observed tide gauges records of both events and then applying numerical simulations. For the Sulawesi tsunami, two tide gauge records were analyzed belonging to Pantoloan (inside the Palu Bay) and Mamuju (outside the Palu Bay). Maximum tsunami trough-to-crest heights of 380 and 24 cm, were measured in Pantoloan and Mamuju, respectively. Spectral analyses of the tide gauge records revealed dominating wave periods of 3.6–4.4 and 10 min at the aforesaid stations, respectively. Spectral results indicate that the tsunami source dimensions should have been most likely in the range of 3.4–4.1 km and 32.5 km, for inside and outside of the Palu Bay, respectively. We were able to reproduce the two observed tide gauge records using numerical simulations. However, the maximum simulated runup was approximately 2 m which was less than the observed runup of 11 m. It is likely that a secondary source, i.e. submarine landslide(s), has contributed to the tectonic source of the tsunami. We identify the southern part of the Palu Bay, around the latitude of -0.82°S, as the most likely location of a potential landslide based on our backward tsunami ray tracing analysis. For the Sunda tsunami, four tide gauges were analyzed revealing wave amplitudes in the range of 44-139 cm. The dominating period of the waves were ~7 min which are shorter than tsunamis generated by earthquakes. We have considered several landslide scenarios and conducted numerical modeling in order to reproduce the observed tsunami waves on the tide gauges and propose a source model for this tsunami.

Keywords: Tsunami, Indonesia, Sulawesi, Krakatoa Volcano

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Abrupt Large Uplift Caused by Volcanic Tsunami Earthquakes near the Kermadec Islands, New Zealand

*Osamu Sandanbata[1], Shingo Watada[1], Kenji Satake[1]

1. Earthquake Research Institute, the University of Tokyo

Abnormal non-double-couple (NDC) earthquakes are sometimes observed near volcanic or geothermal areas [e.g. Shuler et al., 2013, JGR], some of which generate large tsunamis despite their moderate seismic magnitudes, M5-6. The Torishima earthquakes are ones of the few examples and were attributed to a large crustal uplift associated with some volcanic activity at a submarine caldera edifice on Izu-Bonin Ridge [Fukao et al., 2018, Sci. Adv.; Sandanbata et al., 2018, PAGEOPH]. This type of earthquakes therefore can be regarded as "volcanic tsunami earthquakes."

Another series of volcanic tsunami earthquake were observed near the Curtis and Cheeseman Islands, parts of the Kermadec Islands, north of New Zealand, on 17 Feb 2009 and 8 Dec 2017 (UTC). Tsunamis were recorded at tide gauges and ocean bottom pressure gauges with a maximum amplitude of ~40 cm. The two earthquakes are remarkably similar in seismic magnitudes (M~6.0), focal mechanisms (dominant NDC components), centroid locations (gap of ~10 km) and observed tsunami waves.

In order to investigate their tsunami sources, we numerically solved two-dimensional Boussinesq-like equations with the simulation code, JAGURS [Baba et al., 2015, PAGEOPH]. We first located their source region in the vicinity of the Curtis and Cheeseman Islands, by assuming Gaussian-shaped sea-surface uplifts at 9 locations. We then conducted the tsunami waveform inversion with Green’s functions computed from cosine-tapered uplift distributed around the islands. The estimated tsunami source has a large sea-surface uplift concentrated just over a bathymetric depression that is a characteristic structure of calderas. This suggests a large uplift on seafloor was caused by the earthquakes associated with a volcanic activity of the submarine caldera.

Large uplift events called “resurgence” have been observed at calderas in nature and experiments, which are often attributed to reactivation of ring faults due to overpressure of a magma reservoir [e.g. Acocella et al., 2001, JVGR]. We modeled crustal deformation of a caldera with an interacted system of a ring-fault structure and a shallow sill-like magma reservoir [Liu et al., 2017, AGU Fall Meeting]. Our modeling suggests that the system can cause a large uplift concentrated just over the caldera. The uplift also reproduced tsunami waves similar to the observations, while the gap between seismic and tsunami magnitudes can be explained qualitatively. We therefore suggest that a ring-fault reactivation due to overpressure in a sill-like magma reservoir as a possible mechanism of the earthquakes and their resultant tsunamis.

Keywords: volcanic earthquake, volcanic tsunami, volcanic tsunami earthquake, caldera, tsunami, submarine volcano

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Adaptive tsunami waveform inversion for estimating coseismic vertical displacements and slip distribution

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We developed an advanced two-step tsunami source inversion method with adaptive Green's functions by applying an optimization and a reciprocity principle (Mulia et al., 2018 JGR). In the first step, the method reconstructs the sea surface displacement from observed tsunami waveforms based on a superposition of Gaussian-shaped unit sources. Here, we optimize the unit source locations that give the best fit of waveforms to observations. This leads to non-equidistantly distributed unit sources, in which the synthetic waveforms from such sources to the observation points are generated using the reciprocity principle to save computational efforts of Green's functions. In the second step, the reconstructed sea surface displacement is used to estimate the slip on a finite fault plane. We also optimize the fault parameters that produce the closest displacement pattern to the first step result. Therefore, our method provides best fitting of waveforms and optimum fault parameters with automation for the process. The current method improves our previous studies, in terms of the construction of tsunami Green's functions using the reciprocity principle and determination of fault parameters through the optimizations.

We tested the proposed method using tsunami data of the 2004 Kii Peninsula, Japan event generated by an M_w 7.4 intraplate earthquake. Our result revealed a maximum initial displacement of approximately 0.5 m with the uplift region extended northwest to the epicenter. This value is slightly higher than that of most source models by the previous studies (e.g. Baba et al., 2005 EPS, Satake et al., 2005 EPS), but yields more accurate tsunami waveforms, particularly at the later phase of waveform recorded at a Global Positioning System buoy station off Cape Muroto. In terms of fault slip distribution, our model produced a maximum slip of 2.1 m, located at the uplift region of the coseismic displacement. Furthermore, the shallow fault depth resulted from our simulation is consistent with the more reliably relocated aftershock distribution by Bai et al. (2006 EPS).

Keywords: Tsunami, Inversion, Optimization

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Real-time tsunami prediction in a coastal zone, using a superposition of Green’ s function

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Recently, S-net (Seafloor observation network for earthquakes and tsunamis along the Japan Trench) and DONET 1 & 2 (Dense Oceanfloor Network system for Earthquakes and Tsunamis) are installed off the Pacific Ocean, Japan by NIED (National Research Institute for Earth Science and Disaster Resilience) and JAMSTEC (Japan Agency for Marine-Earth Science and Technology); therefore, real-time tsunami forecasting methods using directly tsunami data observed in oceanfloor are proposed (e.g. Yamamoto, 2016; Tanioka, 2018). In this study, focusing on the immediacy and the robustness of tsunami forecasting, we investigated real-time tsunami prediction method in a coastal zone, using a superposition of previously calculated Green’ s function.

In this method, we divide the entire source area of tsunami into element sources (for example, 50 km x 50 km), and we, in advance, calculate the Green’ s function to a coastal point for the unit tsunami water level (1 m) in the element source. Assuming that the tsunami water level is the same within the element source when a tsunami occurs, we the Green’ s function to the element source –the coastal point for the maximum value of the tsunami water level observed at one point in the element source. By applying this to all the divided element sources and superimposing these Green’ s functions, we can obtain the tsunami water level in a coastal zone for the entire source area. Comparing the result predicted by this method to a tsunami simulation result simulated from source model proposed by the Cabinet Office, Government of Japan, for the 2011 off the Pacific coast of Tohoku earthquake, we confirmed that two results are in good agreements.

Moreover, to use the amount of tsunami water level in the source area due to heterogeneous fault rupture, we investigated the possibility to replace the time series of tsunami data observed at a point in the element source with the amount of tsunami water level within the element source area. We confirmed that the time series of tsunami data can be used for real-time tsunami prediction using a superposition of Green’ s functions by appropriately estimating the time when the tsunami propagates within the element source.

Keywords: Real-time tsunami prediction, Green’ s function, Superposition, 2011 off the Pacific coast of Tohoku earthquake

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[J] Oral | H (Human Geosciences)：H-RE Resource and Engineering Geology

Tue. May 28, 2019 3:30 PM - 5:00 PM JST | Tue. May 28, 2019 6:30 AM - 8:00 AM UTC | 301B 3F

[H-RE17] Application of earth science data towards the renewable energy field

convener:Hideaki Ohtake(National Institute of Advanced Industrial Science and Technology), Fumichika Uno(National Institute of Advanced Industrial Science and Technology), Teruhisa Shimada(Graduate School of Science and Technology, Hirosaki University), Daisuke Nohara(Central Research Institute of Electric Power Industry), Chairperson:Hideaki Ohtake(National Institute of Advanced Industrial Science and Technology (AIST))

Renewable energy (RE) penetration is increasing dramatically in the world. RE power generations have made their presence felt in an electric power system. However, it is a challenge for RE to be stable power sources due in part to natural variability of RE and the distributed resources. For effective use of RE, a combination between power resources and energy storage technologies (e.g., pumped-storage power generation, storage battery system and electric vehicle) is required to provide power and energy flexibility. Therefore, we need to understand the amount of REs, causes of variation, and the predictability of power output. Then, enormous and diverse observation data sets and modeling technologies from earth science field should be analyzed and applied to power energy field to achieve easy use of earth science databases.
 This proposed session needs your presentation from the whole of RE fields (solar power, wind power, geothermal power, tidal power, wave power and biomass power generations). Our goal of this session is to exchange views with various researchers between RE field and earth science field (e.g., usage-trends of earth science datasets for RE field, the subjects in hand, earth science datasets availability, and cooperation between RE and earth science fields, and so on).

3:30 PM - 3:55 PM JST | 6:30 AM - 6:55 AM UTC

[HRE17-01] Application of geological dara to ground source heat pump systems with special reference to thermal conductivity of geological materials

★Invited Papers

*Masakatsu SASADA[1] (1.Geo-Heat Promotion Association of Japan)

3:55 PM - 4:10 PM JST | 6:55 AM - 7:10 AM UTC

[HRE17-02] Use of groundwater in the Nishi-Osaka Area and its activities.

*Naoko Kitada[1], Hiroko Ito[1], Tomoo Echigo[1], Teruyuki Fujiwara[1], Makoto Nishigaki[2] (1.Geo-Research Institute, 2.Okayama University)

4:10 PM - 4:25 PM JST | 7:10 AM - 7:25 AM UTC

[HRE17-03] Improvement of prediction of wind power ramp by using monitoring data

*Shinji Kadokura[1], Daisuke Nohara[1], Masamichi Ohba[1], Atsushi Hashimoto[1], Keisuke Nakao[1], Yasuo Hattori[1], Takeshi Watanabe[1], Hiromaru Hirakuchi[1] (1.Central Research Institute of Electric Power Industry)

4:25 PM - 4:40 PM JST | 7:25 AM - 7:40 AM UTC

[HRE17-04] **A study of the use of meteorological data for energy management**

*Hideaki Ohtake[1], Takashi Oozeki[1], Junichi Imura[2] (1.National Institute of Advanced Industrial Science and Technology, 2.Tokyo institute of technology)

4:40 PM - 5:00 PM JST | 7:40 AM - 8:00 AM UTC

Discussion

Application of geological dara to ground source heat pump systems with special reference to thermal conductivity of geological materials

*Masakatsu SASADA[1]

1. Geo-Heat Promotion Association of Japan

Ground source heat pump systems are getting popular in Japan. Ground source means low temperature energy in geological units shallower than 200 meters below the surface. A geothermal heat pump system is much more efficient than a conventional air source heat pump system. A ground source heat pump system also contributes to mitigating a heat island phenomenon in large urban areas like Tokyo, because it does not emit exhaust heat outside in summer.
Effective thermal conductivity is one of the most important parameters to design ground source heat pump systems. Thermal response tests result in effective thermal conductivity of geological units under the building site. The reference values of thermal conductivity for several geological units are also available to building designers.
The regulation of Energy Conservation Standards came into effect in April 2016. Under the regulation annual primary energy consumption for every type of building is standardized. An owner of building has to submit building certification application with data of annual energy consumption calculated by Web Program of Building Research Institute. When ground source heat pump systems are installed in the building, the thermal conductivity of the building site must be input the Web Program for calculation of annual primary energy consumption.
Thermal response test is the best method to estimate the thermal conductivity of the geological units under the building site. However, it is not always applied to residential houses and small size buildings. The reference data of thermal conductivity are usually applied to them. Since geological units are so diverse in the Japanese Islands that much more measured data of thermal conductivity are required for reference database.

Keywords: Ground source heat pump, Effective thermal conductivity, Thermal response test

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Use of groundwater in the Nishi-Osaka Area and its activities.

*Naoko Kitada[1], Hiroko Ito[1], Tomoo Echigo[1], Teruyuki Fujiwara[1], Makoto Nishigaki[2]

1. Geo-Research Institute, 2. Okayama University

On the west side of Osaka plain, several clay layers accompanying repeated sea level change accumulate in layers, and the gravel layer between the clay layers forms a submerged aquifer where abundant underground water resides. On the other hand, due to the severe ground subsidence caused by the massive pumping up of factory water in the 1960s, pumping is currently strictly regulated. However, in recent years, especially in Osaka city, consideration is being made on effective utilization of groundwater, such as the promotion of underground water use project as regenerative thermal energy.

Therefore, we conducted survey of water level, water temperature, and water quality using existing observation holes near Nakanoshima from around Osaka Station for the purpose of acquiring background data on the properties of groundwater at the present time. The aquifer covered in this study is a sand gravel layer (1st aqueduct layer: Dg1) distributed beneath the clay layer (Ma13) of the Holocene, and the gravel layer (the second caught aquifer: Dg 2) distributed under the clay layer (Ma12). Regarding the water quality, we analyzed the composition of the principal components etc. for groundwater sampled 4 times in total in June, September, November 2016 and January 2017. As a result, it was revealed that both Dg 1 and Dg 2 were reductive and showed a Na - Cl type water quality composition, especially Dg 1 had a higher salt concentration.

Keywords: Borehole Database, goundwater, gravel layer

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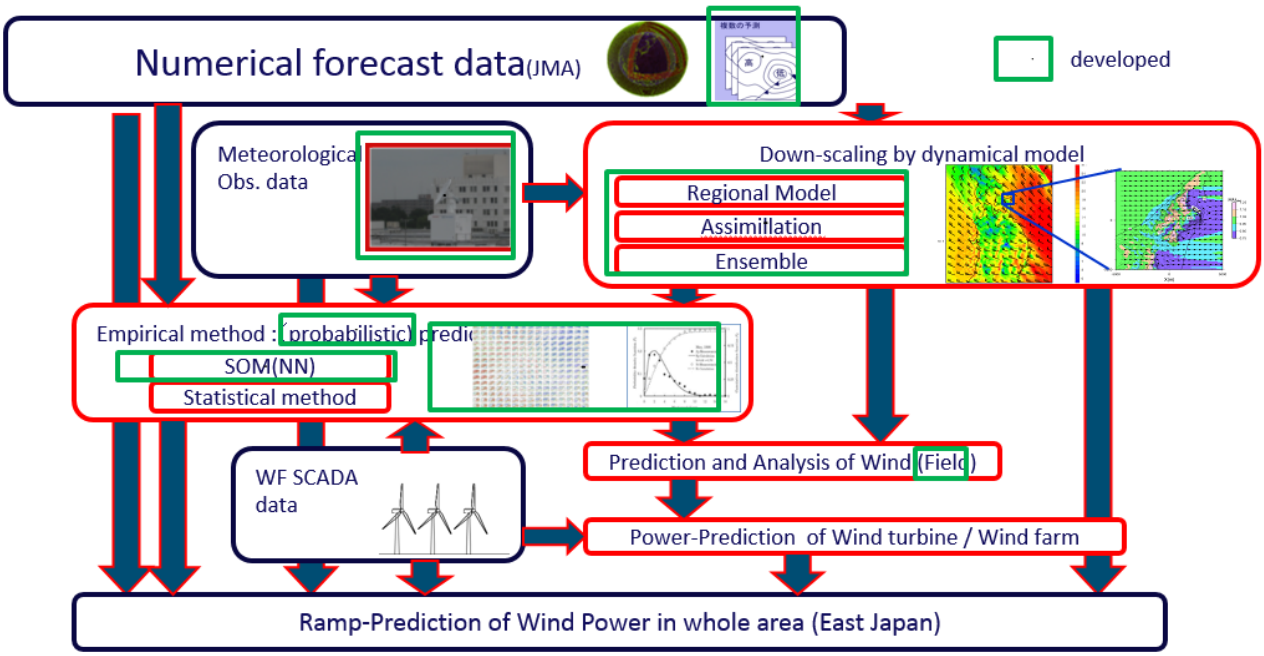
Improvement of prediction of wind power ramp by using monitoring data

*Shinji Kadokura[1], Daisuke Nohara[1], Masamichi Ohba[1], Atsushi Hashimoto[1], Keisuke Nakao[1], Yasuo Hattori[1], Takeshi Watanabe[1], Hiromaru Hirakuchi[1]

1. Central Research Institute of Electric Power Industry

Introduction of power generation by renewable energy such as photovoltaics(PV) and wind power (WT) is worldwidely progressing. Since PV and WT power generation are markedly fluctuated due to the change of the wheather, there is concern about the stability of the electric power system. Therefore, we have been developing a prediction method of wind power generation output to contribute for the stabilization of electric power system. In this method, the numerical forecast value provided by the Japan Meteorological Agency is downscaled using the weather model WRF and CFD model to predict the wind speed at the wind turbine, and the power output is predicted using the power curve. By adding the generated power output for each wind turbine obtained, the total output of the area is obtained. In this study, we have improved the prediction of wind speed and power generation output by using the monitoring data for each wind turbine, by making correction based on multiple regression and by using empirical power curve. Furthermore, we have corrected the accuracy of the area total power output by sequentially correcting the windfarms where data for each windmill is not acquired. In addition, by performing multiple regression on the amplitude of the output change, we have improved the supplementation rate of the wind power generation rapid change henomenon, ramp.

Keywords: Wind power output prediction, wind power ramp, wind power generation, SCADA, Weather forecast



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A study of the use of meteorological data for energy management

*Hideaki Ohtake[1], Takashi Oozeki[1], Junichi Imura[2]

1. National Institute of Advanced Industrial Science and Technology, 2. Tokyo institute of technology

Recently, a large amount of photovoltaics (PV) power systems (approximately 45 GW as of June 2018) have been connected to a power grid in Japan. Electric power supply with PV power generation exceed electric power demand in a power grid. For safety control of an energy manage system (EMS) with variable PV power generation, optimal use of other power plants (thermal power plants etc) and battery systems will be required in a future energy network (Fig.1). PV power monitoring and forecasts based on a meteorological data can be useful information for an optimal control of other power systems. In our research group (referred as a HARPS in a JST CREST project), we developed a communication tool between meteorology and EMS research fields. Impacts of meteorological data have been also investigated in an EMS (e.g., optimal control of electrical power systems and battery systems) under large PV installations. Furthermore, real time monitoring of regional PV power estimation have been also tried using a new geostationary satellite, Himawari 8/9. In this presentation, we will introduce research topic of meteorological data in the EMS field.

Keywords: photovoltaic, energy manage system, meteorological data



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[J] Oral | H (Human Geosciences)：H-TT Technology & Techniques

Tue. May 28, 2019 9:00 AM - 10:30 AM JST | Tue. May 28, 2019 12:00 AM - 1:30 AM UTC | 301B 3F

[H-TT22] New Developments in Shallow Geophysics

convener:Kyosuke Onishi(Public Works Research Institute), Kunio Aoike(Oyo corporation), Keisuke Inoue(National Agriculture and Food Research Organization), Tishiyuki Yokota(National Institute of Advanced Industrial Science and Technology), Chairperson:Toshiyuki Yokota, Keisuke Inoue

The session of shallow geophysics calls many research contributions on geophysical exploration techniques for the near surface. Our target depth is strictly restricted in the depth zone from 5 cm to 30 m (or from 2 in to 100 ft) below the surface of the ground. It may be the closest unknown territory for human society and advanced societies cannot have controlled yet to avoid disasters caused by dynamics in the shallow near surface. Peoples require techniques to manage levee, landslide and earth constructions also knowledge to control groundwater, liquefaction and soil pollution. The near surface has many geotechnical, environmental and hydrogeologic problems.
Major survey techniques are surface wave method, electric exploration, ground-penetrating radar and land streamer, but any methods will be discussed if your target is located in the specified depths. This session welcomes to discuss laboratory tests and rock physics for unconsolidated porous media in the vadose zone. Also, we will welcome not only cutting-edge technologies but also classic theory, if the knowledge is useful for human living.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[HTT22-01] High-frequency seismic reflection measurements for imaging internal structure of a sabo dam damaged by a huge debris flow

*Tomio INAZAKI[1], Hiroshi Kisanuki[2], Takanori Ogahara[1], Takeshi Shimizu[1], Naoki Fujimura[1] (1.Public Works Research Institute, Tsukuba Central Institute, 2.PWRI (Present address: OYO Corporation))

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[HTT22-02] Development and applications of 3D ambient noise tomography

*Chisato Konishi[1], Koichi Hayashi[1] (1.OYO Corporation)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[HTT22-03] An Attempt to Estimate the Level of Non-confind Groundwater by Earthing Resistance (I) - Outline of Theory -

*Kunihiro Ryoki[1] (1.Polytechnic University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[HTT22-04] Experimental and Theoretical Studies for Seafloor Survey by Ground Penetrating Radar

*Jun Sonoda[1], Tomoyuki Kimoto[2] (1.National Institute of Technology, Sendai College, 2.National Institute of Technology, Oita College)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[HTT22-05] Evaluation of the 3-D Distribution of Fractures in a Rock Mass using Directional Borehole Radar Data from a Horizontal Borehole

*Kazuhiko Masumoto[1], Tomoaki Matsushita[2], Suguru Shirasagi[1], Takashi Ueki[3], Shinsuke Karasawa[3], Daiki Makino[3], Kazushige Wada[4] (1.Kajima Technical Research Institute, 2.Kajima Corporation, 3.Matsunaga Geo-Survey Co., Ltd., 4.Mitsui Mineral Development Engineering Co., Ltd.)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[HTT22-06] Automatic Detection of Deteriorated Concrete Bridge Deck using 2 GHz Horn Antennae

*Kunio Aoike[1], Shogo Tanaka[2], Naoto Takase[1], Akio Matsuyama[1], Masaya Yamauchi[1], Yoshinori Uno[1] (1.OYO Corporation, 2.Professor Emeritus of Yamaguchi Univ.)

High-frequency seismic reflection measurements for imaging internal structure of a sabo dam damaged by a huge debris flow

*Tomio INAZAKI[1], Hiroshi Kisanuki[2], Takanori Ogahara[1], Takeshi Shimizu[1], Naoki Fujimura[1]

1. Public Works Research Institute, Tsukuba Central Institute, 2. PWRI (Present address: OYO Corporation)

We conducted high-frequency, high-resolution seismic reflection measurements on the rear face of a sabo dam which had been damaged by a huge debris flow attack in July 9, 2014. The debris flow swept away the top 5 m part of the dam and segmented the dam body into several blocks associated with horizontal cracks. Estimated surface dislocation was at most 20 cm.
iezoelectric type high-frequency accelerometers were pasted on the surface at 10 cm intervals, and manual hit using a rock hammer was employed for generating high-frequency signals. High-performance data acquisition systems were also employed to obtain high-resolution and high sampling seismic data. Minimum sampling rate was set to 2 microseconds. We set 5 horizontal lines and 1 vertical line on the rear surface during December 2014 to April 2016. Relative height was about 5 m between the first and the last horizontal line. Assuming the RMS velocity to the constant value to 2,500 m/s, which was the typical S-wave velocity of concrete, we processed the dataset to reconstruct migrated depth sections. Clear flat reflection events appeared at 10 m and 7 to 5 meters. The former or deeper reflection event was correlated to the frontal face of the dam. The latter events were possible to be correlated to a horizontal joint which had dislocated the dam body caused by the debris flow attack. A gently dipping reflector, which started from the point just the survey line intersected a vertical fracture, was recognized in the lowest depth section.
In conclusion, field measurements demonstrated that high-frequency and high-resolution seismic reflection surveying was helpful to image the internal fracture distributions in a damaged concrete dam body.

Keywords: Sabo dam, debris flow, seismic reflection survey, high-frequency accelerometer

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Development and applications of 3D ambient noise tomography

*Chisato Konishi[1], Koichi Hayashi[1]

1. OYO Corporation

In a microtremor array measurement, receivers are usually placed on a center and the circumference of a circle or a center and the vertexes of a triangle to observe ambient noise from omni-directions for 1D S-wave velocity delineation. We developed 2D/3D ambient noise tomography as an extension of the normal microtremor array method, and we have conducted several field experiments. Cable-less seismographs including GPS clock, AD converter, battery, and SD card memory are used for the survey, and that makes a receiver array deployment flexible. Additionally, the estimated phase velocity is not affected by a specific direction of the ambient noise because several tens of receivers are deployed in X and Y directions on the ground surface. Furthermore, high quality data can be obtained due to a stacking of the multiple receiver pairs even if the observation time is limited.
CMP-SPAC analysis that is a modification of the CMPCC analysis in the 2D surface wave method is used in the 3D ambient noise tomography. SPAC coefficients are calculated for all possible pairs of the receiver arrays, and these are stacked and sorted by receiver separations at each CMP bin to make CMP-SPAC gathers. The frequency versus phase velocity image is obtained by comparing the CMP-SPAC gather with Bessel function. Dispersion curve is obtained from the frequency versus phase velocity image at all CMPs. By the same procedure to the 2D surface wave method, 1D S-wave velocity structure can be estimated by an inversion based on the non-linear least square method. And then 3D S-wave velocity is created by interpolating the 1D velocity structure at all CMPs. The computation time for this analysis is comparable to the 2D surface wave method, so we can easily obtain the 3D S-wave velocity.
Several field experiments have been conducted and the results almost agree with the existing geological information and other geophysical survey results. We found that the accuracy of the estimated S-wave velocity structure is lower around the edge of the survey area, and the estimated phase velocity around the edge might be affected by the direction of the ambient noise due to the limited receiver pairs. Nevertheless, we can eliminate this issue by extending the survey area, which is a usual countermeasure in most of geophysical surveys. Another finding is that even if the ambient noise does not include high frequency or short-wave length, we can investigate the shallow subsurface by adding a manmade vibration around the receiver array easily.

Keywords: Microtremor, S-wave velocity, 3D exploration

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An Attempt to Estimate the Level of Non-confind Groundwater by Earthing Resistance (I) - Outline of Theory -

*Kunihiro Ryoki[1]

1. Polytechnic University

1. Introduction

In the Musashino district of the Kanto plain, some loam layers for several meters with good permeability cover the Musashino gravel layer. The groundwater under no pressure here uses the Musashino gravel layer as the main aquifer. However, the seasonal recharge may raise the water level to the upper loam layer. The impermeable layer, which has a clay-rich lens shape, is often present in the loam layer (Kakuda, 2017). As the perchied water level rises to near the surface of the earth, flood damage is brought about occasionally (for example, Tokyo Metropolitan Geological Survey Association, 2000). Therefore, observation of such groundwater level fluctuation at many points is required to prepare for flood damage. Ohshima *et al*. (2015) examined the stability of these earthing resistances, in order to use the housing foundation as the earthing electrode to ensure safety for the electrical equipment, using a small model foundation of about 2 m ×2 m or the building foundation of a real scale housing. According to this, it was shown that there is a seasonal fluctuation in earthing resistance of about 200% in the small model or about 20% to 30% in the real scale. It is thought that this fluctuation is caused by the characteristic accompanying the temperature change. On the other hand, the observations of groundwater level at the wells around Inokashira pond, from the beginning of December 1988 until March 2001, showed that the peak-to-peak annual change of 2 m to 3 m (Kokubu, 2005). These variation in the groundwater level makes to change the earthing resistivity, and it becomes a factor of changing the earthing resistance of the electrode (Ryoki, 2019). In this memoir, the conseption is introduced, and then, it has been proposed that a method for estimating the level, based on the contribution of the variation of the groundwater level to the earthing resistance.

2. Theory

Consider the point current I flowing from the origin O to the ground of the semi-infinite medium with the resistivity ρ, the potential V_r, that is created on the surface of the distance r, is $V_r=\rho I/2\pi r$. When the hemispherical metal electrode of the radius a, which instead of the point current source, is grounded, the potential in the metal becomes equal to the potential $V_a=\rho I/2\pi a$ on the surface. Therefore, R, as the resistance of the origin O (*eq*. the resistance value of the hemispherical metal electrode) viewed from infinity, is expressed as follows; $R=V_a/I=\rho/2\pi a$. This is the earthing resistance of the hemispherical metal electrode.

Next, let us consider the ground potential when the earth is regarded as a horizontal two-layers structure. According to the mirror image method (Figure 1) shown by Hagiwara (1951), the potential $V_{0(r,\,z=0)}$ on the ground surface, z=0, at the distance r made by the point current source is as follows; $V_{0(r,\,z=0)}=\rho_1 I(1/r+2\Sigma^{\infty}_{k=1}(Q^k/(r^2+(2kd)^2)^{1/2}))/2\pi$. Where Q is the reflection coefficient with respect to the current density; $Q=(\rho_2-\rho_1)/(\rho_2+\rho_1)$. ρ_1 and ρ_2 are the resistivities of the first layer and the second layer, respectively. d is the layer thickness of the first layer. Now, consider R_a, the earthing resistance of the earth electrode on the two-layer structure, as in the case of Wenner's method which is a vertical electrical prospecting, letting $r=a$; $R_a=V_a/I=\rho_1(1/a+2\Sigma^{\infty}_{k=1}(Q^k/(a^2+(2kd)^2)^{1/2}))/2\pi$. This is able to call the equivalent earthing resistance. Consider the ratio of R_a to the earthing resistance R_1 which is in the semi-infinite medium consisting only of the first layer of resistivity ρ_1; $R_a/R_1=1+2\Sigma^{\infty}_{k=1}(Q^k/(1+4k^2(d/a)^2)^{1/2})$. This is able to call the apparent resistivity with respect to the equivalent earthing resistance.

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Fig. 2 shows the relationship between d/a and R_a/R_1, here, d: thickness of the first layer, a: radius of the hemispherical conductive electrode. Shown in Fig. 2, it is able to understand that the equivalent earthing resistance takes a change when the groundwater level varies. Therefore, it is able to expect that variations in groundwater level is sensed by monitoring fluctuation of earthing resistance.

3. Future plans

In order to verify the method introduced here, the observation well will be drilled, and the fluctuation of the groundwater level *etc.* will be measured there. Then, the earthing resistance of the earth electrode for safety of electrical equipment will be continuously measured. The planned observations are (1) the groundwater level, (2) also the temperature, (3) also the electrical conductivity, (4) the apparent resistivity of the earth, and (5) the earthing resistance. Preliminary measurement results will be shown at the JpGU meeting.

Keywords: electrical equipment, Musashino district, loam layers, perchied water, flood damage, equivalent earthing resistance

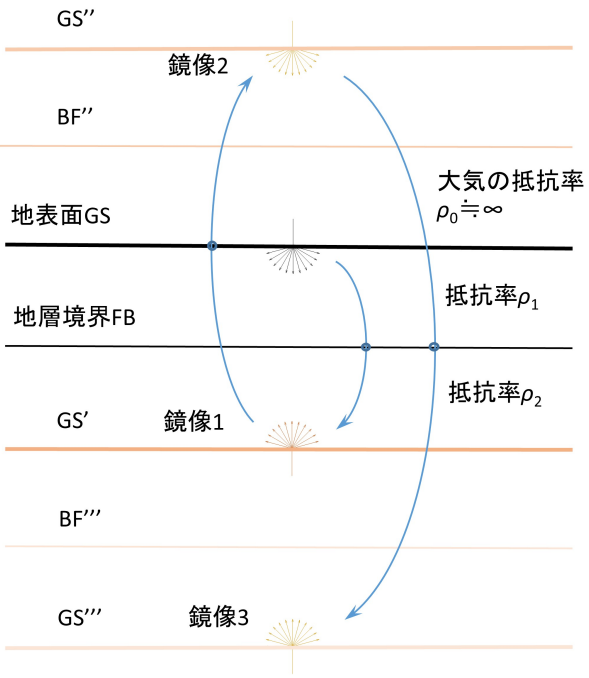


図1　鏡像法の概念図 (領木, 2019).
Fig. 1. Conceptual diagram of the mirror imaging method (Ryoki, 2019).

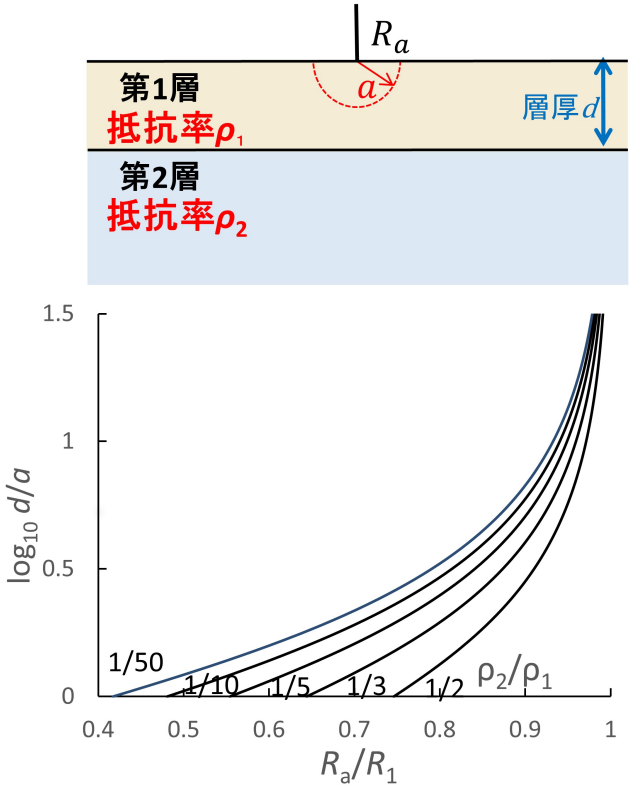


図2　等価接地抵抗と第1層の層厚との関係　それぞれ，半無限媒質での接地抵抗と半球導体電極の半径で基準化してある (領木, 2019).
Fig. 2. Relationship between the equivalent earthing resistance and the 1st layer thickness. Parameters are nor-malized by the earthing resistance in the semi infinite medium and the radius of the hemi-spherical conductor electrode, respectively (Ryoki, 2019).

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Experimental and Theoretical Studies for Seafloor Survey by Ground Penetrating Radar

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The electromagnetic wave (EM) do not propagate in the seawater because of high conductivity. In recent, the ultrasonic wave is widely used in the sea, such as the fish-finder, the side-scan sonar, and so on. We have used the ground penetrating radar (GPR) by several hundred MHz to search missing persons and rubbers in the sea after the tsunami caused by the Great East Japan earthquake. In this study, we have studied the under seawater prospecting using 350/400 MHz GPR in Hiroura Bay, Natori city, in Isohama fisher port, and off the coast of Sakamoto, Yamamoto town, Miyagi prefecture. At first, frequency characteristics of complex permittivity of several seawater samples by the time domain reflectometry (TDR), and conductivity in the depth of seawater by the conductivity temperature depth profiler (CTD) have been shown. Also, it is shown that the reflected wave from several objects at the about 10 meters depth has been observed using the 350 MHz GPR. Finally, the EM wave propagation in the seawater has been analyzed using the FDTD method with the graphics processing unit (GPU).

Keywords: ground penetrating radar, seafloor survey, FDTD

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Evaluation of the 3-D Distribution of Fractures in a Rock Mass using Directional Borehole Radar Data from a Horizontal Borehole

*Kazuhiko Masumoto[1], Tomoaki Matsushita[2], Suguru Shirasagi[1], Takashi Ueki[3], Shinsuke Karasawa[3], Daiki Makino[3], Kazushige Wada[4]

1. Kajima Technical Research Institute, 2. Kajima Corporation, 3. Matsunaga Geo-Survey Co., Ltd., 4. Mitsui Mineral Development Engineering Co., Ltd.

Evaluation of the distribution of fractures in a rock mass ahead of a tunnel face is required for safe and reasonable tunnel excavation. To evaluate not only the position of fractures, but also their inclination before tunnel excavation, a directional borehole radar may be a suitable technique. A directional borehole radar can determine the inclination of fractures with a single pilot boring because it can estimate the arrival direction of the waves reflected by fractures, which are measured by a dipole array antenna with multiple elements. This study first examined the application of a directional borehole radar to investigate within a horizontal pilot boring. Next, field test using the directional borehole radar was conducted in a horizontal borehole drilled in the sidewall of a tunnel in order to confirm the applicability of the directional borehole radar for evaluating the three-dimensional distributions of fractures.

To apply the borehole radar for horizontal pilot boring in a tunnel, a casing is needed to prevent collapse of the borehole. Because the steel casing pipe which is typically used for pilot borings cannot be used for radar measurements, the applicability of a glass fiber reinforced plastic (GFRP) tube was verified as the borehole casing in this study. As the results of the experimental study, it could be concluded that GFRP tubes with steel joint couplers can be used as a borehole casing for measurements with radar.

Next, a directional borehole radar was applied to the survey of fractures in granite in a horizontal borehole drilled in the sidewall of a tunnel in order to confirm its applicability for evaluating the three-dimensional distribution of fractures. The results indicated that the strike and dip of each reflector estimated by the directional borehole radar measurements approximately corresponded to the fractures observed with a borehole scanner. Therefore, it was concluded that a survey with a directional borehole radar in a horizontal borehole could evaluate the three-dimensional distribution of fractures surrounding the borehole.

Keywords: borehole radar, horizontal borehole, distribution of fractures

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Automatic Detection of Deteriorated Concrete Bridge Deck using 2 GHz Horn Antennae

*Kunio Aoike[1], Shogo Tanaka[2], Naoto Takase[1], Akio Matsuyama[1], Masaya Yamauchi[1], Yoshinori Uno[1]

1. OYO Corporation, 2. Professor Emeritus of Yamaguchi Univ.

In 10 years, about 40% road bridges in Japan will become over 50 years old after the construction. Although many inspections have been conducted to the aged road bridges, the upper part of the bridge deck is impossible to inspect visually because of the asphalt concrete layer covering the bridge decks. It is becoming an important problem that slab deterioration is often generated in the upper part of the aged concrete bridge deck. Thus, it is becoming urgently necessary for the deterioration of the aged concrete bridge deck to be detected and repaired to elongate the life of the bridge. Ground penetrating radar (GPR) mounted on a vehicle is one of the effective non-destructive methods, which enables us to inspect the deterioration under no traffic control. A high pulse resolution is required to the GPR to detect anomalies beneath the asphalt concrete layer of the thickness of about 8cm. Adding to it, both a high scan rate in data acquisition and a safe mounting way of the GPR on vehicle are required to achieve the accurate and high-resolution inspection with a high speed traveling of the inspection cars. We adopted the horn antenna, produced by GSSI, whose central frequency is 2 GHz. The antenna can detect reflection waves from the boundary between the asphalt layer and the concrete bridge deck, and also can distinguish them from the surface reflection wave of the asphalt surface. SIR-30 type radar system having 8 channels enables us to realize 989 scans per second with 512 samples, thus it can realize the inspection under the vehicle speed up to 80km/h. We also mount the GPR antennae to the height of 45cm (i.e., lift off) from the road surface. This mounting is important for safe traveling of the inspection vehicle. 8 antennae are mounted on a boat trailer towed by vehicle and aligned in the transverse line to the moving direction. It allows us to scan about 1.7m width at one time. For the inspection of the deterioration of the concrete bridge deck, we developed an automatic processing system. This method predicts a received signal by using two empirical reflection waveforms. We acquired in advance surface reflection waveform and asphalt bottom reflection waveform from an experiment using a real size physical model. We determined the arrival time and the amplitude for each empirical waveform by matching the linear combination of the two empirical waveforms and the actual received signal. To visualize the anomaly distribution of the concrete bridge deck and to inspect the deterioration, we made three types of 2 dimensional maps on thickness of asphalt layer, relative reflectivity at the asphalt bottom, and the fitness between the received and the predicted waveforms. As the results, we could successfully detect the anomalies and delineate their extents. Fig. 1 shows an example of the processing results on a concrete bridge deck model which simulated slab deterioration. We have a plan to continue to modify and update the proposed method by applying the method to real road bridges as a future work.

Keywords: Ground Panetrating Radar, horn antenna, bridge deck

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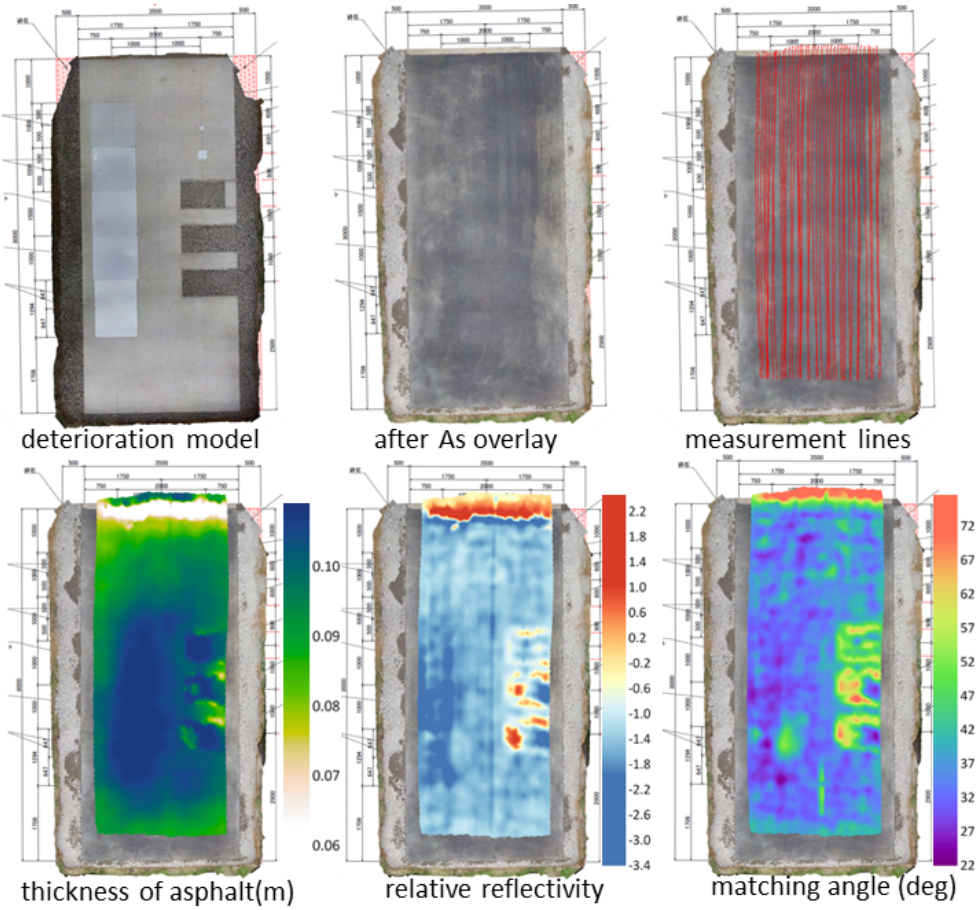


Fig. 1 Simulated deterioration model of concrete bridge deck and the results of automatic processing

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[J] Oral | S (Solid Earth Sciences)：S-GD Geodesy

Tue. May 28, 2019 1:45 PM - 3:15 PM JST | Tue. May 28, 2019 4:45 AM - 6:15 AM UTC | 303 3F

[S-GD01] Gravity and Geoid

convener:Tokuro Kodama(Geospatial Information Authority of Japan), Daisuke Oka(Geological Survey of Hokkaido, Environmental and Geological Research Department, Local Independent Administrative Agency, Hokkaido Research Organization), Chairperson:Toshiyuki Tanaka, Takahito Kazama

Recent precise gravity measurements lead to advances in many kinds of applications, e.g., geophysical exploration of internal structure of the Earth and Moon, studies of earthquake, volcano, subsidence, landslide and tsunami, monitoring ice mass balance, and so on.
In this session, we call wide range of papers related to topics of gravity and geoid, including theory of gravity field, absolute/relative gravity measurements, data analysis of satellite gravity missions, and development of gravity sensors.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SGD01-01] Seasonal variation of gravity values at the Ishioka Geodetic Observing Station

*Akira Tomiyama[1], Tokuro Kodama[1], Shuichi Oomori[1], Yoshifumi Hiraoka[1], Toshihiro Yahagi[1] (1.GSI of Japan)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SGD01-02] Installation of the First Gravity Station in the Mount Fuji Research Institute, and the Phase-Free gravity measurement

*Ryo Honda[1], Yuichi Imanishi[2], Kazunari Nawa[3], Toshiyuki Tanaka[4], Tokuro Kodama[5], Akira Tomiyama[5] (1.MFRI, Yamanashi Prefectural Government, 2.ERI, University of Tokyo, 3.GSJ, AIST, 4.TRIES, ADEP, 5.GSI)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SGD01-03] Absolute gravity and GNSS measurements on bedrock outcrops in Dronning Maud Land, East Antarctica

*Takahito Kazama[1], Yuichi Aoyama[2], Yoichi Fukuda[1], Koichiro Doi[2] (1.Graduate School of Science, Kyoto University, 2.National Institute of Polar Research)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SGD01-04] Capability of ICA Method for separating GIA and Ice Mass Signals in Antarctica

*SHI TIANYAN[1], Yoichi Fukuda[1] (1.Graduate School of Science, Kyoto University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SGD01-05] Preliminary result of continuous observation with an iGrav superconducting gravimeter at the Teshikaga observatory, eastern Hokkaido, Japan

*Kazunari Nawa[1], Hiroaki Takahashi[2], Mako Ohzono[2], Kazumi Okada[2], Teruhiro Yamaguchi[2], Daisuke Oka[3], Noritoshi Okazaki[3], Ryo Honda[4], Hiroshi Ikeda[5] (1.National Institute of Advanced Industrial Science and Technology, 2.Hokkaido University, 3.Geological Survey of Hokkaido, 4.Mount Fuji Research Institute, 5.University of Tsukuba)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SGD01-06] On the anomalous temporal gravity change between VERA and F-net stations at Ishigakijima, Japan

*Kazunari Nawa[1], Yuichi Imanishi[2], Yoshiaki Tamura[3], Hiroshi Ikeda[4], Takeshi Kimura[5] (1.National Institute of Advanced Industrial Science and Technology, 2.Earthquake Research Institute, The University of Tokyo, 3.National Astronomical Observatory of Japan, 4.University of Tsukuba, 5.National Research Institute for Earth Science and Disaster Resilience)

Seasonal variation of gravity values at the Ishioka Geodetic Observing Station

*Akira Tomiyama[1], Tokuro Kodama[1], Shuichi Oomori[1], Yoshifumi Hiraoka[1], Toshihiro Yahagi[1]

1. GSI of Japan

Conventionally consistency between absolute gravimeters has been confirmed through the International Comparison of Absolute Gravimeters (ICAG) which is offered by the Comité International des Poids et Mesures (CIPM) with supports of the International Association of Geodesy (IAG). In order to extent the consistency to inside Japan, the Domestic Comparison of Absolute Gravimeters (DCAG) has been conducted by the Geospatial Information Authority of Japan (GSI) since 2002. Thanks to the opening of a new facility of GSI, named the Ishioka Geodetic Observing Station, the DCAG has been held there with inviting several domestic organizations which own absolute gravimeters. In order to evaluate validity of obtained data, it is necessary to collect data inside the Ishioka station and to examine influences of external factors. Therefore, we carried out periodic measurements using one of our FG5 absolute gravimeters for about one week every month throughout one year at the fundamental gravity point, “Ishioka FGS”, which is installed inside the Ishioka station. In this presentation, we will report the seasonal variation of gravity values obtained from our verification work.

Keywords: Absolute gravimeter, Seasonal variation

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Installation of the First Gravity Station in the Mount Fuji Research Institute, and the Phase-Free gravity measurement

*Ryo Honda[1], Yuichi Imanishi[2], Kazunari Nawa[3], Toshiyuki Tanaka[4], Tokuro Kodama[5], Akira Tomiyama[5]

1. MFRI, Yamanashi Prefectural Government, 2. ERI, University of Tokyo, 3. GSJ, AIST, 4. TRIES, ADEP, 5. GSI

Mount Fuji is an active volcano, the difficult situation is that we can’ t tell where the vent will open. Moreover, the eruption is thought to occur rapidly after the precursors such as grand deformations or increase of the seismic activities, because of its low viscosity magma. As a part of the volcano monitoring system, we are now constructing the gravity monitoring network. We are planning to install multiple continuous gravity monitoring stations. We installed the First Gravity Station in Mount Fuji Research Institute (MFRI) last year, where the absolute gravity value is measured by GSI. We are going to start the continuous observation in this station. Although low frequency events or tremors are observed sporadically, Mount Fuji is quiet at this point of time. So, the purpose of our observation at the beginning is to comprehend the precipitation and ground water effect, including snow melting effect in the spring time.

There is another interesting point for the gravity observation in Mount Fuji. The gravity difference between MFRI and the fifth station of the Yoshida trail is about 320 mGal, and the travel time between two points is about 30 minutes. It means that this is a good observation line for the verification of the gravimeters. Now we suggest the "phase-free" gravity measurement (https://phasefree.org/). The idea of "phase-free" is to eliminate the social phases (time, state) of normal times and disasters, so that goods or services normally used can be appropriately used at the time of disaster. If we continuously use the gravity observation line for the verification by various gravimeters in the normal time, that will be the important data for the volcano monitoring when the Mount Fuji is starting to prepare the eruption.

Keywords: Gravity, Mount Fuji, Volcano Monitoring, Verification of Gravimeter, Phase-Free

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Absolute gravity and GNSS measurements on bedrock outcrops in Dronning Maud Land, East Antarctica

*Takahito Kazama[1], Yuichi Aoyama[2], Yoichi Fukuda[1], Koichiro Doi[2]

1. Graduate School of Science, Kyoto University, 2. National Institute of Polar Research

The Antarctic ice sheet plays a significant role in the long-term global climate change, so the spatiotemporal variations in the Antarctic ice sheet should be precisely monitored to forecast future climate changes. The ice sheet variations can be detected as loading deformations of the solid Earth, which are composed of the elastic deformation due to the present-day ice melting and the viscoelastic deformation due to the past ice melting. These effects can be separated by measuring both of the crustal deformation and land gravity variation, but enough gravity data has not been collected in the Antarctic region as of now. In order to understand more about the ice sheet variations in terms of solid-earth geophysics, land gravity data should be repeatedly measured at more sites in the Antarctic region.
We therefore collected new absolute gravity data using the FG5-210 absolute gravimeter at two stations located on bedrock outcrops in Dronning Maud Land, East Antarctica in November-December 2018. We first stayed at the Norwegian station, Troll (72.01S, 2.53E) from November 13 to 26, and installed the gravimeter on the benchmark (Troll AA) of the gravity hut. We needed to take more time to vacuum the dropping chamber of the gravimeter during the installation, because vacuuming pumps did not work normally, mainly associated with the cold weather in Troll Station. We started to measure absolute gravity values on November 18, and obtained the average gravity value of 982,360,741.41 +/- 1.16 +/- 1.82 microGal from the 178 sets of the gravity data collected for 5 days. We also stayed at the Indian station, Maitri (70.77S, 11.73E) from November 26 to December 4, and started to measure gravity values on the benchmark (Maitri AB) of the gravity hut on November 28. We obtained the 112 sets of the gravity data for 4 days, and determined the average gravity value of 982,576,883.10 +/- 1.23 +/- 1.83 microGal.
Our absolute gravity values collected in November-December 2018 was found to be smaller than those obtained in January-February 2012 (Dr. Jaakko Mäkinen, personal communication) by -4.4 and -4.2 microGal at Troll and Maitri stations, respectively. The gravity decrease may be caused by ground subsidence and/or ice mass decrease around the stations. The cause of the gravity decrease will be investigated in detail by analyzing the GNSS data which was collected simultaneously with the absolute gravity data at two stations.

Keywords: Antarctic ice sheet, absolute gravity, relative gravity, GNSS, Troll Station, Maitri Station

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Capability of ICA Method for separating GIA and Ice Mass Signals in Antarctica

*SHI TIANYAN[1], Yoichi Fukuda[1]

1. Graduate School of Science, Kyoto University

The Gravity Recovery and Climate Experiment (GRACE) mission provided global gravity change data with a spatial resolution of a few hundred kilometers and a temporal resolution of 30 days. The GRACE data revealed the total mass changes in Antarctica and contributed to Antarctic Ice Sheet (AIS) mass balance researches. However, there are large uncertainties in Glacial Isostatic Adjustment (GIA) effects, which should be removed from the GRACE data, for estimating the AIS mass balance. While many studies have been conducted for estimating or removing the GIA effects thus far, we try to use a statistical analysis method called Independent Component Analysis (ICA) and investigated its capability of separating GIA and AIS mass signals.

We primarily employed GRACE RL05 mascon data provided by NASA Jet Propulsion Laboratory (JPL) of all the GRACE available period from January 2002 to June 2017 with the spatial coverage of all Antarctica. And we used three ICA methods, namely, spatial ICA (sICA), temporal ICA (tICA), and spatio-temporal ICA (stICA), for testing the characteristics and/or the capabilities of the methods.

The results showed that the GIA like signal can be recovered successfully with sICA which separated GIA signals and AIS mass change signals into two statistical independent components. On the other hand, tICA decomposed the GIA signal into two independent components. This suggested that tICA could not solve the signals mixing problem completely. Nevertheless, tICA detected an extra anomaly snow-fall signal around 2010. This shows that tICA may have the potential to separate long-term trend signals with different time scales. The results of stICA suggested that its characteristics could be seen as a combination of the above two methods. Thus, an appropriate combination of the methods should be examined.

We also tested other datasets and revealed the different datasets and/or pre-processing of the datasets largely affected the obtained results. It is impossible to assess the validity of the results only using the GRACE data. Therefore, additional information should be necessary to validate and interpret the results.

Keywords: GRACE, GIA, ICA

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Preliminary result of continuous observation with an iGrav superconducting gravimeter at the Teshikaga observatory, eastern Hokkaido, Japan

*Kazunari Nawa[1], Hiroaki Takahashi[2], Mako Ohzono[2], Kazumi Okada[2], Teruhiro Yamaguchi[2], Daisuke Oka[3], Noritoshi Okazaki[3], Ryo Honda[4], Hiroshi Ikeda[5]

1. National Institute of Advanced Industrial Science and Technology, 2. Hokkaido University, 3. Geological Survey of Hokkaido, 4. Mount Fuji Research Institute, 5. University of Tsukuba

In November, 2018, continuous observation with the iGrav type superconducting gravimeter (# 017) was started at the Teshikaga Observatory of the Hokkaido University in order to carry out high spatiotemporal resolution gravity monitoring in the caldera / volcanic area in eastern Hokkaido. The gravity meter used in CCS project of Tomakomai site was temporarily relocated to the Minami-shinkawa Observatory in September of the same year and then moved to the Teshikaga Observatory from Minami-shinkawa at the timing before entering the snowy season . We report what kind of record is obtained by the superconducting gravimeter at each observatory in wide frequency band from the seismic to the geodetic band. The observation data will be registered in the Crustal Deformation Database of Hokkaido University for the purpose of archive, distribution and comparative analysis with other principle data.

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On the anomalous temporal gravity change between VERA and F-net stations at Ishigakijima, Japan

*Kazunari Nawa[1], Yuichi Imanishi[2], Yoshiaki Tamura[3], Hiroshi Ikeda[4], Takeshi Kimura[5]

1. National Institute of Advanced Industrial Science and Technology, 2. Earthquake Research Institute, The University of Tokyo, 3. National Astronomical Observatory of Japan, 4. University of Tsukuba, 5. National Research Institute for Earth Science and Disaster Resilience

Continuous gravity and hydrological observations at Ishigakijima revealed that the gravity difference between the F-net station (gPhone) and the VERA station (superconducting gravimeter) is closely related with the change in the soil water content near the F-net station. It was also noted, however, that the gravity difference did not indicate significant changes on some occasions of heavy rainfall. In addition, our precipitation response model did not predict the observed gravity change well for a particular period expanding a few tens of days. Here we reexamine our data of precipitation, soil moisture, and underground water level as well as gravity, to refine our model of the hydrological effects on gravity at Ishigakijima.

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[J] Oral | S (Solid Earth Sciences)：S-GD Geodesy

Tue. May 28, 2019 3:30 PM - 5:00 PM JST | Tue. May 28, 2019 6:30 AM - 8:00 AM UTC | 303 3F

[S-GD01] Gravity and Geoid

convener:Tokuro Kodama(Geospatial Information Authority of Japan), Daisuke Oka(Geological Survey of Hokkaido, Environmental and Geological Research Department, Local Independent Administrative Agency, Hokkaido Research Organization), Chairperson:Kazunari Nawa, Ryo Honda(山梨県富士山科学研究所)

Recent precise gravity measurements lead to advances in many kinds of applications, e.g., geophysical exploration of internal structure of the Earth and Moon, studies of earthquake, volcano, subsidence, landslide and tsunami, monitoring ice mass balance, and so on.
In this session, we call wide range of papers related to topics of gravity and geoid, including theory of gravity field, absolute/relative gravity measurements, data analysis of satellite gravity missions, and development of gravity sensors.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SGD01-07] **Absolute gravity signals at the Sakurajima volcano since 2009 through 2018**

*Shuhei Okubo[1], Keigo Yamamoto[2], Masato Iguchi[2], Yoshiyuki Tanaka[3], Yuichi Imanishi[1], Ryuichi Nishiyama[1], Miwako Ando[1], Atsushi Watanabe[1] (1.Earthquake Research Institute, The University of Tokyo, 2.Disaster Prevention Research Institute, Kyoto University, 3.Graduate School of Science, The University of Tokyo)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SGD01-08] Detection of Earthquake-induced Prompt Gravity Signals in Multi-channel Data

*Masaya Kimura[1], Nobuki Kame[1], Shingo Watada[1], Makiko Ohtani[2], Akito Araya[1], Yuichi Imanishi[1], Masaki Ando[3], Takashi Kunugi[4] (1.Earthquake Research Institute,The University of Tokyo, 2.National Institute of Advanced Industrial Science and Technology, 3.Department of Physics, The University of Tokyo, 4.National Research Institute for Earth Science and Disaster Resilience)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SGD01-09] Evaluation of atmospheric attraction effect using local-scale objective analysis (LANAL)

*Toshiyuki Tanaka[1] (1.Tono Research Institute of Earthquake Science, Association for the Development of Earthquake Prediction)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SGD01-10] Airborne gravity survey for establishment of a new precise gravimetric geoid model

*Tokuro Kodama[1], Akira Tomiyama[1], Shuichi Oomori[1], Erika Wada[1], Toshihiro Yahagi[1], Yoshifumi Hiraoka[1], Hiroshi Kawawa[1] (1.GSI of Japan)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SGD01-11] Gravimetric geoid modeling using airborne gravity data : a case study in Colorado, U.S.A.

*Koji Matsuo[1], Rene Forsberg[2] (1.GSI of Japan, 2.Denmark Technical University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

Discussion

Absolute gravity signals at the Sakurajima volcano since 2009 through 2018

*Shuhei Okubo[1], Keigo Yamamoto[2], Masato Iguchi[2], Yoshiyuki Tanaka[3], Yuichi Imanishi[1], Ryuichi Nishiyama[1], Miwako Ando[1], Atsushi Watanabe[1]

1. Earthquake Research Institute, The University of Tokyo, 2. Disaster Prevention Research Institute, Kyoto University, 3. Graduate School of Science, The University of Tokyo

In this paper, we present gravity signals based on continuous absolute gravity measurements since 2009 through 2018. During this period, several hundreds to a thousand eruptions/explosions were observed every year during 2009 through 2015 (phase 1). Significant seismicity and crustal deformations were observed on Aug. 15, 2015 (phase 2), followed by unusual quiescence since August 2015 (phase 3). Gravity signal after eliminating groundwater disturbance showed remarkable features according to the phase of volcanic activity as described below. During the phase 1 characterized by frequent vulcanian eruptions from the Showa crater, gravity fluctuated about a mean with rather small amplitude of 10 microgals, suggesting dynamic equilibrium is achieved at the magma chamber; magma supply from deeper interior is balanced with mass loss through eruptions. The phase 2 is interpreted as a dyke intrusion event, which causes elastic deformation and short-term gravity change almost simultaneously. In the current phase 3 (2016-2018), gravity shows monotonous increase of 10 microgal/yr, suggesting deflation of magma.

Keywords: Absolute Gravity, Sakurajima

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Detection of Earthquake-induced Prompt Gravity Signals in Multi-channel Data

*Masaya Kimura[1], Nobuki Kame[1], Shingo Watada[1], Makiko Ohtani[2], Akito Araya[1], Yuichi Imanishi[1], Masaki Ando[3], Takashi Kunugi[4]

1. Earthquake Research Institute,The University of Tokyo, 2. National Institute of Advanced Industrial Science and Technology, 3. Department of Physics, The University of Tokyo, 4. National Research Institute for Earth Science and Disaster Resilience

Seismic waves radiating from an earthquake rupture induce density perturbations of the medium, which in turn generate widespread transient gravity perturbations before the arrival of P-waves. Recently, signal detections of such prompt gravity perturbations from the 2011 Tohoku-Oki earthquake were reported. However, the data used for the detections were only a small subset of the available data, and the statistical significance of the signals were not sufficient nor discussed. In this study, we optimized multi-channel data recorded by several instruments and searched for the signals from the 2011 event. Though the single-trace records did not show any signal, the stacked trace of the broadband seismometer array data in Japan showed a signal clearly standing above the noise level, and this detection was confirmed with a sufficient statistical significance. This result provides the first constraint on the amplitude of prompt gravity signals by observation and will work as a reference for future detections.

Keywords: earthquake-induced gravity perturbation, transient deformation, time variable gravity, 2011 Tohoku-Oki earthquake

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Evaluation of atmospheric attraction effect using local-scale objective analysis (LANAL)

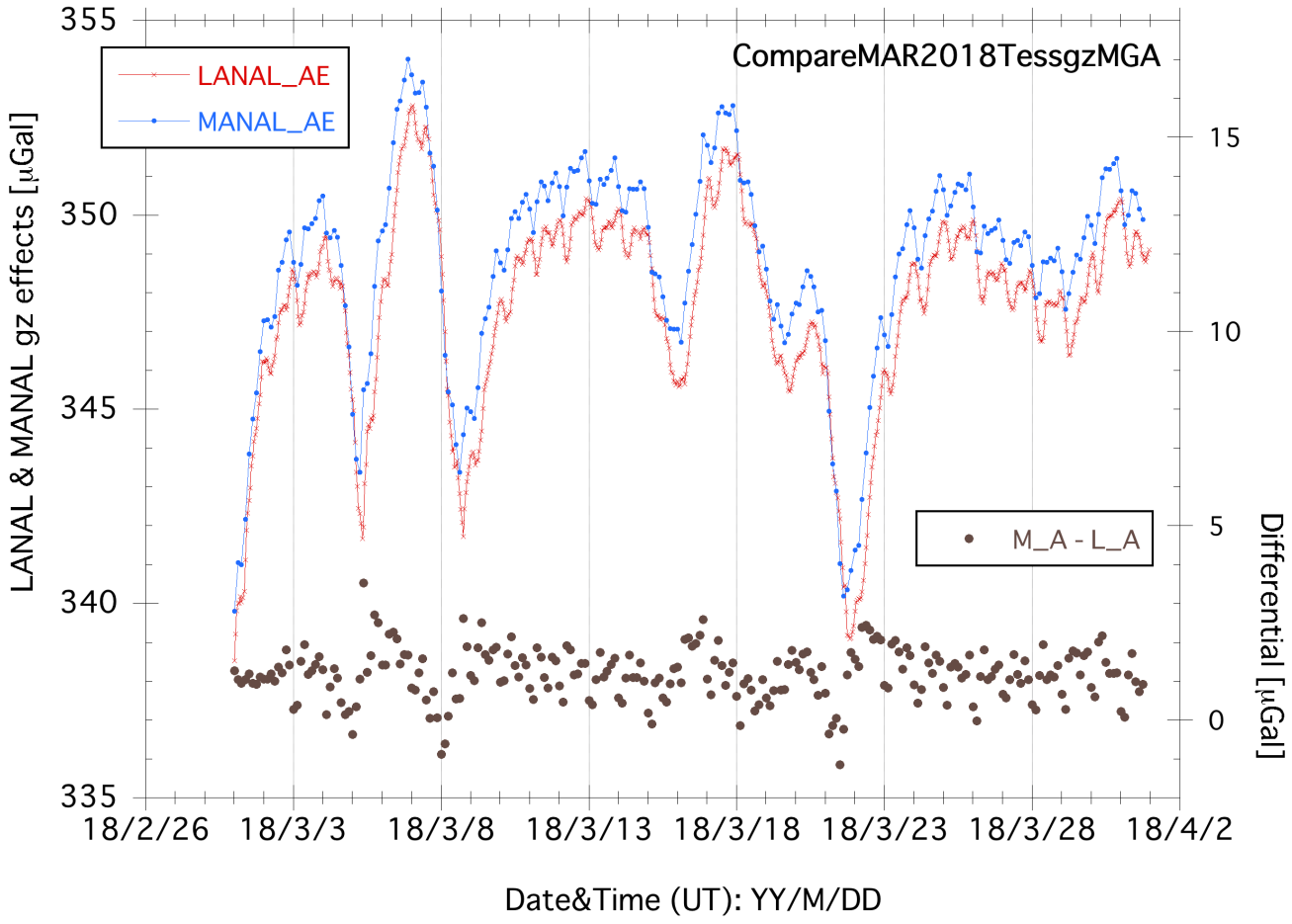
*Toshiyuki Tanaka[1]

1. Tono Research Institute of Earthquake Science, Association for the Development of Earthquake Prediction

Tono Research Institute of Earthquake Science (TRIES) has been conducting continuous gravity observations both above the ground and below the ground of Mizunami Underground Research Institute in order to monitor the underground mass fluctuation including groundwater (Tanaka and Honda, 2018, doi: 10.1002 / 2017EA000311). The mass fluctuation between these two gravimeters can be evaluated from the difference between the two gravimeter values. Also, the sum of the two gravimeter values reflects the gravitational effects both from above the ground gravimeter position and from the below the underground gravimeter position. In order to extract the gravity fluctuation related to earthquake phenomena, that is, the gravitational effect only from below the subsurface gravimeter position, it is necessary to correct the atmospheric attraction effects above the ground gravimeter. Here, for the sake of simplicity, it is assumed that the atmospheric loading deformation effects and the existence of high altitude near the observation point are negligible. TRIES has been used the meso-scale objective analysis (MANAL) to calculate the atmospheric attraction effect in the range of 10 ˚×10 ˚×100 hPa–surf (approximately, 900 km in latitudinal direction ×1100 km in longitudinal direction ×16 km in altitudinal direction) centered on a gravity observation point before now. This attraction effect accounts for approximately 60% of the time-variating amplitude of the global summation. Local-scale objective analysis (LANAL) began publishing since 2018. The lattice spacing was 5 km, the same as MANAL, but LANAL increased the number of isobaric surfaces by 1 (975 hPa surface) from MANAL. This increase improved the spatial resolution of the altitude close to the observation point. Moreover, the time resolution improved as time interval changed from three hours of MANAL to one hour. Therefore, the updating from MANAL to LANAL to calculate the atmospheric attraction effect have to been evaluated quantitatively. Like other objective analysis data, LANAL is also offered in GRIB 2 format. We accessed LANAL using the GrADS software (http://cola.gmu.edu/grads/), but as it was seen in MANAL, it was not possible to display correctly with the control file generated by the g2clt or alt_g2ctl commands. In the PDEF line of the control file, you need to change the jref variable set to 1 to the value of the jsize variable. Also, from the necessity both of atmospheric density calculation on the topographic surface and comparison between isobaric surfaces and a topographic altitude, we use the enclosed terrain data (4-byte real binary). This feature is also the same specification as MANAL, and the GrADS draws the North-South direction reversed figure. In order to correct this problem, the data stored with the northwest end as the starting point was restored as the start point at the southwest end (byte swapping is necessary depending on the processing system). After that, the atmospheric attraction effect was calculated according to the procedure developed for MANAL. At the time of this writing, it was an evaluation for only one month in March 2018. The standard deviation of the difference of simultaneous numerical values between MANAL and LANAL was 0.66 microGal, and the maximum difference of instantaneous values was 2.4 microGal. It turned out that there was a significant difference. In the future, we would like to evaluate the difference from using MANAL by applying to gravity observation data.

Keywords: gravity, local-scale objective analysis, atmosphere

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Airborne gravity survey for establishment of a new precise gravimetric geoid model

*Tokuro Kodama[1], Akira Tomiyama[1], Shuichi Oomori[1], Erika Wada[1], Toshihiro Yahagi[1], Yoshifumi Hiraoka[1], Hiroshi Kawawa[1]

1. GSI of Japan

The vertical datum of Japan has been maintained by the Geospatial Information Authority of Japan (GSI) since more than 130 years ago. Basically it has been realized by conducting periodical leveling surveys in order to determine orthometric height of benchmarks, which are installed at approximately 2 km intervals along main national highways, based on the mean sea level of the Tokyo Bay. However, since this method takes much time and costs a lot, it is quite difficult to reflect vertical land movements quickly caused by such as plate motions and big earthquakes.

In order to tackle this situation, the GSI established a geoid model, called GSIGEO2011+2000, in April 2013 and also implemented a new manual for utilizing the model for public surveys in order to obtain orthometric height from GNSS data. It in fact played a certain role in improving the efficiency of surveying. Geoid models released by the GSI so far are all hybrid, which are constructed of a gravimetric geoid model and geoid heights directly measured by GNSS/leveling surveys, in order to compensate the lack of precision of the gravimetric geoid model. However, since the GNSS/leveling data are based on results of the leveling surveys, they are unavailable once crustal deformation occurs until the leveling surveys are conducted again. In order to improve the precision of the gravimetric geoid model, it is necessary to prepare high quality gravity data all over Japan. But current gravity data contain some problems such as blank areas in both mountainous areas and coastal waters , age of data and inaccuracy of location information decided by topographic map.

In order to solve these problems and make it possible to measure precise orthometric height more quickly, the GSI has been carrying out a new airborne gravity survey project since FY2018. First, we will collect high quality nationwide gravity data using aircraft, then calculate a new precise gravimetric geoid model combined the airborne gravity data with other ones such as terrestrial, marine and satellite gravity data. We are planning to introduce a new height system based on this new geoid model and ellipsoidal heights obtained from GEONET by 2014. Since the geoid model is basically very stable against the crustal deformation, it is expected to update the orthometric height immediately by GNSS data even if crustal deformation occurs.

In this presentation, we will review our future vision of the new height system and report the progress of GSI’ s airborne gravity survey project.

Keywords: Airborne gravity survey, Gravimetric geoid model, Height system

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Gravimetric geoid modeling using airborne gravity data : a case study in Colorado, U.S.A.

*Koji Matsuo[1], Rene Forsberg[2]

1. GSI of Japan, 2. Denmark Technical University

We present the conputational results of gravimetric geoid over Colorado using airborne gravity data. The gravity data and degital elevation model were provided by IAG JWG2.2.2 with the colaboration of National Geodetic Survey. Here we show the gravimetric geoid based on the two Stokes-Helmert approaches, i.e. the classical approach (Moritz, 1980) and UNB approach (Vanicek et al., 2013).

Keywords: Geodesy, Gravity and Geoid, Airborne gravimetry

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[J] Oral | S (Solid Earth Sciences)：S-GD Geodesy

Tue. May 28, 2019 9:00 AM - 10:30 AM JST | Tue. May 28, 2019 12:00 AM - 1:30 AM UTC | 105 1F

[S-GD02] Engineering Application of Space Geodesy

convener:Seiichi Shimada(Graduate School of Frontier Sciences, University of Tokyo Nippo Co. Ltd.), Shuichi Rokugawa(The University of Tokyo), Basara Miyahara(GSI of Japan), Toshiaki Tsujii(Department of Aerospace Engineering, Osaka Prefecture University), Chairperson:Masaatsu Aichi, Kazuki Sakai

In the space geodetic community in Japan, geoscience and other scientific researches, such as seismology, volcanology and meteorology, are predominant. However, engineering application researches are also actively conducted in academic societies abroad. Recent advances in GNSS and InSAR measurement techniques are progressing towards widely engineering usage of space geodetic measurements even in domestic Japan. In addition, the Geospatial Information Authority of Japan (GSI) is about to shift from conventional leveling survey to space geodetic surveying such as GNSS levelling, and the space geodetic method could spread rapidly even in many engineering fields using conventional leveling survey. In this session, we introduce advanced engineering research using space geodetic measurements such as ground measurement / self-driving in particular to young earth scientists. We will also welcome a wide range of general presentations on measurements/research in engineering fields using space geodetic technology.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SGD02-01] Future vision of the society for utilizing highly precise three dimensional positioning data by applying crustal deformation and precise gravimetric geoid model

*Toshihiro Yahagi[1], Kensuke Kokado[1], Kenji Yoshida[1], Takashi Toyofuku[1], Masao Iwata[1], Basara Miyahara[1] (1.GSI of Japan)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SGD02-02] Preliminary study on the application of satelite-based monitoring for land surface displacement to inverse analyses of groundater flow/land subsidence modeling

*Masaatsu Aichi[1] (1.Graduate School of Frontier Sciences, The University of Tokyo)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SGD02-03] Monitoring of ground deformation all over Japan by InSAR and utilizing 2.5-D analysis

*Kazuki Sakai[1], Kyonosuke Hayahsi[1], Masaki Kuwahara[1], Tatsuya Yamashita[1], Masaki Honda[1], Hiroshi Munekane[1] (1.GSI of Japan)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SGD02-04] Resource Exploration using Interferometric Synthetic Aperture Radar Measurement Technology

*Shuichi Rokugawa[1], Takako Nakamura[1] (1.The University of Tokyo)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SGD02-05] The application example of GNSS for natural gas development together with PDCA Management Method

★Invited Papers

*Yoshiyuki Muramoto[1], Susumu Hayatsu[1], Michiharu Hiyama[1], Daisuke Murai[1], Shoji Kunisue[1] (1.KANTO NATURAL GAS DEVELOPMENT CO., LTD)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SGD02-06] New threats and countermeasures in the aviation field where the use of GNSS satellite navigation expands

★Invited Papers

*Takeshi Fujiwara[1], Toshiaki Tsujii[2] (1.Japan Aerospace Exploration Agency, 2.Osaka Prefecture University)

Future vision of the society for utilizing highly precise three dimensional positioning data by applying crustal deformation and precise gravimetric geoid model

*Toshihiro Yahagi[1], Kensuke Kokado[1], Kenji Yoshida[1], Takashi Toyofuku[1], Masao Iwata[1], Basara Miyahara[1]

1. GSI of Japan

Global Navigation Satellite System (GNSS) are conventionally used for determining reference positions in Japan by static survey activities following a uniform standard based on the survey low. In recent years, thanks to improvement of satellite positioning techniques, the utilization of GNSS positioning has been expanded to various real-time positioning services such as autonomous driving system, intelligent construction, smart agriculture and drone delivery. This trend would accelerate in the future due to new services like Centimeter Level Augmentation Service (CLAS) offered by Quasi-Zenith Satellite System (QZSS) or Precise Point Positioning (PPP) provided by private companies. Basically those kind of real-time positioning data give us ‘current’ location though most geospatial information, represented by maps, are built based on the certain ‘past’ epoch. The difference between them becomes larger year by year because of active crustal deformation in Japan. The more precise the real-time position are decided, the more careful we should treat this difference.

Therefore GSI has been developing a new system for correcting this difference in order to fully utilize the real-time positioning data by keeping consistency between existed geospatial information. The prototype of the system was offered to public from January to March in 2019 to collect feedbacks from stakeholders. We plan to launch this system officially until 2020.

It is also important to obtain precise elevation for three dimensional positioning. Historically the height system in Japan has been maintained by conducting nationwide split leveling surveys for more than 130 years. However, since it needs a lot of time and cost, it is necessary to prepare a precise geoid model for determining an orthometric height directly from an ellipsoidal height obtained by GNSS data. Hence GSI launched a new airborne gravity survey project in 2018 to collect high quality gravity data all over Japan, which is necessary to construct a new precise gravimetric geoid model within several centimeters precision. It is expected to introduce a new height system based on the new geoid model and GNSS data up to 2014. It will enable users to determine reasonable elevation data by GNSS without leveling surveys.

Through these efforts, GSI will contribute to realize the future society which fully utilize precise three dimensional position data for various geospatial information services. In this presentation, we will review the current actions of GSI and share a future vision derived from them.

Keywords: Crustal deformation model , Gravimetric geoid model, Airborne gravity survey

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Preliminary study on the application of satelite-based monitoring for land surface displacement to inverse analyses of groundater flow/land subsidence modeling

*Masaatsu Aichi[1]

1. Graduate School of Frontier Sciences, The University of Tokyo

Incerasing land subsidence monitoring data with InSAR and GNSS techniques are expected to improve a calibration process of groundwater flow/land subsidence model. However, the observed data possibly includes the displacement caused not only by known groundwater abstraction but also natural displacements such as seismic/post-seismic crustal motion. Then, it is not straight forward to use the observed data for inverse analysis. It is important to separate known and unknown components from monitoring data with a simultaneous
calibration of land subsidence model.
This study presents a new method based on the prior assumption that the crustal deformation is smooth in space relative to land subsidence cone caused by groundwater abstraction. It consists of the iteration of the following three steps. In the first step, the map of difference between the observed data and the calculated result of the land subsidence model with assumed parameters. In the next step, the spatial roughness of difference map is evaluated from the rotational energy. In the final step, the model parameters are modified to minimize the spatial roughness of unknown components.
This method was tested by a synthetic data composed of land subsidence from the assumed groundwater abstraction, the assumed sudden and long-term displacement like earthquake and post seismic motion. The proposed method successfully separated the land subsidence caused by groundwater abstraction and other components, and exactly found the model parameters. The results suggest that the porposed method has the possibility to enhance the application of satellite-based land subsidence monitoring data to the calibration of land subsidence models.

Keywords: groundwater, land subsidence modeling, inverse analysis, satellite-based monitoring

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Monitoring of ground deformation all over Japan by InSAR and utilizing 2.5-D analysis

*Kazuki Sakai[1], Kyonosuke Hayahsi[1], Masaki Kuwahara[1], Tatsuya Yamashita[1], Masaki Honda[1], Hiroshi Munekane[1]

1. GSI of Japan

GSI (Geospatial Information Authority of Japan) has been conducting SAR interferometry (InSAR) analysis with ALOS-2 data to monitor ground deformation all over JAPAN. In addition, we have conducted InSAR urgent analyses once natural disasters such as volcanic crisis or large earthquakes occur. We provide InSAR-derived deformation data to the Earthquake Research Committee, the Coordinating Committee for Prediction of Volcanic Eruptions and others. Furthermore, we publish those data on GSI website for general users.

InSAR analysis with a pair of observation data can reveal only line-of-sight (LOS) deformation. However, quasi-up-down and quasi-east-west component deformation may be calculated by combining LOS deformations observed from both east and west direction. This analysis method is called 2.5-D analysis (Fujiwara et al., 2000). “Quasi” means that the directions of obtained deformation by 2.5-D analysis are slightly different from up-down and east-west.

LOS deformation from InSAR analysis is usually represented in rainbow color, and is difficult to understand intuitively. Furthermore, deformation direction can’t be identified from such InSAR image. On the other hand, 2.5-D analysis image is easier to understand and deformation direction can be identified. GSI has been considering a way to make InSAR image more understandable to general public, and 2.5-D analysis is one of the candidates. The 2018 Hokkaido Eastern Iburi Earthquake is an example of utilizing 2.5-D analysis. The quasi-up-down component deformation was utilized in setting a recovery survey area.

In this presentation, we will introduce ground deformations detected by InSAR analysis and some examples of 2.5-D analysis derived from earthquakes and volcanic activities.

*Acknowledgment

ALOS-2 data were provided based on the joint research agreement with JAXA (Japan Aerospace Exploration Agency). The ownership of ALOS-2 data belongs to JAXA.

Keywords: InSAR, 2.5-D analysis, Ground deformation, ALOS-2

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Resource Exploration using Interferometric Synthetic Aperture Radar Measurement Technology

*Shuichi Rokugawa[1], Takako Nakamura[1]

1. The University of Tokyo

InSAR using synthetic aperture radar (SAR) is a technology that enables the detection of the earth surface deformation without any observation points on the ground. The L-band SAR mounted on ALOS / PALSAR-2 is effective even in the vegetated areas because of relatively long wavelength of the sensor. InSAR has the potential to be used in the various technical applications. This technique has been primarily used to analyze fluctuations due to natural disasters and large-scale deformations such as crustal movement caused by earthquakes and volcanic eruptions. However, the extraction of the small deformation is also possible by continuously monitoring the ground deformation. Compared with the leveling and global navigation satellite system, InSAR provides the advantage of wide range observation capability. However, accumulating a certain amount of data is required for this kind of analysis. In this study, the second largest oil filed in Kuwait and East Kanto gas field in the Chiba prefecture, were analyzed as case study fields. InSAR data from 2004 to 2010 are applied to derive the surface deformation. The results of the detailed analysis confirmed remarkable ground deformation mainly at four locations in Kuwait. It was confirmed that each of these four points coincided with the positions of the Burgan, Minagishu, Umm Gudair and the Wafra oil fields, respectively. Therefore, it was discovered that InSAR can accurately grasp the ground deformation near the oil production wells. Moreover, these results reveal that there was a linear correlation between the influence range of the oil and the production amount of the oil field. A high correlation was also observed between the subsidence amount of the oil field and the actual production amount. Therefore, it is established that the InSAR analysis results can be applicable in production management, as well. Similarly, in Chiba prefecture, the InSAR time series analysis was conducted to grasp the spatial distribution of the ground change in time series. It also demonstrate the possibility of the tools for monitoring and management of the actual oil/gas fields.

Keywords: InSAR, ALOS/PALSAR-2, oil/gas fields

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The application example of GNSS for natural gas development together with PDCA Management Method

*Yoshiyuki Muramoto[1], Susumu Hayatsu[1], Michiharu Hiyama[1], Daisuke Murai[1], Shoji Kunisue[1]

1. KANTO NATURAL GAS DEVELOPMENT CO., LTD

[Background]
We have been developing the Southern Kanto gas field for many years. This field which contains natural gas dissolved in water is located primarily under Chiba prefecture, and it extends across a wide area of the Kanto region, including Ibaraki, Saitama and Kanagawa prefectures as well as Tokyo Metropolis. This field's recoverable reserves are estimated 368.5 billion cubic meters, making it the largest field of gas dissolved in water in Japan. The gas is dissolved in formation water which is called brine, so it is produced together with brine. Commercial production of natural gas has been conducted in Chiba prefecture since 1931 and has contributed to the growth in the region. Formerly, it was mainly used for industrial gas, but now most common usage is for city gas. On the other hand, land subsidence has been confirmed in Kujukuri area, east of Chiba prefecture. Brine production is considered as one of possible causes of it. Companies producing natural gas in this area including our company have made a land subsidence prevention agreement with the Chiba prefectural government to prevent and control land subsidence. Also, from the technical point of view, we conduct joint study on environmental issues with other gas production companies as a member of "Environmental Technology Research Association for Natural Gas Dissolved in Water".

[Observation of land subsidence]
The Chiba prefectural government has conducted leveling every year. We also have conducted it, but it takes a lot of time to get the survey result because we have to revise the observation data based on the leveling result conducted by local government. On the other hand, GNSS observation which is one of the surface level observation techniques has been prevailed recently. The advantage of GNSS is that continuous observation is possible at the place where it is installed. In Japan, the Geographical Survey Institute has established GEONET (GNSS Earth Observation Network System) throughout the country. We installed GNSS stations in our operating area and analyze these data together with GEONET's since 2013 to get circumstance of land subsidence quickly.

[Application example of GNSS for natural gas production]
We installed GNSS station to monitor the land subsidence in a certain area where natural gas is newly developed. The reason for that is because we need to adjust the brine production rate based on land subsidence. We use GNSS data in "PDCA Management for Land Subsidence Control", one method for controlling land subsidence systematically. This method consists of four elements. "P", Plan, means making of production plan based on the simulation result. "D", Do, means production of natural gas based on the production plan. "C", Check, means observation and evaluation of land subsidence by GNSS and leveling. "A", Act, means update of simulation model. By repeating this method every year, we will improve the way of subsidence management.
In the presentation, we will introduce the application example of GNSS for natural gas development together with PDCA Management Method.

Keywords: GNSS, Natural gas dissolved in water, Southern Kanto gas field

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New threats and countermeasures in the aviation field where the use of GNSS satellite navigation expands

*Takeshi Fujiwara[1], Toshiaki Tsujii[2]

1. Japan Aerospace Exploration Agency, 2. Osaka Prefecture University

To contribute to the realization of the next-generation air transportation system, JAXA is promoting the research and development project named DREAMS (Distributed and Revolutionary Efficient Air-safety Management System). Research and development of high precision and reliable navigation system is one of the most important targets of this project. In this paper, the impact of the plasma bubble, a kind of ionospheric anomalies, on the availability of GBAS precision approach is investigated based on the collected data under the actual plasma bubbles and the mathematical models of the plasma bubbles are introduced to be used in the Monte-Carlo simulations to estimate the availability.

Keywords: aviation, GNSS, satellite navigation

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Tue. May 28, 2019 1:45 PM - 3:15 PM JST | Tue. May 28, 2019 4:45 AM - 6:15 AM UTC | A10 TOKYO BAY MAKUHARI HALL

[S-SS10] Seismicity

convener:Kei Katsumata(Institute of Seismology and Volcanology, Hokkaido University), Chairperson:Aitaro Kato(Earthquake Research Institute, University of Tokyo), Shinji Toda(東北大学)

This session aims to improve our understanding on seismicity. Any contribution on behavior of earthquakes as a cluster, such as regional seismicity and aftershocks, are welcomed. We also welcome contribution on temporal and spatial interactions that control seismicity, and tectonic processes, and geological and thermal structures that regulate seismicity.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SSS10-01] Seasonal variations in crustal seismicity in San-in district, southwest Japan

*Taku Ueda[1], Aitaro Kato[1] (1.Earthquake Research Institute, the University of Tokyo)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SSS10-02] **Source fault model of the 2018 M_W 5.6 northern Osaka earthquake, Japan, inferred from the aftershock sequence**

*Aitaro Kato[1], Taku Ueda[1] (1.Earthquake Research Institute, the University of Tokyo)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SSS10-03] The 2018 Hokkaido Eastern Iburi earthquake (M_{JMA} = 6.7) was triggered by a strike-slip faulting in a stepover segment: Insights from the aftershock distribution and the focal mechanism solution of the mainshock

*Kei Katsumata[1], Mako Ohzono[1], Hiroshi Aoyama[1], Ryo Tanaka[1], Masamitsu Takada[1], Masayoshi Ichiyanagi[1], Teruhiro Yamaguchi[1], Kazumi Okada[1], Hiroaki Takahashi[1], Shin'ichi Sakai[2], Satoshi Matsumoto[3], Tomomi Okada[4], Toru Matsuzawa[4], Shuichiro Hirano[5], Toshiko Terakawa[6], Shinichiro Horikawa[6], Masahiro Kosuga[7], Hiroshi Katao[8], Yoshihisa Iio[8], Airi Nagaoka[8], Noriko Tsumura[9], Tomotake Ueno[10], the Group for the Aftershock Observations of the 2018 Hokkaido Eastern Iburi Earthquake (1.Institute of Seismology and Volcanology, Faculty of Science, Hokkaido University, 2.Earthquake Research Institute, University of Tokyo, 3.Institute of Seismology and Volcanology, Faculty of Science, Kyushu University, 4.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University, 5.Nansei-Toko Observatory for Earthquakes and Volcanoes, Graduate School of Science and Engineering, Kagoshima University, 6.Earthquake and Volcano Research Center, Graduate School of Environmental Studies, Nagoya University, 7.Graduate School of Science and Technology, Hirosaki University, 8.Research Center for Earthquake Prediction, Disaster Prevention Research Institute, Kyoto University, 9.Graduate School of Science, Chiba University, 10.National Research Institute for Earth Science and Disaster Prevention)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SSS10-04] Layered structure of the upper mantle and the crust revealed in the time series analyses of the aftershocks of the 2018 Hokkaido Eastern Iburi Earthquake

*Takayuki Kawabe[1] (1.Faculty of Education, Arts and Sciences, Yamagata University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SSS10-05] Aftershock sequence of the 1847 Zenkoji earthquake: Temporal decay presented in four historical materials and best fit values of paramaters for Omori-Utsu law

*Kentaro Hattori[1], Ichiro Nakanishi[1] (1.Kyoto Univ.)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SSS10-06] The aseismic islands, Amakusa-Kamishima and Shimoshima, Kumamoto Prefecture, southwest Japan: What persistently shuts off regional seismicity

*Shinji Toda[1] (1.International Research Institute of Disaster Science, Tohoku University)

Seasonal variations in crustal seismicity in San-in district, southwest Japan

*Taku Ueda[1], Aitaro Kato[1]

1. Earthquake Research Institute, the University of Tokyo

A growing body of evidence suggests that seismicity is seasonally modulated in a variety of tectonic environments (e.g., Gao et al., 2000; Heki, 2003; Bettinelli et al., 2008; Ben-Zion & Allam, 2013; Amos et al., 2014; Johnson et al., 2017). Identifying cyclic variations in seismicity leads to an improvement of our understanding about the physics of earthquake triggering.

San-in district, southwest Japan, is an active seismicity zone characterized as high shear strain rate by geodetic measurement (Nishimura and Takada, 2017). Moreover, Ogata (1983) has pointed out a possibility of seasonal variations in seismicity rate in the Inner Zone of southwest Japan. We here focus on seasonal variations in crustal seismicity in San-in district.

We used the JMA catalog (constructed by Japan Meteorological Agency) from 1975 through 2017 (magnitude M >= 3.0 and depth <= 20 km). We applied space-time Epidemic Type Aftershock Sequence (ETAS) model (e.g., Ogata, 1998; Zhuang et al., 2004) to the catalog and used a probability-based declustering procedure based on the work of Zhuang et al. (2002) to evaluate the significance of the seasonal variations, adopting uncertainties derived from the declustering scheme.

We demonstrated that semiannual variations in background seismicity rate, which increases in spring and autumn, are statistically significant from 1980 through 2017. The distribution of large historic and modern earthquakes (from 1850 through 2017, magnitude M >= 6.2, constructed by Chronological Scientific Tables) shows a similar pattern to recent background seismicity, suggesting that seismicity in San-in district has shown seasonal variations for over 150 years. There is some correlation between the monthly averaged background rate shifted backward 2 months and monthly averaged rain amount in the studied region. These results infer that seasonal variations in seismicity in San-in district can be explained by increasing pore pressure within fault zones, caused by infiltration of rainfall in autumn and decreasing surface mass due to snow melting in spring. Some correlation between seismicity and precipitation suggests that modulation of precipitation may be a key ingredient to produce time-dependence of background seismicity.

Keywords: Seismicity, Seasonal variations, Stochastic declustering, San-in shear zone

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Source fault model of the 2018 M_w 5.6 northern Osaka earthquake, Japan, inferred from the aftershock sequence

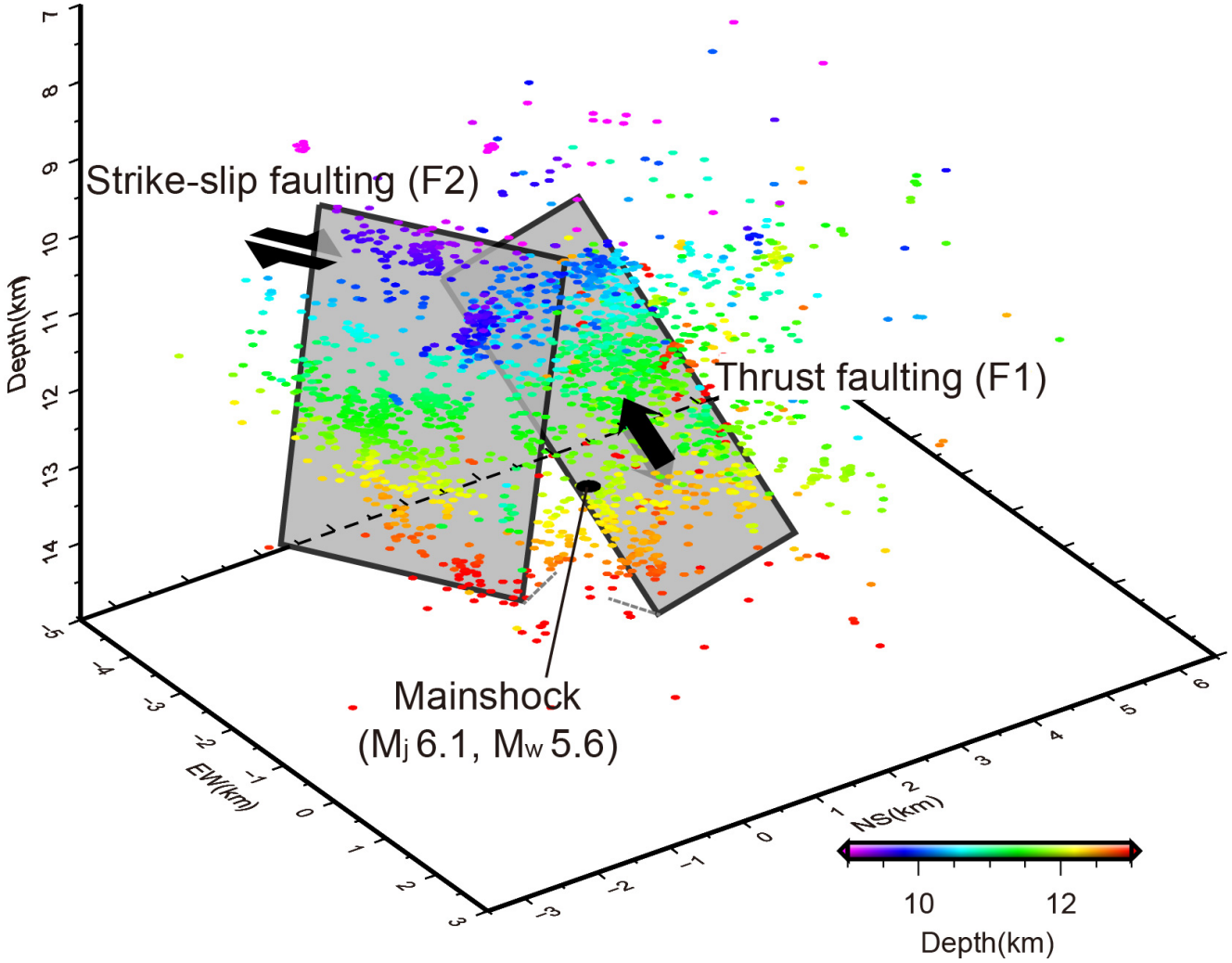
*Aitaro Kato[1], Taku Ueda[1]

1. Earthquake Research Institute, the University of Tokyo

We reconstructed the spatiotemporal evolution of seismicity associated with the 2018 M_w 5.6 northern Osaka earthquake, Japan, to discuss the source fault model of the mainshock rupture, the possible link between this rupture and known active faults, and subsequent crustal deformation. We first relocated the hypocenters listed in the earthquake catalog determined by the Japan Meteorological Agency using a double-difference relocation algorithm. We then searched for the earthquake waveforms that closely resembled those of the relocated hypocenters by applying a matched filtering technique to the continuous waveform data. The relocated hypocenters revealed two distinct planar alignments with different fault geometries. A combination of the relocated hypocenters and focal mechanisms suggests that the mainshock rupture initiated on a NNW–SSE-striking thrust fault, dipping ~45° to the east, with the rupture propagating to an adjacent sub-vertical ENE–WSW-striking strike-slip fault ~0.3 s after the initial mainshock rupture, resulting in the simultaneous propagation of dynamic rupture along the two faults. The strike-slip fault is oblique to the strike of the Arima-Takatsuki Fault, indicating that blind strike-slip faulting occurred. While the east-dipping thrust fault is located deeper than the modeled extent of the Uemachi Fault, a simple extrapolation of the near-surface geometry of the Uemachi fault partially overlaps the mainshock rupture area. Although it is unclear as to whether a blind thrust fault or a deep portion of the Uemachi Fault ruptured during this mainshock–aftershock sequence, a mainshock rupture would have transferred a static stress change of >0.1 MPa to a portion of the east-dipping thrust fault system. Intensive aftershocks have persisted along the northern and southern edges of the source area, including moderate-magnitude events, whereas the seismicity in the central part of the source area has shown a rapid decay over time. Delayed triggered aftershocks were clearly identified along the northern extension of the rupture area. Because the background seismicity is predominant in this northern area, we interpret that aseismic deformation, such as cataclastic flow lubricated by crustal fluids, triggered this off-fault seismicity.

Keywords: the 2018 Mw 5.6 northern Osaka earthquake, afershocks, Source fault model

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The 2018 Hokkaido Eastern Iburi earthquake (M_{JMA} = 6.7) was triggered by a strike-slip faulting in a stepover segment: Insights from the aftershock distribution and the focal mechanism solution of the mainshock

*Kei Katsumata[1], Mako Ohzono[1], Hiroshi Aoyama[1], Ryo Tanaka[1], Masamitsu Takada[1], Masayoshi Ichiyanagi[1], Teruhiro Yamaguchi[1], Kazumi Okada[1], Hiroaki Takahashi[1], Shin'ichi Sakai[2], Satoshi Matsumoto[3], Tomomi Okada[4], Toru Matsuzawa[4], Shuichiro Hirano[5], Toshiko Terakawa[6], Shinichiro Horikawa[6], Masahiro Kosuga[7], Hiroshi Katao[8], Yoshihisa Iio[8], Airi Nagaoka[8], Noriko Tsumura[9], Tomotake Ueno[10], the Group for the Aftershock Observations of the 2018 Hokkaido Eastern Iburi Earthquake

1. Institute of Seismology and Volcanology, Faculty of Science, Hokkaido University, 2. Earthquake Research Institute, University of Tokyo, 3. Institute of Seismology and Volcanology, Faculty of Science, Kyushu University, 4. Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University, 5. Nansei-Toko Observatory for Earthquakes and Volcanoes, Graduate School of Science and Engineering, Kagoshima University, 6. Earthquake and Volcano Research Center, Graduate School of Environmental Studies, Nagoya University, 7. Graduate School of Science and Technology, Hirosaki University, 8. Research Center for Earthquake Prediction, Disaster Prevention Research Institute, Kyoto University, 9. Graduate School of Science, Chiba University, 10. National Research Institute for Earth Science and Disaster Prevention

The Hokkaido Eastern Iburi earthquake (M_{JMA} = 6.7) occurred on 6 September 2018 in the Hokkaido-corner region where the Kurile and the northeastern Japan island arcs meet. We relocated aftershocks of this intraplate event immediately after the mainshock by using data from a permanent local seismic network and found that the aftershocks concentrated in depths from 20 to 40 km, which is extraordinarily deep when comparing with other shallow intraplate earthquakes in the inland area of Honshu and Kyushu, Japan. Moreover, we found that the aftershock area consists of three segments. The first one is located in the northern part of the aftershock area, the second one is located in the southern part, and the third one is located in a stepover segment between the first one and the second one. The hypocenter of the mainshock, which is a rupture initiation point, is located in the stepover segment. The centroid moment tensor solution for the mainshock indicates a reverse faulting, whereas the focal mechanism solution determined by using a first motion polarity of *P* wave indicates a strike-slip faulting. To explain this mismatch qualitatively, we present a model that the rupture started as a small strike-slip faulting in the stepover segment of the aftershock area and it is followed by the large rupture of two reverse faulting in the northern and the southern segments.

Keywords: the Hokkaido Eastern Iburi earthquake, aftershock distribution, focal mechanism solution

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Layered structure of the upper mantle and the crust revealed in the time series analyses of the aftershocks of the 2018 Hokkaido Eastern Iburi Earthquake

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1. Faculty of Education, Arts and Sciences, Yamagata University

The 2018 Hokkaido Eastern Iburi Earthquake, occurred at September 6, 2018 03:07:57 am. Many aftershocks occurred along a plane which is striking north-northeastward and is dipping to the east at an inclination of 70 ˚. The depth of the upper limit at which aftershocks occurred has been becoming shallow over time.
According to time series analyses of the aftershocks, four depth zones are recognized. They are as follows;
Depth zone of 45 to 30 km deep: Many aftershocks occurred in the zone just after the main shock.
Depth zone of 30 to 20 km deep: Less aftershocks occur. However the magnitude of many of them are larger.
Depth zone of 20 to 10 km deep: Many small aftershocks were active. They distribute not uniformly but on multiple radial lines, and they occurred line by line.
Depth zone of 10 to 5 km deep: less aftershocks occur. However the dip of the plane on which aftershocks occurred is gentle as 45 ˚
These recognized zones seems to show the difference in physical properties of the underground geology. According to the slow development of aftershock and distribution form of epicenters suggest strongly the involvement of the deep hot water flow along the fault plane.

Keywords: Layered structure of the Crust, the 2018 Hokkaido Eastern Iburi Earthquake, time series analyses of the aftershocks

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Aftershock sequence of the 1847 Zenkoji earthquake: Temporal decay presented in four historical materials and best fit values of paramaters for Omori-Utsu law

*Kentaro Hattori[1], Ichiro Nakanishi[1]

1. Kyoto Univ.

Seismic intensities estimated from damage caused by earthquakes have been most commonly used to locate earthquake epicentral area since Irish seismologist Mallet used degree of damage by the great Napoli earthquake of 1857 to locate earthquake source area. However, the scales of seismic intensity are different among countries. The seismic intensities are somewhat subjective and are affected by ground conditions.

Matsui and Oike (1997) proposed the use of the numbers of felt aftershocks right after large historical earthquakes to locate source area. A problem in their approach is that it is usually difficult to count the number of aftershocks in epicentral area or places close to the area.

We attempt to fit Omori-Utsu law (Utsu, 1961) to aftershock sequences of a historical large earthquake to overcome the above mentioned problem of the location of epicentral area. The value from counting aftershocks is integer, and seems to be more robust than the estimation of ground motion from the description in historical materials. The temporal decay of the number of aftershocks n(t) is described by the empirical Omori-Utsu law as $n(t) = K (t+c)^{-p}$, where t is the lapse time after the mainshock, p is an exponent showing the decay rate, c is a time scale, and K is a parameter showing aftershock activity.

We use aftershock sequence data of the 1847 Zenkoji earthquake presented in four historical materials owned in Matsushiro, Suwa, Fujinomiya, Gifu, in order of the distance from the epicentral area. We assume c=0.1 and p is common in four data, and obtain the best fitting p and four K. The result is shown in Fig.1. In the figure, it is clear that Omori-Utsu law does not fit the time range right after the earthquake occurrence for Matsushiro, Gifu, Suwa data, but fits Fujinomiya data. Another clear feature in Fig.1 is that the parameter K for Gifu data is 300. This value is much larger than those for Suwa (K=80) and Fujinomiya (K=6), both places are located closer to epicental area than Gifu. Fig.1 may suggest that the data preserved in Gifu were not written in Gifu, but in a place much closer to epicentral area.

Keywords: the 1847 Zenkoji earthquake, aftershock sequence, Omori-Utsu law

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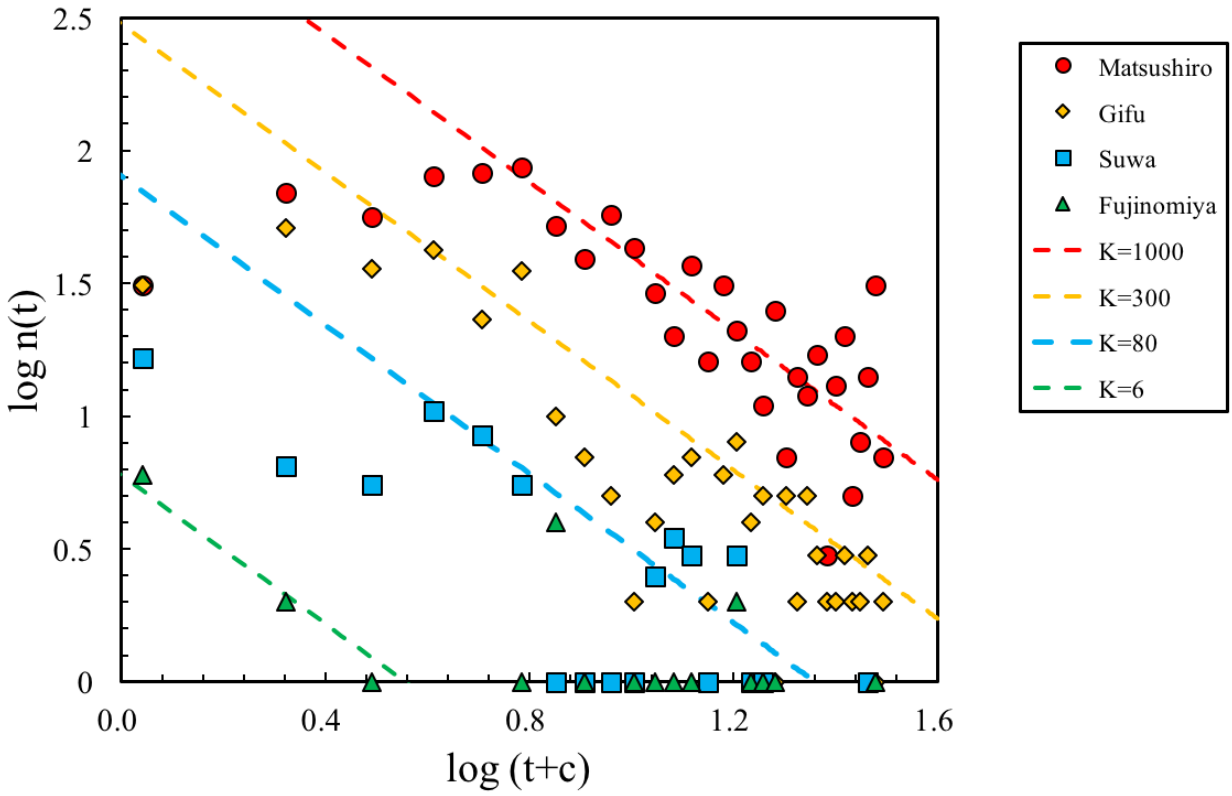


Fig. 1 Temporal decay of the aftershocks of the 1847 Zenkoji earthquake with lines (p=1.4) from Omori-Utsu law (Utsu, 1961)

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The aseismic islands, Amakusa-Kamishima and Shimoshima, Kumamoto Prefecture, southwest Japan: What persistently shuts off regional seismicity

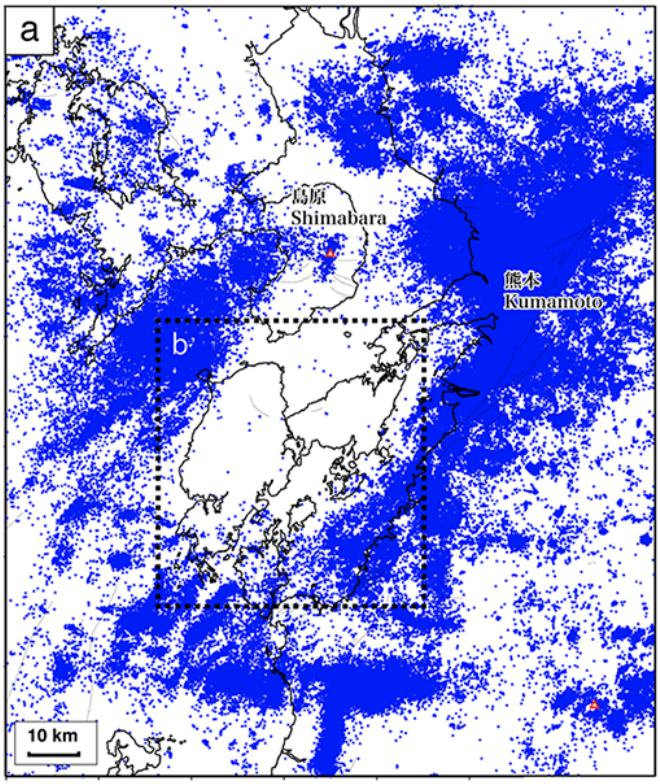
*Shinji Toda[1]

1. International Research Institute of Disaster Science, Tohoku University

Is there any inland region in Japan totally aseismic? This is a simple question against the frequently releasing comment by seismologists to the general public “none of the region in Japan can be avoided from strong ground motion.” To strictly check if this is true, we simply examined the Japan Meteorological Agency (JMA) earthquake catalog of 1923-January 2019, and then found one of the significantly aseismic regions in Kumamoto Prefecture, Amakusa-Kamishima and Shimoshima islands that extend about an area of 2,000 km^2 (hereinafter AAR). Neither historical destructive earthquake is documented in the AAR (Usami et al, 2013). Instead the AAR is surrounded by tectonically and seismically active zones of the Beppu-Shimabara graben to the north, Amakusa-nada graben to the west, the Futagawa-Hinagu fault system that caused the 2016 Kumamoto earthquake to the east, and highly seismic zone to the south. The AAR is characterized by high-Bouguer gravity anomaly possibly related to the underlying metamorphic rocks, while the most of the area exposes upper Cretaceous to Paleogene sedimentary rocks folded along NNE-trending axes (Takai and Sato, 1982). Numerous WNW-trending strike-slip faults, transverse these anticlines and synclines, are thought to have developed in the Miocene period but not been active during the late Quaternary period. Although the coastal geomorphologic features suggest uplifted marine terraces to the north and rias-type subsidence to the south formed during the late Quaternary, we infer long-term very gradual crustal uplift has been lasting since late Miocene due to the lack of sediments. Since the recent GNSS observation indicates a very low rate of strain in the AAR (GSI, 2018), we believe the AAR behaves as a rigid block enclosed by active tectonic zones mentioned above, those condition brings long-term stress shadow to bear such a persistent aseismic region.

Keywords: aseismicity, inland earthquake, seismicity

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Tue. May 28, 2019 3:30 PM - 5:00 PM JST | Tue. May 28, 2019 6:30 AM - 8:00 AM UTC | A10 TOKYO BAY MAKUHARI HALL

[S-SS10] Seismicity

convener:Kei Katsumata(Institute of Seismology and Volcanology, Hokkaido University), Chairperson:Akio Katsumata(気象研究所地震津波研究部第一研究室), Yasushi Harada(東海大学)

This session aims to improve our understanding on seismicity. Any contribution on behavior of earthquakes as a cluster, such as regional seismicity and aftershocks, are welcomed. We also welcome contribution on temporal and spatial interactions that control seismicity, and tectonic processes, and geological and thermal structures that regulate seismicity.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SSS10-07] Seismicity in the matle wedge around Ogasawara Islands and Lesser Antilles

*Akio Katsumata[1], Kenji Nakata[1], Akio Kobayashi[1], Fuyuki Hirose[1], Takahito Nishimiya[1] (1.Meteorological Research Institute, Japan Meteorological Agency)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SSS10-08] Improvement of the accuracy of the unified Japan Earthquake Catalog using ocean bottom seismographs

*Hiroshi UENO[1], Mitsuharu Ueda[1], Hiromi Misu[1], Hirofumi Yokoyama[1], Yuriko Iwasaki[1], Iwakiri Kazuhiro[1] (1.Seismology and Volcanology Department, Japan Meteorological Agency)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SSS10-09] Spatial distribution of seismic activity and stress field in the source region after the 2011 Tohoku-Oki earthquake

Tomoya Nishimori[1], *Ryota Hino[1], Masanao Shinohara[2] (1.Graduate School of Science, Tohoku University, 2.Earthquake Research Institute, The University of Tokyo)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SSS10-10] Assessment for a large earthquake occurrence on the northern side of the focal region of the 2011 off-Tohoku mega-thrust earthquake

*Kazuyoshi Nanjo[1], Kazuki Miyaoka[2], Akio Yoshida[3] (1.University of Shizuoka, 2.Japan Meteorological Agency, 3.Shizuoka University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SSS10-11] Spatial and temporal distributions of *b*-values related to long-term slow-slip and low-frequency earthquakes in the Bungo Channel and Hyuga-nada regions, Japan

*Keita Chiba[1] (1.Institute of Seismology and Volcanology, Faculty of Science, Kyushu University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SSS10-12] 4D b-Value Mapping for Japan

*Yasushi Harada[1], Yuichi Akamine[1], Masayoshi Anzai[1] (1.School of Marine Science and Technology, Tokai University)

Seismicity in the matle wedge around Ogasawara Islands and Lesser Antilles

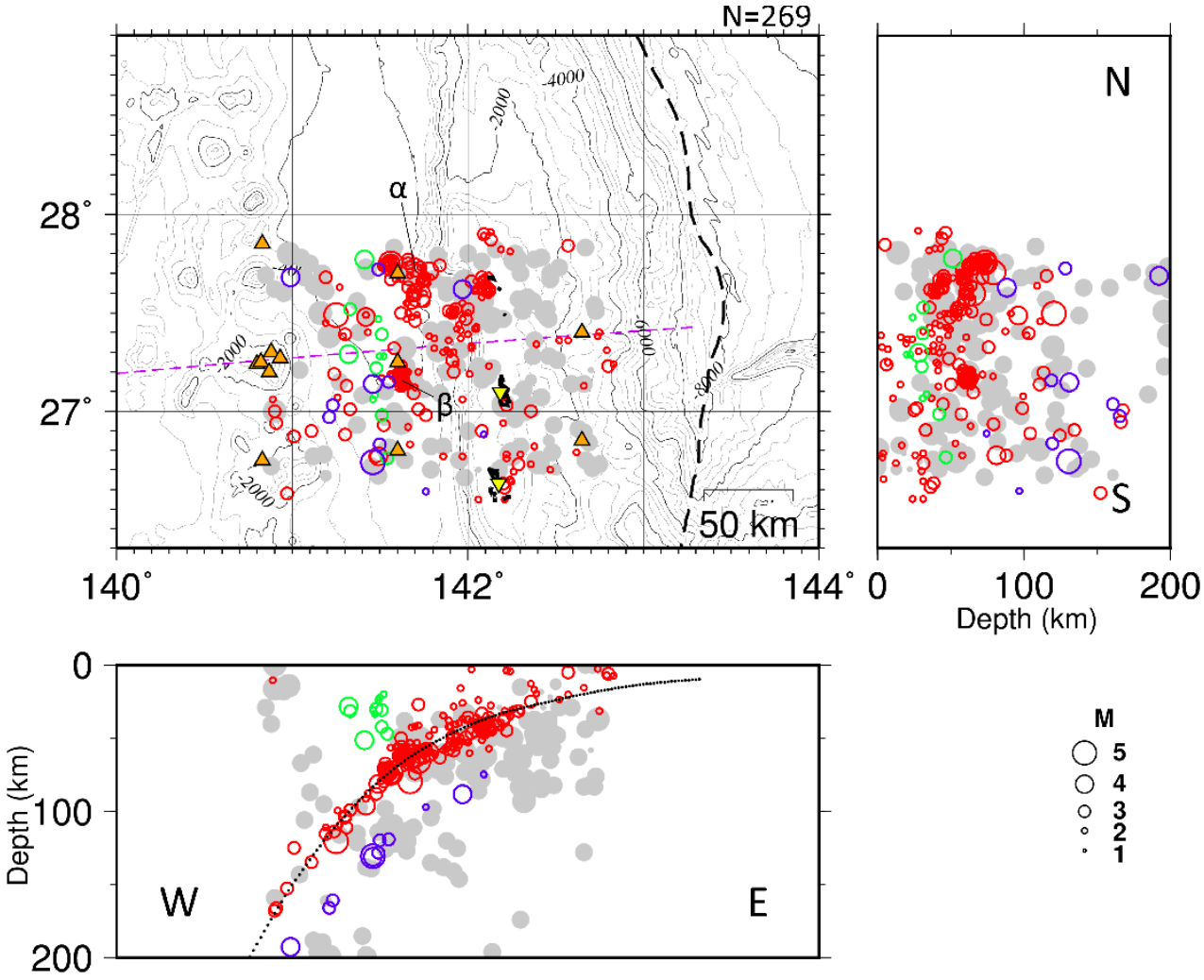
*Akio Katsumata[1], Kenji Nakata[1], Akio Kobayashi[1], Fuyuki Hirose[1], Takahito Nishimiya[1]

1. Meteorological Research Institute, Japan Meteorological Agency

Nakata et al. (2018) deployed ocean bottom seismometers around Ogasawara Islands from July to October in 2015, and observed seismicity of the area. Double seismic zone and seismicity in the mantle wedge (green circles in the figure) were identified. Some hypocenters were distributed in the 20-50 km depth range inside the mantle wedge. These earthquakes are located beneath the Ogasawara Trough without forming any clusters. Ogasawara Trough is a forearc basin between the the current volcanic arc and the Ogasawara ridge.
Seismic activity is usually low in the mantle wedge in areas without complex plate interactions. However, seismicities in the mantle wedge have been reported for other regions. Uchida et al. (2010) found supraslab seismicity off Sanriku coast. Davey and Ristau (2011) reported seismicity observed in the mantle wedge beneath northeast New Zealand. Laigle et al. (2013) reported seismicity in the mantle wedge along the Lesser Antilles subduction zone. The seismicity in the mantle wedge beneath Lesser Antilles is distributed over trench-normal distance more than 50 km, which is wider than that seen in the figure.
Supraslab earthquakes offshore Sanriku (Uchida et al. 2010) are distributed mainly near the toe of the mantle wedge, and form clusters. Earthquakes in the mantle wedge beneath northeast New Zealand form clusters near the boundary of subducting slab. The seismicity around Ogasawara Islands looks like that of Lesser Antilles rather than those offshore Sanriku and beneath northeast New Zealand.
The tectonic features of the forearc basins in the Lesser Antilles and Ogasawara Island regions are similar. Ogasawara ridge was formed with volcanic activities in 41-48 Ma related to beginning of the Pacific plate subduction in this area (Ishizuka et al. 2006). The backarc and forearc basins of the Lesser Antilles were formed as a single structure, and the Lesser Antilles were formed by volcanic activities with dividing the single basin into the two (Aitken et al. 2011). The volcanic activity started at about 40 Ma (Briden et al. 1979) due to the rollback of the Atlantic oceanic slab subduction (Aitken et al. 2011). Both forearc basins around Ogasawara Islands and Lesser Antilles are related to beginning of oceanic slab subduction. The seismic activity in mantle wedge may be related to dehydration of minerals which were formed at the time of subduction onset.

Keywords: Ogasawara Islands, the Lesser Antilles, seismicity in the mantle wedge, onset of oceanic slab subduction

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Improvement of the accuracy of the unified Japan Earthquake Catalog using ocean bottom seismographs

*Hiroshi UENO[1], Mitsuharu Ueda[1], Hiromi Misu[1], Hirofumi Yokoyama[1], Yuriko Iwasaki[1], Iwakiri Kazuhiro[1]

1. Seismology and Volcanology Department, Japan Meteorological Agency

The Unified Earthquake catalog for Japan has already been made available to the public by the Japan Meteorological Agency (JMA). In this catalog, hypocenters are determined using high-density seismic data collected by Japanese institutes and universities.

Recently, many ocean bottom seismographs(OBS) were installed around Japan Trench and Nankai trough.

In order to utilize many OBS data, we will optimize the hypocenter determination method of JMA from the following viewpoints.
1. Applications of the correction travel times of OBS for sedimentary beneath OBS.
2. Applications of velocity structures for OBS stations estimated from some velocity structure investigations.
3. Applications of the correction values of OBS for calculating magnitude with velocity amplitudes.

Keywords: Unified Japan Earthquake Catalog, Ocean bottom seismograph, hypocenter determination

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Spatial distribution of seismic activity and stress field in the source region after the 2011 Tohoku-Oki earthquake

Tomoya Nishimori[1], *Ryota Hino[1], Masanao Shinohara[2]

1. Graduate School of Science, Tohoku University, 2. Earthquake Research Institute, The University of Tokyo

The 2011 Tohoku-Oki earthquake changed the stress field around its source region. Significant coseismic rotation of the principal stress axes was observed and it was suggested that almost all the accumulated shear stress was released on the ruptured plate boundary (e.g. Hasegawa et al. 2011). Therefore, it is important to study the spatial variation of the stress state after the Tohoku-Oki earthquake in detail to understand not only the coseismic stress change but also the stress state before the occurrence of the earthquake. Since previous studies used the focal mechanism solutions to estimate stress field inversion are based on the data of the onshore seismic networks, it has been difficult to discuss detailed features of the spatial variation of the stress state, especially of the depth variation, because accuracies of focal depths (centroid depths) of offshore earthquakes are not sufficient. In this study, we relocated the hypocenters by using arrival time data of ocean bottom seismic stations deployed in the central part of the Japan trench where the coseismic slip was large to improve three-dimensional distribution of the focal mechanism solutions of the earthquakes in the area occurred before and after the Tohoku-Oki earthquake. As a result of stress field estimation based on the improved focal mechanism catalogue, it was shown that the stress field after the Tohoku-Oki earthquake shows clear difference between the overring and the subducting plates in the west side of the coseismic slip region. This sharp change in the stress field across the plate boundary suggests that the shear stress along the plate interface is extremely small. The area corresponds to the region with extensive afterslip estimated from the postseismic deformation data. A remarkable intraplate seismicity extending upward from the plate interface by ~ 25 km was identified after the Tohoku-Oki earthquake at the western rim of the large coseismic slip area. By applying a moment tensor inversion to these earthquakes, we investigated the depth variation of the stress field in the upper plate above the large coseismic slip zone. As a result, the minimum principal stress axis was found to orient almost in the direction of the coseismic slip just above the plate boundary, whereas its direction changed to the along-strike direction in the shallow depth range. The change can be interpreted by the decrease of the tensional stress associated with the coseismic slip with the increasing distance from the rupture plane.

Keywords: 2011 Tohoku-Oki Earthquake, Stress tensor inversion, postseismic processes

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Assessment for a large earthquake occurrence on the northern side of the focal region of the 2011 off-Tohoku mega-thrust earthquake

*Kazuyoshi Nanjo[1], Kazuki Miyaoka[2], Akio Yoshida[3]

1. University of Shizuoka, 2. Japan Meteorological Agency, 3. Shizuoka University

Eight years have passed since the occurrence of the 2011 off-Tohoku mega-thrust earthquake (off-Tohoku earthquake). Seismic activity in the central part of the focal region has settled down. However, magnitude (*M*) 5 to 6 earthquakes occur occasionally along the coast and inland areas of Tohoku and Kanto. Therefore, it can be said that seismic activity in a wide area is still in a higher level than that before the off-Tohoku earthquake.
Soon after the off-Tohoku earthquake, it was worried that a large earthquake might occur in the northern or southern adjacent regions, for it is not rare that a mega-thrust earthquake was succeeded by an occurrence of another large shock within several years. Last year, Matsu’ura (2018) warned impendence of a large earthquake occurrence in east-off Hokkaido, based on analysis of seismicity changes as well as historical records about great earthquake occurrence in the concerned area. Here, we report results of a detailed investigation about changes in the seismicity and the *b* value in the sea area on the northern side of the focal region of the east-off Tohoku earthquake.
Based on a *b* value analysis using data in three years after the off-Tohoku earthquake, Tormann et al. (2015) inferred that stress level in the focal region had already returned to the state before the earthquake, and presented an idea that a large earthquake may not repeat at an interval of a characteristic period, but rather occur at random. On the other hand, Nanjo and Yoshida (2017) showed, by re-analyzing data of a longer time period, that such a feature of the notable lowering of the *b* value as was observed before the off-Tohoku earthquake in the large-slip area was not seen. However, it was found that the *b* value in the northern adjacent area, far-east off Aomori Prefecture, is notably low. The area covers the focal region of the 1994 far-off Sanriku earthquake partly and extends further north. Further, it was seen that seismicity there has been decreasing in recent years.
Based on seismicity in the study region covering from off Aomori Prefecture to east-off Hokkaido, we found, in this study, spatiotemporal variability in *b* value. In particular, the 2003 *M*8.0 Tokachi earthquake did not show a transition of *b* value to normal levels but further lowered *b* value and expanded zones of low *b* values. The result obtained here is consistent with that by our previous work (Nanjo and Yoshida, 2017). From these observations, we think that a large earthquake may occur in the northern adjacent area of the focal region of the off-Tohoku earthquake in the near future.
Seismicity along the coast of Tohoku on the down-dip side of the coupling region is still high. A seismic quiescence as well as lowering of the *b* value is often observed before occurrence of an *M*5~6-class earthquake in the area around their foci. Although effectiveness of the observation of seismic quiescence and lowering of the *b* value in the prediction of a large-earthquake occurrence is still a problem under debate, we would like to propose here that extent of the low-*b* value area and the *b* value at the center of the area may be useful indices in evaluating results of the *b* value analysis. This is an analogy of a typhoon where their magnitude and intensity are evaluated by an extent of the storm area and air pressure at the central point. We expect further that imminence of a large earthquake occurrence may be assessed by noting tendency of the lowering of the *b* value.

Keywords: 2011 off-Tohoku mega-thrust earthquake, b value , seismicity

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Spatial and temporal distributions of *b*-values related to long-term slow-slip and low-frequency earthquakes in the Bungo Channel and Hyuga-nada regions, Japan

*Keita Chiba[1]

1. Institute of Seismology and Volcanology, Faculty of Science, Kyushu University

Long-term slow-slip events (SSEs) and low-frequency earthquakes (LFEs) repeatedly occur in the area encompassing the Bungo Channel and Hyuga-nada region in Japan (e.g., Shelly et al., 2006; Ide et al., 2007; Ozawa et al., 2013; Ozawa, 2017). SSEs are slow earthquake events with a duration of months to years, characterized by a type of slip that is considered transitional between the fast rupture of regular earthquakes and stable sliding along a plate interface, and have characteristics sensitive to stress states near the plate interface (e.g., Obara and Kato, 2016). In addition, since LFEs are also thought to occur at the plate interface, it would be useful to infer the stress state in this region. This study focuses on the stress-dependent characteristics of the *b*-value of regular earthquakes, SSEs, and LFEs, as well as the spatio-temporal relationships between *b*-values and these events in this area, using the Japan Unified high-resolution relocated Catalog for Earthquakes (JUICE) (Yano et al., 2017). The *b*-value, which represents the relative proportion of large to small earthquakes (Gutenberg and Richter, 1944), is inversely related to differential stress or effective stress (e.g., Scholz, 1968, 2015; Wyss, 1973; Urbancic, 1992). As a result, the *b*-values are moderate to low (b = 0.6–1.1) in regions with a high incidence of long-term SSEs. This spatial anomaly in *b*-values is attributed to a partial release of the accumulated stress in regions with relatively high differential stress that are characterized by SSEs. In addition, the *b*-values in the Bungo Channel region are relatively higher than those in the Hyuga-nada region. It was also found that the difference of the *b*-values in the vertical direction within the plate for the Bungo Channel region is larger than that for the Hyuga-nada region. These findings support a generation model of LFEs by Nakajima and Hasegawa (2016), in which undrained conditions in the overlying plate are a key factor for generating LFEs. On the other hand, the *b*-values increase and decrease before and during periods of enhanced LFE activity in the Bungo Channel, respectively. The increase and following decrease in *b* -values are thought to reflect episodes of low and high shear strength along the plate interface, which were caused by the presence of abundant fluids supplied from the subducting slab under undrained conditions above the plate interface and the decreased pore pressure related to fluid consumptions by the generation of the LFEs, respectively.

Keywords: b-value, stress states, long-term slow slip, low-frequency earthquake

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4D b-Value Mapping for Japan

*Yasushi Harada[1], Yuichi Akamine[1], Masayoshi Anzai[1]

1. School of Marine Science and Technology, Tokai University

b-value is considered as an index for seismicity, and smaller b-value means relatively more earthquakes of large magnetude, larger b-value means relatively less earthquakes of large magnetude. We tied to produce 4D b-value map for Japan to examine the difference of seismicity before and after the M9-class 2011 Tohoku quake. Dr. Kazuki Nanjo kindly provided us his code for calculating b-value and the standard deviation(SD). We created not only 4D b-value maps of Japan but also maps of the SD of b-value. Since large SD may mean a failure of Gutenberg–Richter law. Also from the map of b-value around Japan, we noticed a tendency of smaller b-value at distant area from the coastline. The tendency can be explained by the fact that seismometers cannot detect small distant earthqukes. Therefore we constructed a correction formula for b-values. With this formula, the most of the effect of smaller b-value around the M9-class 2011 Tohoku quake are disappeared. However the current formula is not good enough and it have to be improved in future studies.

Keywords: b-Value Mapping for Japan, 4D analysis, maps of SD of b-value, correction formula

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Tue. May 28, 2019 9:00 AM - 10:30 AM JST | Tue. May 28, 2019 12:00 AM - 1:30 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-SS11] Seismic wave propagation: Theory and Application

convener:Kiwamu Nishida(Earthquake Research Institute, University of Tokyo), Kazuya Shiraishi(Japan Agency for Marine-Earth Science and Technology), Takao Nibe(JAPEX), Kaoru Sawazaki(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Shunsuke Takemura(防災科研)

Seismic wave propagation provides rich information of earth's heterogeneities and the excitation sources. In order to extract the information, integrated studies are needed among mathematical/numerical studies based on the wave theory, miniature physical experiments using rock specimens, and practical data analyses. Furthermore, it is greatly beneficial to conduct comparative studies of various kinds of waves, such as elastic, acoustic, traveling ionospheric disturbances, and oceanic waves. This session widely invites presentations about the theories and applications related to seismic and other geophysical waves.

9:00 AM - 9:01 AM JST | 12:00 AM - 12:01 AM UTC

Introduction

9:01 AM - 9:23 AM JST | 12:01 AM - 12:23 AM UTC

[SSS11-13] Fluid flows inferred from microseismic events associated with injection test in Okuaizu Geothermal Field

★Invited Papers

*Kyosuke Okamoto[1], Li Yi[2], Hiroshi Asanuma[1], Takashi Okabe[3], Yasuyuki Abe[4], Masatoshi Tsuzuki[5] (1.National Institute of Advanced Industrial Science and Technology, 2.Osaka University, 3.Geothermal Energy Research and Development Co., Ltd., 4.Okuaizu Geothermal Co., Ltd., 5.Japan Oil, Gas and Metals National Corporation)

9:23 AM - 9:45 AM JST | 12:23 AM - 12:45 AM UTC

[SSS11-14] 3D distribution of intrinsic attenuation factors and random velocity fluctuations in southwestern Japan inferred from seismogram envelopes

★Invited Papers

*Masashi Ogiso[1] (1.Meteorological Research Institute, Japan Meteorological Agency)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SSS11-15] Regional to teleseismic strong ground motions from a 610 km deep 24 May 2013 Sea of Okhotsk earthquake

*Takashi Furumura[1], Brian LN Kennett[2] (1.Earthquake Research Institute The University of Tokyo, 2.Research School of Earth Sciences, The Australian National University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SSS11-16] Trial estimation of eclogitization depths within subducting oceanic crust of the Philippine Sea slab inferred from head wave propagating along the oceanic Moho

*Shunsuke Takemura[1], Takashi Tonegawa[2], Junichi Nakajima[3], Katsuhiko Shiomi[1] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Japan Agency for Marine-Earth Science and Technology , 3.Tokyo Institute of Technology)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SSS11-17] **Transient gravity perturbations due to a buried gravitational source in a homogeneous elastic half space**

*Aditya Nitin Deshmukh[1], Pratik Laxman Borate[1], Abhishek Venkatesh Chitgopkar[1], Nobuki Kame[2], Ranjith Kunnath[1] (1.Mahindra Ecole Centrale, Hyderabad, India , 2.Division of Theoretical Geoscience, Earthquake Research Institute, University of Tokyo, Japan)

Fluid flows inferred from microseismic events associated with injection test in Okuaizu Geothermal Field

*Kyosuke Okamoto[1], Li Yi[2], Hiroshi Asanuma[1], Takashi Okabe[3], Yasuyuki Abe[4], Masatoshi Tsuzuki[5]

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In the Okuaizu geothermal field (Yanaizu, Fukushima Prefecture), a recharge water injection test has been carried out to stabilize the steam production since 2015. In order to avoid cooling of the geothermal reservoir by the water injection and to obtain a larger recharge effect, it is important to grasp and anticipate the flows of the injected water. On the other hand, subsurface structures are generally complicated, especially within the brittle region. Therefore, it is difficult to predict the flows with a simple homogeneous model because the following phenomena are expected in real cases; selective flows passing through a highly permeable region such as a fracture zone as well as creation of a new flow path by shearing. In the shearing, the mechanism of its creation (e.g., reduction of effective stress due to in-flow into fractures, propagation of stress change, stress accumulation due to thermal change) is hard to identify, which is essential information to expect new flow paths.

In the Okuaizu geothermal field, a microseismic monitoring network has been established as part of the JOGMEC project named "Geothermal Reservoir Evaluation and Management Technology" since fiscal year 2015. In this study, we use the seismic record to estimate the subsurface fluid flows associated with the injection test. We investigate factors of the creation of microseismicity associated with the injection test by using elastic wave velocity changes in fractures estimated by seismic scattering analysis as well as pressure and temperature information.

Keywords: Microseismic monitoring, Scattering analysis, Geothermal reservoir

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3D distribution of intrinsic attenuation factors and random velocity fluctuations in southwestern Japan inferred from seismogram envelopes

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Hi-frequency (> 1 Hz) seismogram envelopes show various envelope shapes due to the influence of seismic scattering as well as intrinsic attenuation of the medium. Intrinsic and scattering attenuation structures inferred from seismogram envelopes are important for precise strong ground motion prediction as well as understanding the Earth structure. Ogiso (2019) have proposed a two-step approach to estimate the 3D distribution of intrinsic attenuation factors and scattering coefficients using envelope fitting method and sensitivity kernels proposed by Takeuchi (2016). In this study, we propose the method to estimate 3D distribution of intrinsic attenuation factors and random velocity fluctuations, which is the improved version of Ogiso (2019).

The same as Ogiso (2019), the proposed method consists of two steps. First, we estimate appropriate attenuation parameters (intrinsic attenuation factor and strength of random velocity fluctuation) for each observed envelope. Second, we map the estimated attenuation parameters in step 1 into 3D space using sensitivity kernels. Radiative transfer theory with non-isotropic scattering coefficients based on the Born approximation is used to model seismogram envelopes. The effect of depth-dependent velocity structure is also considered for modeling envelopes.

The proposed method is applied in southwestern Japan. The estimated structure has three main features: (1) both intrinsic attenuation factors and random velocity fluctuations are stronger in the Kyushu than the other regions, (2) both intrinsic attenuation factors and random velocity fluctuations are smaller in the lower crust than the upper crust, which is clearly found in the Chugoku region, and (3) horizontal heterogeneity in intrinsic attenuation factors at the depth of 10-50 km of the Shikoku region. These features, probably reflecting the tectonic settings of southwestern Japan, seem to be consistent with previous studies.

Acknowledgment

We used seismic waveforms recorded by Hi-net operated by the NIED. This study was financially supported by the JSPS KAKENHI Grand No. JP17H02064 and JP18K13622.

Keywords: seismogram envelope, seismic wave scattering, seismic attenuation structure, southwestern Japan

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Regional to teleseismic strong ground motions from a 610 km deep 24 May 2013 Sea of Okhotsk earthquake

*Takashi Furumura[1], Brian LN Kennett[2]

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A very large deep earthquake (Mw8.3, 610 km depth) occurred in the Sea of Okhotsk near Kamchatka on 24 May 2013 producing a large shocks across the Japanese Islands. The maximum shaking intensity reached 3 on the JMA scale at Sarufutsu, Hokkaido and Akita, and the felt area spread to Kagoshima, 3000 km from the hypocenter. According to USGS, the shake was also reported in Northern India, California, and Dubai 6000 km away; also CNN reported that people in Moscow were evacuated from the buildings. Kuge (2015) analyzed teleseismic records and claimed that shaking at large distance is consistent with the radiation pattern of P wave, similar to the 1994 Bolivia Mw8.3 earthquake (Anderson et al., 2015). In this study we aim to understand the cause of large ground motion at regional to teleseismic distances from this very deep event using dense F-net, Hi-net, and IRIS DMC observations, complemented by 3D FDM simulation of seismic wave propagation.

Observed strong ground motion in Japanese Islands

The observed pattern of peak ground velocity (PGV) over Japan demonstrates large motions in Sea of Japan side, opposite to the large shake on the Pacific Ocean side as is usually seen in deep earthquakes. The PGV does not attenuate monotonically with distance, and a second PGV peak was seen at distance of about 2000 km.

At shorter distances (<2000 km) upward travelling waves arrive from the 610 km deep source, waves emitted downwards overlap somewhat and dominate beyond 2000 km. The large PGV is associated with successive arrivals of upgoing and downgoing S waves (near a caustic). S waves incident on the surface at the critical angle generates large sP conversions, which propagate in the crust and uppermost mantle to sustain PGV. Furthermore, a third PGV peak occurs at distances around 3000 km created by the SS wave traveling through deep mantle and reflected twice on the surface. Similar anomalous PGV attenuation is found for other deep earthquakes e.g. near Sakhalin in 2012 (Mw7.7; 600 km).

Strong motion simulation of deep earthquake

FDM simulations using ak135 model demonstrate the ways in which the S wave caustics and sP conversion create the second large PGV peak at regional distances, which moves from 1500 to 3000 km as the source depth increases from 200 to 610 km. The efficiency of sP and SS conversion and reflection is very sensitive to the thickness of the crust; SS is large and sP is weak by reflection from thick continental crust, and thin oceanic crust gives the reverse. The large SS observed over Japanese Island is due to the reflection of S wave at the thicker crust (20-30 km) in the Sea of Okhotsk, and large sP phase at Izu-Ogasawara Islands and the Northwest Pacific, corresponds well with the simulation results.

With a Pacific slab model (Yokota et al., 2017) in the 3D FDM simulation model, we find that S waves traveling through the High-V plate are refracted into the Low-V mantle, making large ground motions on the Sea of Japan side. This anti-waveguide effect differs from the stochastic waveguide effects in the plate at high-frequency (>1-2 Hz) waveguide effect, which is weak for the long-period wave of this distant earthquake with oblique transmission.

Shaking at thousands of kilometers due to long-period ground motion?

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The IRIS DMC records show that the PGV has large peak at distance of about 3500 km due to the arrival of the SS wave. Then, PGV attenuate gently until the next large PGV peak around 7000 km with the arrival of the SSS phase. Shaking in the distance range 4000-6000 km from the Sea of Okhotsk earthquake comes from long-period SS and SSS waves. At Obinisk (OBN; 6050 km) near Moscow long-period S and SS produce 0.7 cm/s ground velocity at a period of 3.5 s. With amplification of long-period ground motions in sedimentary basins, the ground motion can grow to the JMA’s long-period intensity scale 1 (> 5 cm/s).

Keywords: Deep earthquake, Strong ground motion

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Trial estimation of eclogitization depths within subducting oceanic crust of the Philippine Sea slab inferred from head wave propagating along the oceanic Moho

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To investigate structural properties within the subducting oceanic crust of the Philippine Sea slab, we analyzed head wave propagating along the oceanic Moho (P_{PHS}). In the case of offshore earthquakes occurred at depths shallower than oceanic Moho, P_{PHS} is first arrival at onshore seismic stations (e.g., Takemura et al., 2016 EPS). During southeast off Mie earthquake, observed Hi-net seismograms illustrated first arrivals with an apparent velocity of 7.2 km/s, which correspond to apparent velocity of P_{PHS}, at epicentral distances of 70-200 km. At distances greater than approximately 200 km, apparent velocity of first arrivals was increased. Such distance change of apparent velocities is related with velocity structure at depths below the continental Moho.

We conducted two-dimensional (2D) finite-difference method (FDM) simulations of seismic wave propagation using the realistic slab model (Hirose et al., 2008 JGR). Thickness of subducting oceanic crust was assumed to be 7 km. Crust and mantle structures were referred from the F-net 1D model (Kubo et al., 2002 Tectonophys.). Although P_{PHS} was clearly found in simulated seismograms, the simulation result with oceanic crust at deeper (> 70 km) depths did not reproduced observed first arrivals at greater (>200 km) distances. By replacing structural properties of the oceanic crust with ones of the oceanic mantle at depths of 40-60 km, simulated first arrivals were changed depending on structural change depth. A structural change depth of 52 km is the optimal model for explaining observed first arrivals. This depth well corresponds to an eclogitization depth of the subducting oceanic crust beneath the Kii Peninsula (Kato et al., 2014 EPS).

We consider that estimated structural change depth within the oceanic crust is linked with transformation to anhydrous eclogitic oceanic crust (Fukao et al., 1983 Nature; Abers et al., 2003 GRL; Hacker et al., 2003 JGR). Our analysis using head wave propagating along the oceanic Moho may provide depth of eclogitization within the oceanic crust.

Acknowledgement
NIED F-net MT catalog and Hi-net velocity seismograms were used. Finite-different method simulations were conducted on the Earth Simulator at the JAMSTEC.

Keywords: Nankai Trough, Philippine Sea Slab, Oceanic crust, Eclogitization, Head wave

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Transient gravity perturbations due to a buried gravitational source in a homogeneous elastic half space

*Aditya Nitin Deshmukh[1], Pratik Laxman Borate[1], Abhishek Venkatesh Chitgopkar[1], Nobuki Kame[2], Ranjith Kunnath[1]

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Earthquake ruptures induce transient deformations which result in changes in the gravity field (Harms, *et. al* (2015)). Prompt elastogravity signals due to the earthquake source arrive before any seismic wave from the source and it has been proposed that these signals could be used for earthquake early warning systems. In this work, we study the model of a buried gravitational load in an isotropic, homogenous elastic half-plane or half-space. The response at the surface is determined for a suddenly applied gravitational line-load in an elastic half-plane. Also, the response at the surface is calculated for a suddenly applied gravitational point-load in an elastic half-space. Due to the gravitational field induced by a suddenly applied line-mass, every point in the half-plane acts as a source by itself. The elastic response due to each point in the half-plane is calculated using the solution of Garvin (1956) for a buried line blast load in an elastic half-plane. The total response at the receiver point on the surface of the half-plane is determined numerically by the convolution of Garvin’ s solution with the gravitational force. Similarly, the elastogravitational response to a suddenly applied point mass in a half-space is determined using the solution of Johnson (1974) to Lamb’ s problem of a source buried in a half-space. We show that in both these models, prompt gravity signals are obtained.Earlier, Kame and Kimura (2018) had considered the elastic response to a suddenly applied point mass in an unbounded medium. They showed that the ground acceleration at any receiver point is exactly cancelled by the gravity perturbation during the entire duration of the prompt period so that a gravimeter at the receiver will not detect any prompt signals. This appears to be a peculiarity of the model of an unbounded medium.

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Keywords: Geomechanics , Elastogravity, Transient deformation, Computational mechanics

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Tue. May 28, 2019 3:30 PM - 5:00 PM JST | Tue. May 28, 2019 6:30 AM - 8:00 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-SS14] Fault Rheology and Earthquake Physics

convener:Keishi Okazaki(Japan Agency for Marine-Earth Science and Technology), Hideki Mukoyoshi(Department of Geoscience Interdisciplinary Graduate School of Science and Engineering, Shimane University), Hiroyuki Noda(Kyoto University, Disaster Prevention Research Institute), Keisuke Yoshida(Tohoku University), Chairperson:Keisuke Yoshida(東北大学大学院理学研究科 地球物理学専攻), Keishi Okazaki(JAMSTEC)

The goal of this session is to integrate theoretical, experimental, observational, and numerical perspectives from various fields such as seismology, geodesy, geology, mineralogy, and so on, to define what is known about earthquake source processes and the physical and chemical elementary processes of faulting. This session welcomes studies that address such issues as pre-, co-, and post-seismic processes, the rheology of seismogenic faults and fault rocks, laboratory experiments on elementary processes, numerical models based on frictional laws, and estimates of the stress field in the seismogenic zones. We also welcome studies on fault-zone drilling projects and in situ stress measurements.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SSS14-01] **Spatio-temporal Evolution of Micro-Earthquakes illuminated by “0.1 manten” Hyper Dense Seismic Observation: Implication of Fault Growth**

*Aitaro Kato[1], Shin'ichi Sakai[1], Satoshi Matsumoto[2], Yoshihisa Iio[3] (1.Earthquake Research Institute, the University of Tokyo, 2.Kyushu University, 3.Kyoto University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SSS14-02] Estimation of fault model of the 2017 Pohang, South Korea earthquake using seismic and geodetic analyses

*Sun-Cheon Park[1], Won-Jin Lee[2], Geunyoung Song[1], Duk Kee Lee[1] (1.Korea Meteorological Administration, 2.National Institute of Environmental Research)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SSS14-03] Estimation of rupture directivity, fault plane, and stress drop of small earthquakes in inland areas of Japan

*Keisuke Yoshida[1], Tatsuhiko Saito[2], Kentaro Emoto[1], Yumi Urata[2] (1.Tohoku University, 2.NIED)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SSS14-04] **Possible aseismic phenomena causing the hypocenter migration in the precursory activity and aftershocks of the 2017 M 5.3 Kagoshima Bay earthquake, Kyusyu, SW Japan**

*Yoshiaki Matsumoto[1], Keisuke Yoshida[1], Toru Matsuzawa[1], Akira Hasegawa[1] (1.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Tohoku University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SSS14-05] Stress and pore fluid pressure changes in fault zone preceding the earthquake occurrence

*Teruo Yamashita

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SSS14-06] Micromechanical model of fluid-induced seismicity to reproduce observed spatiotemporal changes in source parameters and on-fault fluid diffusion

*Daisuke Sato[1], Keisuke Yoshida[2] (1.Disaster Prevention Research Institute, Kyoto University, 2.Tohoku University)

Spatio-temporal Evolution of Micro-Earthquakes illuminated by “0.1 manten” Hyper Dense Seismic Observation: Implication of Fault Growth

*Aitaro Kato[1], Shin'ichi Sakai[1], Satoshi Matsumoto[2], Yoshihisa Iio[3]

1. Earthquake Research Institute, the University of Tokyo, 2. Kyushu University, 3. Kyoto University

To deepen fundamental understanding of earthquake faulting, it is of crucial importance to image fine scale structure of fault zone. We installed a thousand of seismic stations in the source area, which covers an entire aftershock zone of the 2000 Western-Tottori earthquake (Mw 6.7) from March 2017 to March 2018. The spatial interval of each seismic station ranges from 1 to 2 km. We initially detected ~3000 earthquakes from the continuous waveforms, using automatic arrival time picking technique. Applying a double-difference algorithm to the arrival data-set, we relocated more precise hypocenters in the studied region. The completeness magnitude of the catalog is around -0.7.

From the center to the southeast part, the relocated hypocenters are aligned along sharp fault planes, which are dipping almost vertically. In contrast, at the northwest area, the hypocenter distributions are complex, including several fault planes which are conjugate to the main NW-SE aftershock trend.

We focus on a tiny seismic cluster associated with Mj 1.7 event (main event) in the aftershock zone, which took place on 24th Dec., 2017. Following this event, a total of ~80 micro-earthquakes were detected by automatic-processng and matched filter technique. We visually picked up P-wave arrival times for each micro-earthquake. Using differential travel times derived from waveform cross-correlation technique, we succeeded to relocate them very precicely. The relative hypocenter acuuray appears to be less than 5 m. The relocated micro-earthquakes are sharply aligned along vertically NNW-SSE-striking fault. The length and dip-width of the fault dimension is about 200 m, respectively. This hypoenter alignment is well consisten with a focal mechanism of the main event. Based on the distribution of the earthquakes, the fault zone width is estimated to be ~10 m. The ratio of the fault (process) zone width to the fault length is ~0.01, which fairly matches with that geological observation of fault exposure.

In addition, we identify spatial-temporal evolution of the micro-earthquakes after the main Mj 1.7 event. Interestingly, these migrating events occurred so that they did not overlap events that occurred earlier, like complementary manner. The migration speed is estimated to be < ~0.1 km/day, which is quite lower than that slow slip events observed typically along subduction. This slow migration is similar to fluid migration speeds inferred from seismic observation of induced seismicities following the 2011 Tohoku-Oki earthquake. These results indicate a growth of fault network on a scale of tens of meters.

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Estimation of fault model of the 2017 Pohang, South Korea earthquake using seismic and geodetic analyses

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1. Korea Meteorological Administration, 2. National Institute of Environmental Research

After the 2017 Pohang, South Korea earthquake with magnitude (ML) 5.4, surface deformation was observed using Interferometric Synthetic Aperture Radar (InSAR) technique. This observation of surface deformation can be a constraint to estimate the fault model in addition to aftershock distribution and other seismic information. As the result of InSAR processing using X-band Cosmo-Sky-Med and C-band Sentinel-1 data, we observed the maximum deformation of about 4 cm in Line-Of-Sight (LOS) direction. Considering this observation, we estimated the fault model of the 2017 Pohang earthquake. We determined hypocenters of the earthquake sequence and carried out moment tensor inversion. Then we estimated the dimension and depth of the fault plane using aftershock distribution and displacement on the fault using the seismic moment. Surface deformation was calculated using the formula of Okada (1985) and assuming several models of slip distribution on the fault and was compared with the surface deformation pattern in LOS direction. Larger surface deformation toward the satellite was observed to the northeast from the epicenter and this pattern was well explained by fault models having the slip on the shallow fault plane. During the presentation, we will discuss more about the fault model comparing surface deformation and the aftershock distribution.

Keywords: 2017 Pohang earthquake, surface deformation, aftershock distribution, fault model

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Estimation of rupture directivity, fault plane, and stress drop of small earthquakes in inland areas of Japan

*Keisuke Yoshida[1], Tatsuhiko Saito[2], Kentaro Emoto[1], Yumi Urata[2]

1. Tohoku University, 2. NIED

Dominant frequency or duration of seismic waves is considered to reflect the fault size. Some studies used the dominant frequency for the estimation of fault size and stress drop for small earthquakes assuming simple fault models (e.g., Brune, 1970; Sato & Hirasawa, 1973; Madariaga, 1976) without estimating heterogeneous slip distribution on the fault. Some of the simple source models are based on a symmetrical circular fault model (Madariaga & Ruiz, 2016). The assumption of the isotropic rupture evolution on a symmetrical circular fault can lead to a large estimation error of the fault size and thus the stress drops if the real source process is asymmetrical or exhibits a significant directivity effect (e.g., Kaneko & Shearer, 2015). We should carefully check if we can assume a symmetrical source model when we apply it in analyzing seismograms of small earthquakes.

We investigated the rupture directivities of small and moderate-sized earthquakes (M_JMA>2) in the Yamagata-Fukushima border earthquake swarm which was estimated to be triggered by the upward fluid movement after the 2011 Tohoku-Oki earthquake. We utilized the dense nationwide seismic network in Japan to estimate the rupture directivity. Apparent source time functions were calculated at each station for 1,782 earthquakes based on the waveform deconvolution technique with nearby (< 300 m) small earthquakes to remove the propagation- and site-effects. We found clear directional dependences of the peak amplitude and the pulse width in the apparent source time functions, suggesting the earthquake rupture directivity, for 904 of 1,782 events.

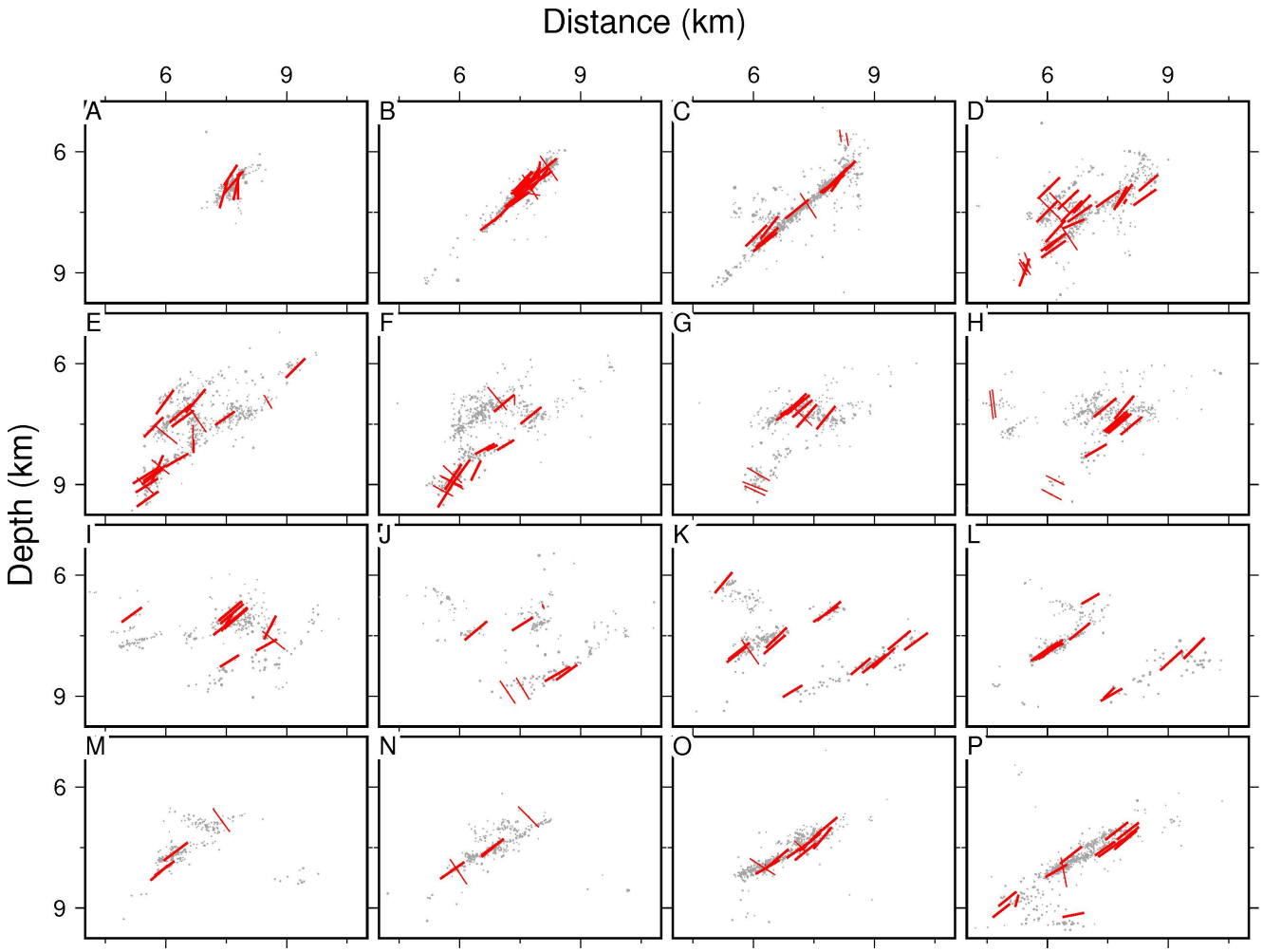
Based on the unilateral rupture model, we estimated the direction, duration, and velocity of rupture for each earthquake. Rupture directions of most earthquakes tend to be different from those of the hypocenter migration. This difference between the microscopic and macroscopic propagations of rupture might be explained by the spatial variation of the frictional strength; ruptures of each earthquake are hindered to develop toward shallower part due to higher frictional strength ahead of the pore-pressure front (shallower part) than behind (deeper part). It suggests the importance of the knowledge of frictional strength on fault to understand fracture dynamics of small earthquakes.

Besides, we estimated fault planes of small and moderate-sized earthquakes based on focal mechanism and rupture directivity (Fig.). Most of fault planes are parallel to the macroscopic planar structures, which suggests that they were triggered by fluid intrusions along those common planar structures. By taking the limitation of the resolution of hypocenter relocation, information from the rupture directivity can be unique data to reliably determine the fault planes of small and moderate-sized earthquakes.

By considering the estimated fault planes and areas of small earthquakes, we confirmed the temporal increase in stress drop reported by Yoshida et al. (2017, JGR). The systematic temporal changes in frictional strength, stress drop, background seismicity rate, b-values, the upward hypocenter migration along the planar structures, and the rupture directivity rather opposite to the hypocenter migration can be explained in a consistent manner by the effects of the upward fluid flow along several pre-existing planes after the 2011 M9 Tohoku-Oki earthquake.

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Keywords: frictional strength, stress drop, hypocenter migration



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Possible aseismic phenomena causing the hypocenter migration in the precursory activity and aftershocks of the 2017 M 5.3 Kagoshima Bay earthquake, Kyusyu, SW Japan

*Yoshiaki Matsumoto[1], Keisuke Yoshida[1], Toru Matsuzawa[1], Akira Hasegawa[1]

1. Research Center for Prediction of Earthquakes and Volcanic Eruptions, Tohoku University

An earthquake occurs when the shear stress acting on the fault plane reaches the frictional strength. It has been suggested that an increase in pore pressure plays an important role in earthquake occurrence (e.g. Hasegawa, 2017; Hubbert & Rubey, 1959; Nur & Booker, 1972; Sibson, 1992). Migration behavior of earthquake hypocenters is considered to be caused by aseismic processes such as fluid movements or aseismic slip propagations. It is expected that information on aseismic processes in the crust can be obtained by examining the hypocenter migration in detail.

On 11 July 2017, an M 5.3 earthquake occurred at approximately 10 km depth in Kagoshima Bay, Kyusyu, SW Japan. Near the main shock hypocenter, seismicity had been activated since December 2016. In order to investigate the generation mechanism of this seismic sequence, we improved relative locations of hypocenters of the precursory activity and aftershocks by using waveform cross correlations.

First, precise differential arrival times were obtained by calculating cross correlations of a pair of waveforms out of the earthquakes that occurred after January 2010 in the Southern Kagoshima Bay region. We used waveform data observed at 20 stations located around the main shock hypocenter. Calculations of cross correlations of waveforms were performed in the same way as Yoshida & Hasegawa (2018). Then, we applied the double-difference relocation method (Waldhauser and Ellsworth, 2000) to the differential arrival time data thus obtained by cross correlations and those listed in the JMA (Japan Meteorological Agency) unified catalog. We used hypocenters listed in the JMA unified hypocenter catalog as the initial hypocenters in the relocation.

The relocated hypocenters are concentrated forming several thin “planes”. The dominant orientations of the planes agree with the eithers of nodal planes of focal mechanisms of the main shock and aftershocks.

Hypocenters of the precursory activity are neatly concentrated along one of the planes and exhibit distinct migration behavior. Hypocenter distribution of the precursory activity along that plane shows a clear seismic gap located adjacent to the main shock hypocenter. Most of aftershock hypocenters are distributed along the same plane but did not fill this seismic gap. We calculated the corner frequency of the mainshock source spectrum using the spectral ratio method and estimated the mainshock fault size. The estimated fault size is consistent with the size of the seismic gap. It suggests that the seismic gap reflects the main shock rupture area (e.g. Wetzler et al., 2018).

Aftershocks tend to move upward with time along several thin planes. This spatiotemporal feature of earthquake hypocenters is similar to those observed in the earthquake swarms in central Tohoku that were triggered by the 2011 M9 Tohoku-Oki earthquake probably due to the upward movement of fluids (Yoshida & Hasegawa, 2018)

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We explain the characteristics of the precursory activity, main shock and aftershocks as follows. (1) Prior to the occurrence of the main shock, crustal fluids penetrated into an existing weak plane from below and reduced the frictional strength, which caused the precursory seismic activity along the plane and the migration of hypocenters. Aseismic slip might also contribute to the hypocenter migration. (2) Then the seismic gap, which had not been ruptured by the precursory activity, was finally ruptured by the main shock. (3) Due to the stress change associated with the main shock, aftershocks were triggered in the region surrounding the main shock hypocenter. Aftershock hypocenters moved upward due to the upward fluid movements after the main shock.

Keywords: seismic activity in Kagoshima Bay, precursory seismic activity, aftershocks, hypocenter migration, seismic gap

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Stress and pore fluid pressure changes in fault zone preceding the earthquake occurrence

*Teruo Yamashita

I theoretically study stress and fluid pressure changes in fluid-saturated fault zone that deforms elasto-plastically. Such study will be useful to gain an insight into the process leading to the earthquake occurrence. I employ poro-elasto-plasticity theory (Coussy,2006) and assume a Capped Drucker-Prager model as the yield criterion (Figure 1). The line segment (A) is described by the equation $f= \tau_J + f_m \sigma_{eff} + \kappa = 0$, where f_m and κ are the internal friction coefficient and a function of the hardening variable; $(\tau_J)^2$ and σ_{eff} denote the second deviatoric stress invariant and the effective mean stress. The point I represents the initial state in the elastic region and the yield criterion is satisfied first at point P on A; relatively low effective normal stress is assumed. The stresses τ_J and σ_{eff} move in a direction indicated by the arrow along the line segment A with the increase in the remotely applied stresses. I assume a non-associated flow law; the plastic potential corresponding to the line segment A is given by the equation $g= \tau_J + f_d \sigma_{eff} + \kappa$, where f_d is the dilatancy factor. It is known that the plastic component of volumetric strain is positive on the line segment A, so that the fluid pressure change will be negative there. It is known that f_m is larger for larger values of porosity (Chang et al.,2006). It is also known for low porosity rocks that permeability is higher at locations closer to the fault core, so that it will be allowed to assume that f_m is smaller at locations closer to the fault core. I therefore assume a 1D model such that f_m takes a minimum value just outside the fault core ($|y|=c+0$) and it increases linearly with the distance and attains a constant value (Figure 2). The f_m-increase zone is defined as the fault damage zone. Since the porosity is sufficiently low in the fault core, the value of f_m in the fault core is assumed to be equal to that at $y=\infty$; the boundary at $|y|=c$ is assumed to be impermeable. I also assume the absolute values of the remotely applied principal stresses ($\sigma_1 < \sigma_2 < \sigma_3 < 0$) increase quasi-statically with time. Hence, the yield criterion is first satisfied at $|y|=c+0$; the plastic zone expands with further stress accumulation. The plastic deformation never occurs in the fault core during the calculation. In this model, the time scale is governed by the magnitude of permeability. I assume that the increase rate of the maximum principal stress σ_1 that is remotely applied is 0.2MPa/year. Figure 3 shows examples of fluid pressure change at $|y|=c+0$ for the permeability$10^{-18}m^2$. The curve A is the case of plastic hardening. While both B and C are the cases of perfect plasticity, the damage zone width for C is twice as large as that for B. The figure shows that the fluid pressure decrease is larger for smaller degree of plastic hardening or for larger damage zone width. However, the elastic component of fluid pressure change (elevation) is estimated to be about 10MPa at time t/dt=10,000. Hence, the plastic decrease of fluid pressure is almost negligible. The calculation also shows that the values of $|\sigma_1 - \sigma_3|$ and $|\sigma_1 + \sigma_3|$ in the plastic zone are, respectively, smaller and larger than those in the elastic zone; the difference grows with the expansion of plastic zone. This suggests that the fault damage zone become more stable with the expansion of plastic zone, while the sudden stress and fluid pressure changes formed at $|y|=c$ may damage the impermeable boundary there. However, such stable situation never lasts indefinitely. The yield criterion such as represented by the curve B in Figure 1 seems to be satisfied once stresses exceeds a critical threshold. The plastic component of volumetric strain turns negative on the curve B, so that the damage zone may become unstable. Hence, the stress point is required to move onto the curve B for the occurrence of earthquake. I will show numerical examples of the whole process leading to the earthquake occurrence in the presentation.

Keywords: poro-elasto-plasticity theory, Drucker-Prager model, fault zone

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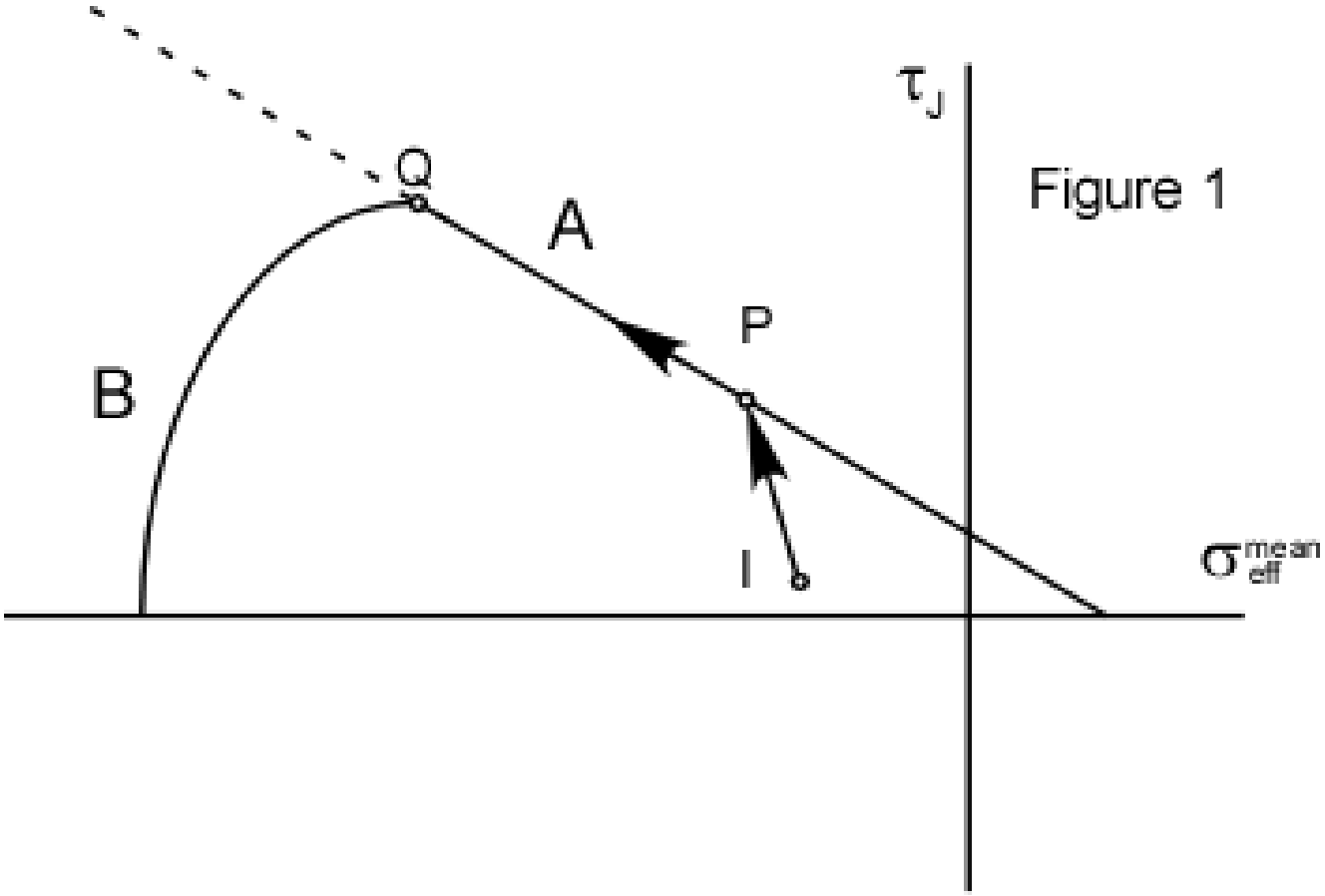


Figure 1

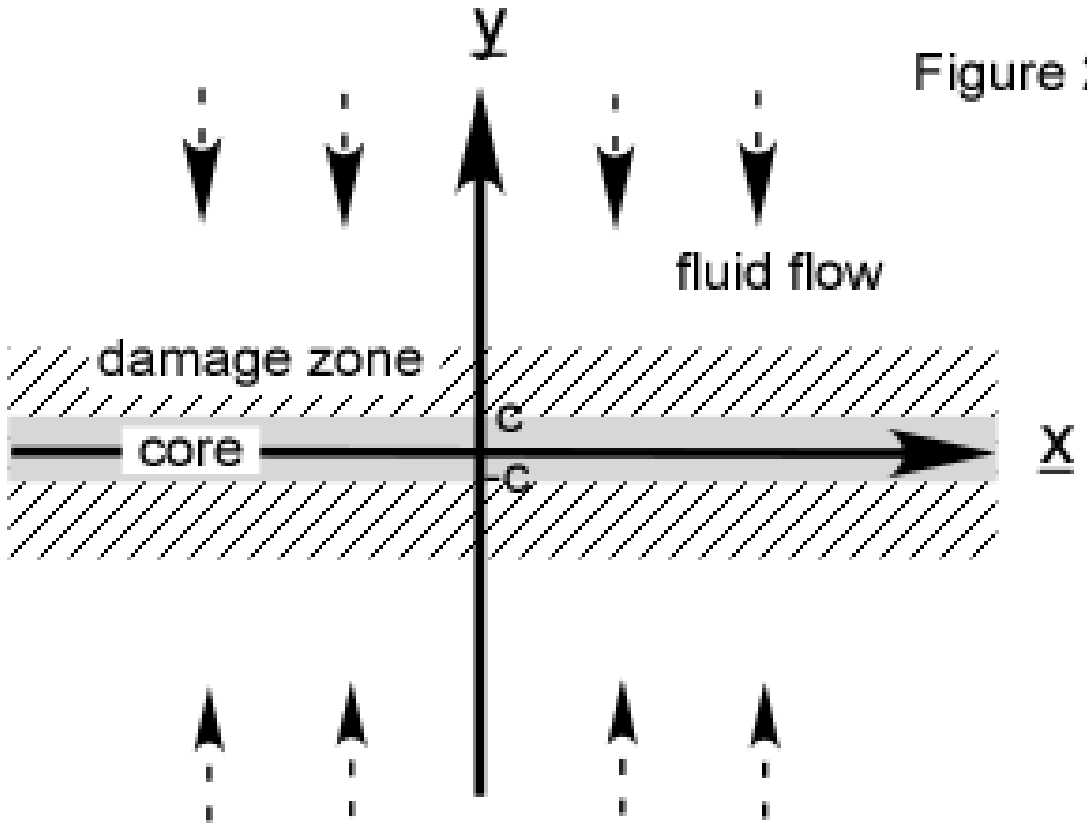


Figure 2

Figure 3

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Micromechanical model of fluid-induced seismicity to reproduce observed spatiotemporal changes in source parameters and on-fault fluid diffusion

*Daisuke Sato[1], Keisuke Yoshida[2]

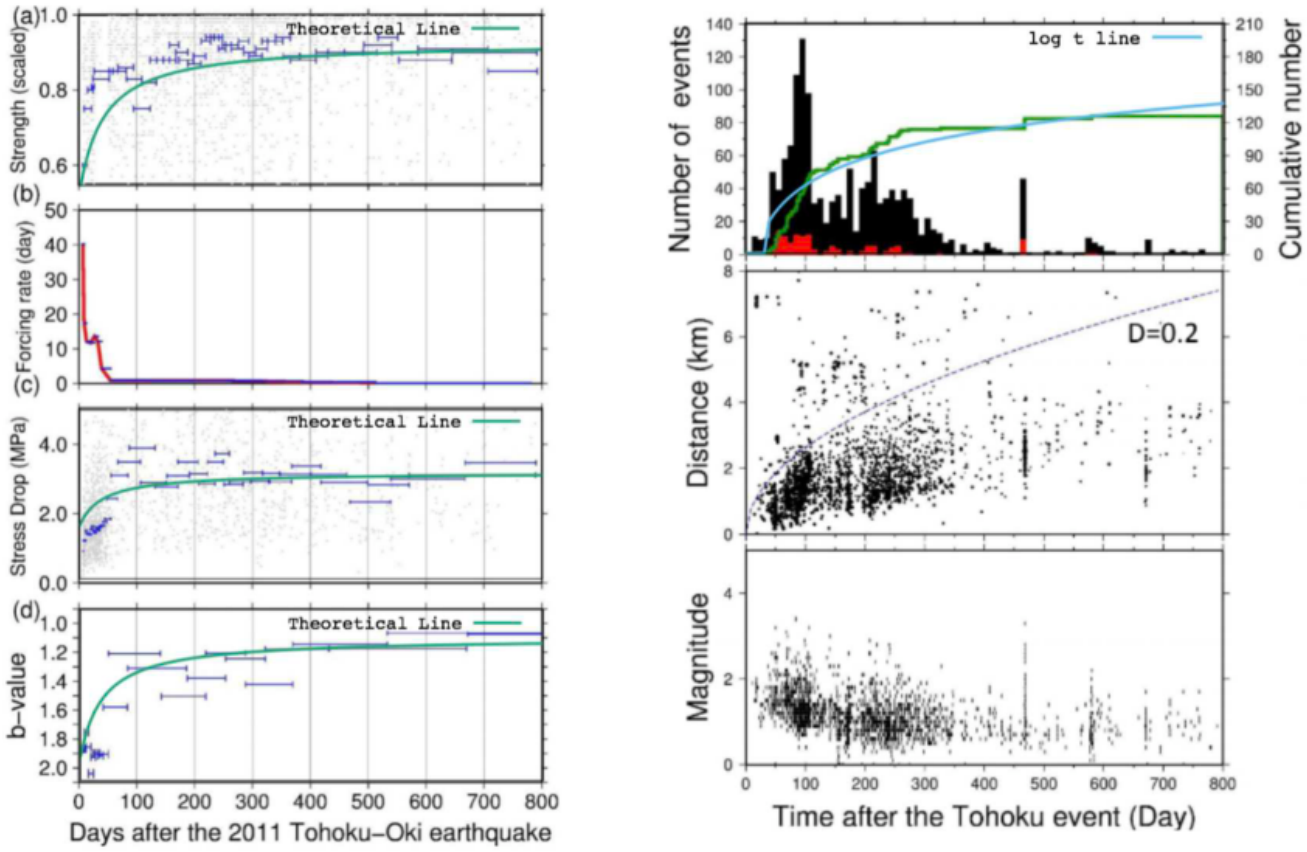
1. Disaster Prevention Research Institute, Kyoto University, 2. Tohoku University

Fluid and seisimicity are considered to be related, as suggested from earthquake swams of natural earthquakes and man-made earhtquakes induced by fluid injection. Some data analysis with relocation techniques of earthquake sources showed that the earthquake activities propagete facially (e.g., Yukutake et al., 2010), and that some source parameters (such as stres drops, strength, b-value, seismicity rate) are functions of elapsed time from fluid injection (Bachmann et al., 2012) or sudden increase of (possibly fluid-induced) seisimicity rate not following mainshocks (Yoshida et al., 2017). In this research, by considering strength heterogeneity of faults expected from experimentally verified physics, we provide the micromechanical model of such seismicity induced by on-fault fluid diffusion, and explain the results of the above data-driven analysis.

Presentation contains following four contents. First, the micromechanical model is proposed. In the model, many patches are distributed randomly on a fault so that the patches are sufficiently small (or distant) to interact with each other; those patches rupture when the effective strength becomes smaller than applied shear stress due to the fluid diffusion. Second, the spatiotemporal changes of the source parameters are obtained as the solutions of the model. Consequently, multiple source parameters are parametrized by injected pressure, diffusion raidus of fluid, normal stress on the fault, and the fluctuation of the exess strength; after the parametrization, those source parameters are shown to follow the common master curve. Third, the observed data is fitted, and the consistency between the theory and the observation is suggested. Fourth, the thoretical prediction for the temporal transience in the moment release rate is checked by the data of Yoshida et al. (2017), and the result strongly supports the theory.

Keywords: earthquake swarms and induced-seismicity, micromechanical model, source paraemters

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Yoshida et al. (2017)

Fig. 1. A data example of Yoshida et al. (2017) fitted by our theoretical model (written as theoretical or log t line in the figure), after Yoshida et al (2017). (Left) Temporal evolution of the source paramters. (Right) Number of events and the spatial patterns of the seismicity.

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Tue. May 28, 2019 3:30 PM - 5:00 PM JST | Tue. May 28, 2019 6:30 AM - 8:00 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[S-SS15] Active faults and paleoseismology

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Takashi OGAMI(National Institute of Advanced Industrial Science and Technology), Ryosuke Doke(Hot Springs Research Institute of Kanagawa Prefecture), Hisao Kondo(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Chairperson:Mamoru KOARAI(Ibaraki University), Taku Komatsubara(産業技術総合研究所)

Geologic and historic information on seismic cycles and on the magnitude and source faults of past earthquakes is essential information to understand future large earthquakes. The study of past faulting and seismicity is an important issue for an interdisciplinary community of seismologists, geologists, geomorphologists, archaeologists, and historians.

3:30 PM - 4:00 PM JST | 6:30 AM - 7:00 AM UTC

[SSS15-01] Historical documents and oral transmissions on historical tsunamis in the Paciffic coast of Tohoku

★Invited Papers

*ebina yuichi[1] (1.International Research Institute of Disaster Science)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SSS15-02] Co-seismic crustal movements along reverse faults which subsidence component is larger than uplifting component

*Taku Komatsubara[1] (1.Institute of Geology and Geoinformation, Advanced Industrial Science and Technology)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SSS15-03] The Iyo-Bungo, southwest Japan, earthquake on September 1st, 1596 as deduced from contemporary historical records

*Katsuhiko Ishibashi[1] (1.Emeritus Professor, Kobe University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SSS15-04] Geologically recorded historical and prehistoric tsunamis in the Tonankai region

*Shigehiro Fujino[1], Haruo Kimura[2], Junko Komatsubara[3], Dan Matsumoto[3], Yuichi Namegaya[3], Yuki Sawai[3], Masanobu Shishikura[3] (1.Faculty of Life and Environmental Sciences, University of Tsukuba, 2.Civil Engineering Research Laboratory, Central Research Institute of Electric Power Industry, 3.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST))

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

Discussion

Historical documents and oral transmissions on historical tsunamis in the Paciffic coast of Tohoku

*ebina yuichi[1]

1. International Research Institute of Disaster Science

I analyzed historical tsunamis which attacked the Pacific coast of Tohoku, especially on the AD 1611 Keicho Oshu earthquake and tsunami (commonly called as the Keicho Sanriku earthquake and tsunami), based on historical documents, oral transmissions, and formation process of them.

After the AD 2011 Great East Japan Earthquake, huge historical tsunamis which damaged in the Pacific coast of Tohoku district have received attention. Some people consider the AD 869 Jogan earthquake as the precursor of AD 2011 earthquake and believe huge tsunamis occur once a thousand years. People also recognize the importance of oral transmission and the place name comes from past disasters. Previous studies pointed out the underestimation of the AD 1611 Keicho Oshu earthquake and tsunami but reinvestigated the earthquake and tsunami based on historical documents (Ebina and Imai 2014). Recently, some studies considered the AD 1454 Kyotoku earthquake as a similar event to AD 1611 Keicho oshu earthquake (Namegaya and Yata 2014; Sawai et al., 2015). Furthermore, the tsunami deposit can be correlated with this event have been found in Miyagi and Iwate Prefectures (e.g., Sawai et al., 2012; Takada et al., 2016).

According to “Sunpu Seiji Roku” and “Sunpu Ki", a vassal of the Date family said that another vassal of that encountered the tsunami on the boat during fishing and the boat was driven to the top of the mountain “Senganmatsu”. This event was estimated to occur near the mouth of Abukumagawa River in Iwanuma City. Watanabe (1998) considered this story was not true because Senganmatsu area is too high to be inundated. However, the pictorial map around Iwanuma created in Edo period indicates that Abukumagawa River was located inland from the present position of the river in that time, where a fishing village has been located since the middle ages (Ebina, 2014). Therefore, it is likely that the tsunami actually attacked the area although the story has a little exaggeration.
It is important to restore old geographical features for constraining the sizes of earthquakes and tsunamis. For instance, Fukuhara and Tanioka (2018) estimated that the magnitude of the Keicho earthquake is similar to or large than that of AD 2011 earthquake based on the data of tsunami height inferred from historical documents and oral transmissions in Miyako City, Iwate Prefecture compiled by Ebina and Imai (2014). However, the restored geographical features show that places inundated by the Keicho tsunami were located near the old channel. Therefore, the inundation in Miyako can be interpreted as the result of river run-up.

The knowledge of historical earthquakes and tsunamis along the Pacific coast of Tohoku have not been known by local residents before AD 2011 earthquake and tsunami. According to “Zishigaku Oyobi Chirigaku Kenkyu Zairyo Hokoku”, when the Imperial Science University of Tokyo (present the University of Tokyo) carried out a questionnaire about the existence of "Kaisyo" to municipal corporations all over the country in the 1890s, those in the coastal regions of Iwate answered that there are no historical records and oral transmissions on the historical earthquakes and tsunamis before AD 1856 Ansei Hachinohe-oki earthquake tsunami (Ebina and Satake 2018). This report shows that the coastal residents did not recognize that tsunamis frequently attack the Pacific coast of Tohoku in those days. Shoshin Yamana reevaluated the historical records and oral transmissions still remained in the coastal area. He

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carried out the survey after the AD 1896 Meiji Sanriku earthquake tsunami and wrote “Sanriku Engan Daikaisyo Torisirabe Syo”. This book includes that the description of the damage in many areas and Keicho Oshu earthquake tsunami hand-copied from the reference books of "Muto Rokuemon Syozo Komonzyo" and “Miyako Yurai Ki. These materials are obtained by the survey for influential local persons in various places. Yamana also studied the place name may be coming from driftage by past tsunamis through the interview survey to the local residents and compiled those as “Iwate Engan Kochimei Ko”. Among those 40 place names, half of them still exist (Muranaka et al., 2017). However, it is difficult to consider that many of those places were inundated by tsunamis. The possibility that some oral transmissions of those place names newly generated under the confusion by the Meiji Sanriku earthquake and tsunami.
Considering the historical viewpoint on formation processes of historical documents and oral transmissions will be useful for studies on paleo earthquakes and tsunamis.

Keywords: historical tsunamis, historical documents and oral transmissions, Interdisciplinary research, Keicho Oshu earthquake and tsunami

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Co-seismic crustal movements along reverse faults which subsidence component is larger than uplifting component

*Taku Komatsubara[1]

1. Institute of Geology and Geoinformation, Advanced Industrial Science and Technology

Introduction

Reverse faulting should cause crustal movement which uplifting component is larger than subsidence component. There are many reverse faults which subsidence component is larger than uplifting one in the Niigata-Kobe and eastern margin of Japan Sea tectonic zones during geological era, Presenter gathered examples of historical co-seismic crustal movement along such faults.

Example 1. Kuwana fault and AD 1586 Tensho Earthquake, Mie Pref., central Japan

Height of the MIS5e shoreline in the uplift area of the Kuwana fault is +63m, it of the upper surface of MIS5e marine deposits in the subsidence area is -92 to -72m.

This fault is one of the source of the 1586 Tensho Earthquake, however a house built on AD 1576 is existing in the subsidence area near the coast at that time. Almost all medieval structural remain surfaces in the subsidence area are less than 1m beneath ground in depth.

Example 2. Hyuuga fault and AD 1662 Kambun Ohmi-Wakasa Earthquake, Fukui Pref., central Japan

Height of the MIS5e shoreline in the uplift area of the Hyuuga fault is +15 to +16m, and it of the upper surface of the MIS5 lacustrine sediments in the subsidence area is -90 to -80 m.

Ahistorical document reported 2.4 m uplift on the north eastern side of Lake Mikata (Suga) and 1.5 m subsidence on the south western side of it occurred during the 1662 Kambun Ohmi-Wakasa Earthquake.

Example 3. Noshiro fault zone and AD1694 Genroku Noshiro Earthquake, Akita Pref., north eastern Japan

Height of the MIS5e shoreline in the uplift area of the Noshiro fault is +30 to 60m, it of the upper surface of the MIS5e marine deposits in the subsidence area is -85m. The 1694 Genroku Noshiro Earthquake induced uplifting of northern bank of the Hachiro-gata lagoon, but no reports describes subsidence in the footwall side of it.

Conclusion

These three historical co-seismic crustal movement along the subsidence prevailing reverse fault did not go with distinct subsidence. This suggests aseismic subsidence in the footwall side of these faults have occurred in the geological era.

Keywords: historical earthquake, co-seismic crustal movement, reverse fault, Niigata-Kobe tectonic zone, eastern margin of Japan Sea tectonic zone

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The Iyo-Bungo, southwest Japan, earthquake on September 1st, 1596 as deduced from contemporary historical records

*Katsuhiko Ishibashi[1]

1. Emeritus Professor, Kobe University

In leap July of the 5th year of the Bunroku era (in the old Japanese lunar calendar; September, 1596 in the Gregorian calendar) Bungo province (present-day Oita Prefecture) in Kyushu, southwest Japan, suffered from severe earthquake and tsunami disasters. Concerning the occurrence date of the causative earthquake, currently prevailing idea is that a large earthquake took place on leap July 9 in Iyo province (present-day Ehime Prefecture) in Shikoku, on the eastward opposite shore of Bungo, and another large earthquake occurred on leap July 12 around Bungo. Against this idea I claim that a single event which could be called "the Iyo-Bungo earthquake" occurred around seven p.m. on leap July 9 in the Iyo-Bungo region based on reliable contemporary historical records.

There are more than 70 documents on this (these) earthquake(s) printed in the existing collections of historical earthquake materials, but their values as historical records vary considerably. Since the essential principle of historiographical seismology is to utilize only reliable first-grade documents, I performed historical source criticism to select 16 contemporary materials. I referred to their original or best texts, not using texts printed in the collections.

According to the contemporary records, in Bungo, violent earthquake ground motion collapsed shrines around seven to nine p.m. on leap July 9 and a large tsunami hit Fuchu (Oita) in the twilight (*"Yusuhara-no-miya Nendai Ryakki"*). *"Kodo-ji Daihan'nyakyo Okugaki"* and *"Shibayama Kanbei Ki"* also describe strong earthquake shaking and large tsunami around Fuchu on that day. In Kyoto, roughly 430 km east-northeast of Bungo, earthquake ground motion was felt around seven to nine p.m. on leap July 9 (*"Kotokuni-kyo Ki"*), or around seven p.m. on the same day rather strongly (*"Ozuki-Takasuke-Sukune Ki"*). In Hiroshima Prefecture, at Hatsuka-ichi and Itsukushima strong ground motions were felt at night on leap July 9 without damages (*"Hoida Motokiyo's letter"*), and at Mihara strong earthquake tremors continued from leap July 9 till 12 (*"Buttsu-zenji Juji Ki"*). In Iyo, *"Yakushi-ji Daihan'nyakyo Okugaki"* says a severe earthquake tremor occurred on leap July 9 and the whole Iyo province had trouble, suggesting earthquake disaster in a wide area. In Satsuma and Osumi provinces (present-day Kagoshima Prefecture), *"Kabayama Shoken Jiki"* writes a strong earthquake on leap July 9, and *"Nanko Nikki Zankan"* also writes an earthquake on the same day. *"Chosa Yachi's letter"* written on leap July 29 describes that since leap July 8 earthquake tremors had continued.

As a fundamental methodology of historiographical seismology, these tremors and tsunami in Bungo, Iyo, Kyoto, Hiroshima and Kagoshima on leap July 9 are considered to have been produced by an identical earthquake unless there is any counter-evidence. Leap July 12, the other proposed date of the Bungo earthquake, comes from historical materials written after 1698, which probably mistook the great Kyoto earthquake in the midnight of leap July 12 for the Bungo event. The seismic intensities are evaluated to be stronger 6 in some places in Bungo and Iyo, 4 in Hiroshima, stronger 3 in Kyoto, and about 3 in Kagoshima on the JMA scale. The most simple and reasonable interpretation is that a large earthquake with the source region from around Oita to the midst of Iyo took place around seven p.m. on leap July 9, whose magnitude being around 7.5, and the tsunami on the Bungo coast followed. The rupture of the Kawakami fault in the MTL fault zone during this earthquake suggested by Tsutsumi *et al.* (2000) may have

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occurred.

Keywords: 1596, Iyo-Bungo earthquake, historical source criticism, contemporary historical documents, MTL fault zone

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Geologically recorded historical and prehistoric tsunamis in the Tonankai region

*Shigehiro Fujino[1], Haruo Kimura[2], Junko Komatsubara[3], Dan Matsumoto[3], Yuichi Namegaya[3], Yuki Sawai[3], Masanobu Shishikura[3]

1. Faculty of Life and Environmental Sciences, University of Tsukuba, 2. Civil Engineering Research Laboratory, Central Research Institute of Electric Power Industry, 3. Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)

A coring survey at a coastal lowland in Mie Prefecture exposed 10 sand layers deposited from about 4500 to 500 years ago. The layers are interpreted as tsunami deposits because of the presence of abundant bioclasts of marine organisms such as foraminifers and gastropods, and sedimentary structures common in modern tsunami deposits. At the study site, no substantial seawater inundations and sand depositions have been recorded even for the largest typhoons to ever hit the region. On the other hand, written document tells that the Ansei-Tokai earthquake tsunami (1854 CE) inundated the study site and deposited substantial sand layer. Estimated ages of the youngest three sand layers overlap well with tsunamis in 1498, 1096, and 684 CE. Our results support the hypothesis suggested by archaeological studies that the 684 CE rupture extended farther eastward than the historical record indicates or that another tsunami occurred at some time close to 684 CE. We did not find any sand layers that were definitely correlated with the tsunamis of 1361 and 887 CE, which are thought to have occurred by multi-segment ruptures of the Nankai Trough that includes the segment directly offshore from the study site. If the sand layers found at the study site were deposited by the tsunamis of 1498, 1096, and 684 CE, and if the tsunamis of 1361 and 887 CE did not inundate the study site, the tsunami recurrence interval during the relevant time period was about 400 years. This finding does not support the widely believed hypothesis that earthquakes and tsunamis occur at regular intervals of approximately 100 years in this area. In addition, similar to the historical tsunamis, intervals of geologically recorded prehistoric tsunamis at the study site vary from about 100 to 600 years. The hypothesis of variable recurrence of earthquakes and tsunamis along the Nankai Trough should be tested by future geological and historical studies in unbiased way.

Keywords: tsunami deposit, Nankai Trough, recurrence interval

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[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

Tue. May 28, 2019 9:00 AM - 10:30 AM JST | Tue. May 28, 2019 12:00 AM - 1:30 AM UTC | IC 2F

[S-VC38] Active Volcanism

convener:Yuta Maeda(Nagoya University), Takahiro Miwa(National research institute for earth science and disaster prevention), Takeshi Nishimura(Department of Geophysics, Graduate School of Science, Tohoku University), Chairperson:Fukashi Maeno, Yosuke Aoki

This session discusses various aspects of active volcanisms including, but not limited to, recent and historical eruptions, various phenomena associated with the volcanic activities, underground structures of the volcanoes, and developments of new instruments based on geophysical, geochemical, geological, and multidiscipline approaches. We also welcome studies on understanding and predicting the transitions of the eruptive activities from observational, theoretical, and experimental approaches.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SVC38-06] A sequence of volcanic flank collapse and tsunami event on 22 December 2018 at Anak Krakatau volcano, Indonesia

*Fukashi Maeno[1], Takayuki Kaneko[1] (1.Earthquake Research Institute, University of Tokyo)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SVC38-07] The 2018 eddifice collapse event of Anak Krakatau, Indonesia: Telseismic waveform analysis and tsunami simulation

*Shingo Watada[1], Iyan E. Mulia[1], Masumi Yamada[2], Dimas Sianipar[3] (1.Earthquake Research Institute, University of Tokyo, 2.Disaster Prevention Research Institute, Kyoto University, 3.TIGP-ESS Academia Sinica, National Central University, Taiwan)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SVC38-08] The 2018 edifice collapse event of Anak Krakatau, Indonesia: Landslide movement history estimated from seismic waveforms

*Masumi Yamada[1], Shingo Watada[2], Haruhisa Nakamichi[1], Iyan Mulia[2], Karyono Dr.[3] (1.Disaster Prevention Research Institute, Kyoto University, 2.Earthquake Research Institute, University of Tokyo, 3.Center for Earthquake and Tsunami, BMKG)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SVC38-09] Intense Swarm Activity in the Vicinity of Yake-dake Volcano, Central Japan, Started in November 2018

*Shiro Ohmi[1] (1.Earthquake Hazards Division, Disaster Prevention Research Institute, Kyoto University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SVC38-10] Change of the volcanic activity at Kuju volcano.

*Mori Takehiko[1], Muga Yaguchi[1], Yasushi Kawamura[2], Hideyuki Hiramatsu[3], Keiji Ikeda[2], Sugai Akira[2], Michitomo Sugahara[2], Kenichi Takata[2], Kyo Matsumoto[2], Fukuoka Regional Headquarters Japan Meteorological Agency, Oita Meteorological Office Japan Meteorological Agency (1. Meteorological Research Institute, Japan Meteorological Agency, 2.Fukuoka Regional Headquarters, Japan Meteorological Agency, 3.Oita Meteorological Office, Japan Meteorological Agency)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SVC38-11] Posteruptive Thermoelastic Deflation of Intruded Magma in Usu Volcano, Japan, 1992–2017

*Yosuke Aoki[1], Xiaowen Wang[1] (1.Earthquake Research Institute, University of Tokyo)

A sequence of volcanic flank collapse and tsunami event on 22 December 2018 at Anak Krakatau volcano, Indonesia

*Fukashi Maeno[1], Takayuki Kaneko[1]

1. Earthquake Research Institute, University of Tokyo

Tsunamis were generated at the Sunda Strait, Indonesia, on 22 December 2018 (~21:00 local time), and a disaster (>430 victims) occurred along the coastal area close to Krakatau. As it became clear that the southwest side of Anak Krakatau Island that has continued eruptive activity in recent years had collapsed, the tsunamis are thought to have occurred with the edifice collapse of this volcanic island (PVMBG, 2018). The volume of collapsed material, the process of the collapse event, the tsunami generation and propagation processes, and the relationship between these and the eruption activity are still unclear. Therefore we investigated the sequence of the eruption and tsunami event at Anak Krakatau on 22 Dec 2018 based on satellite images and tsunami numerical simulation. Infrared data of Himawari-8 showed that thermal anomaly has continued since the middle of June 2018 but no specific anomaly signals were detected before the collapse-tsunami event. Then the data showed that the eruptive plume occurred from ~13:50 UTC on 22 December 2018. This time was 40-70 min before tsunami arrival at the coastal areas around Sunda Strait (~14:30-15:00 UTC). The first eruptive plume developed after ~13:50 but soon declined within an hour, then the second eruptive plume developed from ~15:20. It became much higher than the first one and sustained in the next couple of days. Numerical simulation of tsunami and volcanic flank collapse was carried out with the two-layer shallow water model based on non-linear long wave theory that has been developed for the tsunamis generated by gravity flows (pyroclastic flows, debris avalanche, etc.) flowing into the water. It was solved with a finite difference method. Bathymetry data is the same as that used in Maeno and Imamura (2011). The bottom friction coefficient of the gravity current was set to be 0.01 for subaerial condition and 0.06-0.12 for submarine condition. The interfacial drag coefficients between the gravity current and seawater were set to be 0.2. The four cases with different collapsed volumes (0.16, 0.21, 0.26, 0.31 km^3) were examined. The computed tsunami waveforms were compared with tide gauge records (PVMBG, 2018) at representative locations. The most likely initial condition to explain the tide gauge records was the initial collapse volume of 0.21-0.26 km^3. Other parameters don't significantly affect the results. Numerical results also showed that, for all cases, the maximum wave height (>3 m) in the SW coast of Java became higher than other areas. This tendency is consistent with the observational records that the SW coast of Java was more heavily damaged by tsunamis. This is probably because the direction of the collapse was southwestward but the direction of tsunami propagation was gradually changed from SW to S-SE by the effect of bathymetry. We also calculated tsunami travel times and estimated the occurrence time at the source, comparing with tsunami arrival times recorded in the tide gauges. As a result it seems that the tsunamis were caused by 13:54±2 min. We conclude that the collapse occurred almost simultaneously with the small eruption from ~13:50 UTC then followed by the main sustained eruption from ~15:20. In order to determine the timing and mechanism of the collapse event more precisely, it is necessary to further evaluate initial conditions and models as well as to compare with other geological and geophysical data.

Keywords: volcanic flank collapse, tsunami, Anak Krakatau

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The 2018 eddifice collapse event of Anak Krakatau, Indonesia: Telseismic waveform analysis and tsunami simulation

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On December 22, 2018 at around 14:30 UT, a tsunami hit the coast of Java and Sumatra islands near the Sunda Strait, Indonesia and claimed more than 400 lives. The Anak Krakatau volcano island in the Sunda Strait erupted coeval with the tsunami and the summit elevation decreased from 300 m before the eruption to 100 m after the eruption, suggesting that the tsunami was generated by the subaerial or submarine edifice collapse of Anak Krakatau. SAR images show that the edifice including the summit collapsed toward southwest and disappeared into the sea. Tide gauge records around the strait suggest that the tsunami was generated at around 13:58. There were no report of a strong seismic event in Indonesia before the tsunami event, although broadband seismic networks in and around Indonesia clearly recorded unusual seismic waves (S-waves and Rayleigh waves) dominated by the long-period (50-100 sec) components. S-waves arrived at the Ryukyu islands at 14:11 and Hokkaido at 14:16. Rayleigh waves arrived at Hokkaido at 14:27. All seismic waveforms indicate occurrence of a long-period seismic event at around 13:56 near Anak Krakatau. Teleseismic body waves hint that the source duration is less than 100 sec (about 1min). Three-component broadband seismic records from four stations near the Sunda Strait can be explained by a near horizontal slightly upward force of $5x10^{11}$ N acting toward northeast for the first 20 sec followed by a near horizontal slightly dipping force of the similar magnitude acting toward southwest for about 50 sec. The force direction and angle is consistent with a collapse model predicted by Giachetti et al. (2012, Geol. Soc. London) in which a resurgent volcano Anak Krakatau collapses into the bottom of submarine Krakatau caldera at 250 m deep along a sliding slope with a dip of 8 deg. The estimated total mass of the edifice collapse is $3x10^{11}$ kg based on the empirical formula between the maximum force and the total mass of landslides (Ekström and Stark 2013, Science). Assuming the soil density 2 g/cm^3 the volume is about 0.15 km^3, roughly consistent with the submarine landslide volume 0.2 km^3 estimated from our numerical tsunami simulation for tide gauge records. Based on the routine seismic monitoring no large earthquake enough to cause tsunami was registered. On the other hand, long-period seismic waves from the seismic event at Anak Krakatau coeval with the tsunamis arrived at Jakarta 40 sec after the event. If long-period seismic events were routinely monitored in Indonesia, we could have detect the edifice collapse of the Anak Krakatau volcano and were aware of the possibility of tsunami generation prior to the arrivals of disastrous tsunamis to the coasts.

Keywords: 2018 tsunami in Sunda Strait, 2018 Anak Krakatau volcano eruption edifice collapse, seismic waves and tsunamis from the edifice collapse, submarine landslide

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The 2018 edifice collapse event of Anak Krakatau, Indonesia: Landslide movement history estimated from seismic waveforms

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On December 22, 2018, a huge Tsunami occurred at the Sunda strait in Indonesia, and more than 400 people were killed. There was no large earthquake at that time and the tsunami was associated with the volcanic eruption and edifice collapse in Anak Krakatau island.

The seismic signals due to this event are recorded by the broadband seismic network in Indonesia. There are about 170 broadband stations all over Indonesia, with a spacing 50-100 km. We performed the seismic waveform inversion using long-period component (20-100 s) at the near-field distance (60-200 km), assuming a single force mechanism. We also performed a grid search with 10 km spacing to estimate the location of the source.

Our result shows that the onset of the event was about 14:55:50 (UTC), December 22, 2018. The duration of the source time function is about 1 min with a large amplitude, followed by a smaller signal about a few min. The particle motion of the source time function suggests the event was occurred from northeast to southwest direction with very low dipping angle (about 10 degree). The location of the event was estimated at the Anak Krakatau.

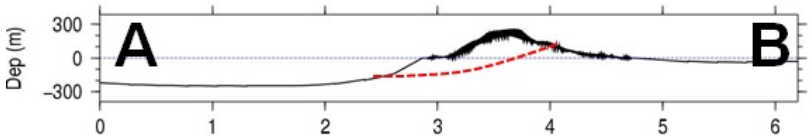
This seismic event was most likely caused by the edifice collapse of the Anak Krakatau. The satellite image shows that the southwest half of the island was subsided after the collapse, and there is a oceanic basin at the depth of 200 m in the southwest of the island, which was the old crater created by the eruption in 1883. These geometries are consistent with the movement history estimated by the seismic waveform inversion.

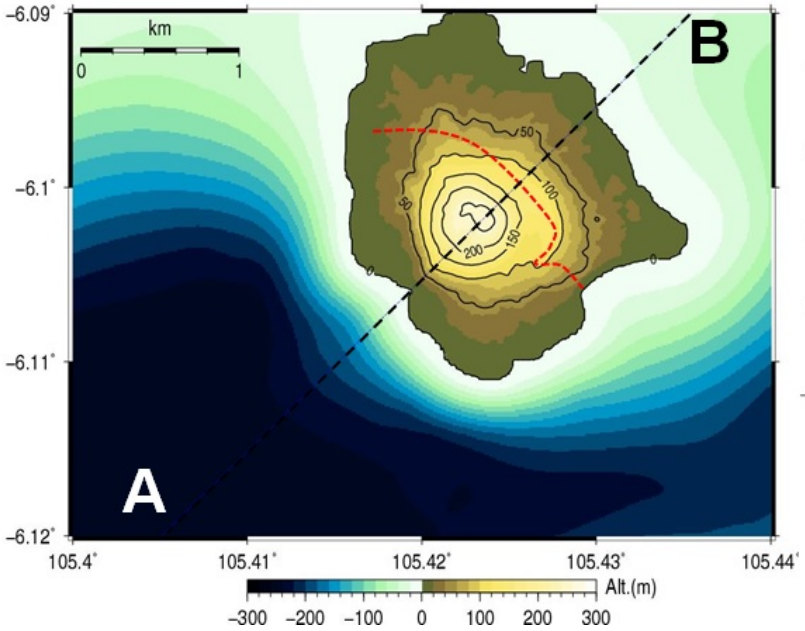
Based on the scaling relationship between single force amplitude vs mass of the landslide (Ekström and Sterk, 2013), the mass was estimated as 0.2-0.4 * 10^12 kg. This number is consistent with the volume estimated by the tsunami waveform simulation (Maeno and Kaneko 2019; Watada et al., 2019). We think that the edifice collapse was very low-dipping and moved like a landslide, and the mass sliding into the ocean caused the huge tsunami.

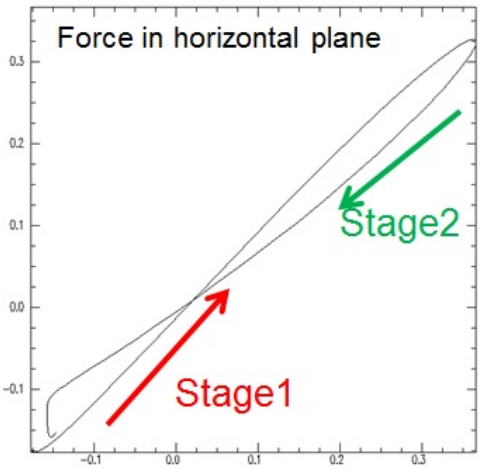
The relationship between this landslide and volcanic eruption is still debating, but Center for Volcanology and Geological Disaster Mitigation in Indonesia officially reported the timing of the eruption was 15:03 (UTC). Since the occurrence of the landslide was estimated as 14:55:50, the eruption may be triggered by the landslide, such as the 1980 eruption of Mount St. Helens triggered by the massive landslide.

Keywords: Anak Krakatau, Volcanic eruption, Landslide, Seismic waveform inversion

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Intense Swarm Activity in the Vicinity of Yake-dake Volcano, Central Japan, Started in November 2018

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An intense seismic swarm activity started in November, 2018 in the vicinity of the Yakedake volcano, Hida mountain range, central Japan. It started on November 22 and lasted for about 10 days (hereafter sited as Series A) . Hypocenters are located at the western flank of the Yakedake volcano in the depth range from 3 km to 4 km below sea level. On December 4, a small swarm activity occurred in the Kamikochi area, where is the eastern flank of Yake-dake volvano, that lasted for two days (Series B). Other small activities took place at the end of January 2019 (Series C) to the western area of the activity of Series A, as well as an activity just beneath the ridge of Hida mountain range where is several kilometers south to the summit of the Yake-dake volcano in the beginning of February 2019 (Series D).

Earthquakes in Series A exhibit ordinary characteristics of tectonic earthquakes with NW-SE compressional stress field and neither significant hypocenter migration nor change in source mechanism were observed during the activity. Earthquakes in Series B, however, some exhibit normal fault type stress field which is not coincide with the regional stress field.

The maximum intensity reported by JMA was less or equal to level 2 for all the events during the activity, however, instrumental seismic intensity observed nearby hypocentral area by DPRI recorded as large as level 4 for some earthquakes. Monitoring data of Yakedake volcano, that include crustal movement by GNSS and tiltmeter, geomagnetic total intensity by proton magnetometer, and ground temperature nearby summit, did not show the anomalous behavior during the swarm activity.

Keywords: Yake-dake volcano, volcano tectonic earthquakes, swarm activity

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Change of the volcanic activity at Kuju volcano.

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In Kuju volcano, after an eruption occurs at the east-hillside of Mt. Hossyo (near Mt. Iwo) in October 1995 and January 1996, the eruption has not occurred. The continuous volcanological observation by a research institution and Japan Meteorological Agency started after the eruption in 1995. Although the active seismicity which has the hypocenter in the shallow zone under Mt. Iwo was observed, the activity became calm after 2005. Moreover, after 1995, continued cooling in the shallow zone under Mt. Iwo was obtained by the geomagnetic observation, and the trend for fumarolic activity to decline gradually was seen. In this way, the declining volcanic activity was captured by various observation data.
Changes in volcanic activity of Kuju volcano began to appear around 2012. First, the GNSS observation showed that the length of the base line between the two points crossing Kuju volcano began to grow slightly. Next, the geomagnetic observation began showing the heat-reserve trend in the shallow region of Mt. Iwo from 2014. The gradual increase in fumarolic activity starts around 2015, and the slight increase in seismic activity also started around 2016.
Before the 1995 eruption, continuous volcano observation at Kuju volcano was not done, so the change of various phenomena preceding the eruption was not sufficiently obtained. We have not been able to judge whether the current volcanic activity change is an activity suggesting future eruptive activity. However, we believe that accumulation of observational data will help predict future volcanic activity. Then, by continuous observation of multiple items not only including geophysical observations but a volcano chemistry observation, the character of the volcanic activity in Kuju Volcano is grasped, and change of volcanic activity is monitored.

Keywords: volcanic activity, crustal deformation, geomagnetic variation, Volcanic Gas, phreatic explosion

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Posteruptive Thermoelastic Deflation of Intruded Magma in Usu Volcano, Japan, 1992–2017

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Secular ground subsidence at Usu volcano (Japan) has been reported around the eruption vents following the four eruptions in 1910, 1943, 1977, and 2000. However, the mechanisms accounting for the subsidence have not been well understood. In this study, we systematically investigated the posteruptive deformation at Usu volcano using interferometric synthetic aperture radar based on 111 JERS, ALOS-1, and ALOS-2 images acquired from 1992 to 2017. We also calculated quasi east-west and vertical ground displacements between 2006 and 2017. Our results show three localized deformation regions from west to east of Usu volcano with their locations corresponding to the 2000, 1977, and 1943 eruption vents, respectively. All the deformation sites show patterns of east-west contraction and subsidence. The extent and rate of posteruptive subsidence declined dramatically at the vent of the 2000 eruption site from 2006 to 2017, decreased gradually at the 1977 vent, and show a steady pattern for the 1943 site during 1992-2017. We ascribed the observed posteruptive subsidence to thermoelastic contraction of a sphere intruded at the time of the eruptions to constrain locations, depths, and volumes of heat sources with the assumption of the spherical source shapes. Thermoelastic modeling reveals that the heat sources are embedded at shallow depths not deeper than 400 m below sea level with volumes of about (8.72 ±0.19) $\times 10^6$, (132.18 ±5.21) $\times 10^6$, and (49.51 ±2.02) $\times 10^6$ m^3 for the 2000, 1977, and 1943 eruption sites, respectively. The modeling also highlights the importance of underground water in assessing the thermal diffusion process and the associated posteruptive deformation.

Keywords: Lava dome, Thermal contraction, InSAR

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[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

Tue. May 28, 2019 10:45 AM - 12:15 PM JST | Tue. May 28, 2019 1:45 AM - 3:15 AM UTC | IC 2F

[S-VC38] Active Volcanism

convener:Yuta Maeda(Nagoya University), Takahiro Miwa(National research institute for earth science and disaster prevention), Takeshi Nishimura(Department of Geophysics, Graduate School of Science, Tohoku University), Chairperson:Jun Oikawa, Takeshi Tameguri

This session discusses various aspects of active volcanisms including, but not limited to, recent and historical eruptions, various phenomena associated with the volcanic activities, underground structures of the volcanoes, and developments of new instruments based on geophysical, geochemical, geological, and multidiscipline approaches. We also welcome studies on understanding and predicting the transitions of the eruptive activities from observational, theoretical, and experimental approaches.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SVC38-12] Volcanic tremors and ash fall volumes associated with the 2018 vulcanian eruptions of Shinmoe-dake

*Jun Oikawa[1], Yasuhisa Tajima[2] (1.Earthquake Research Institute, University of Tokyo, 2.NIPPON KOEI CO.,LTD.)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SVC38-13] Crustal deformation around the Kirishima Volcano Group detected by GNSS and SAR observation after 2018 eruption.

*Hiroshi Yarai[1], Tomokazu Kobayashi[1], Satoshi Fujiwara[1], Tomokazu Kobayashi[1], Hiroshi Munekane[1], Masaki Honda[1], Kyonosuke Hayahsi[1], Satoshi Kawamoto[1], Atsuko Oowaki[1] (1.GSI of Japan)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SVC38-14] Harmonic tremor during 2011 eruption at Shinmoedake, Japan

*Minoru Takeo[1] (1.Earthquake Research Institute, University of Tokyo)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SVC38-15] Forecasting Volcanic Eruption of Sakurajima Volcano Based on Magma Intrusion Rate

*Masato Iguchi[1], Takeshi Tameguri[1], Jun-ichi Hirabayashi, Haruhisa Nakamichi[1] (1.Sakurajima Volcano Research Center, Disaster Prevention Research Institute, Kyoto University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SVC38-16] Tilt and strain change before and after the explosion at Minami-dake, Sakurajima, in 2017

*Kohei Hotta[1], Masato Iguchi[2] (1.University of Toyama, 2.Disaster Prevention Research Institute, Kyoto University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SVC38-17] Pyroclastic Flow Accompanied with an Eruption on June 16, 2018 at Sakurajima Volcano

*Takeshi Tameguri[1], Masato Iguchi[1], Masayuki Maki[2], Haruhisa Nakamichi[1], Daisuke Miki[1] (1.Sakurajima Volcano Research Center,Disaster Prevention Research Institute, Kyoto University, 2.Research Field in Integrated Studies,Kagoshima University)

Volcanic tremors and ash fall volumes associated with the 2018 vulcanian eruptions of Shinmoe-dake

*Jun Oikawa[1], Yasuhisa Tajima[2]

1. Earthquake Research Institute, University of Tokyo, 2. NIPPON KOEI CO.,LTD.

Kirishima volcanic chain is one of the active volcanoes in southern Kyushu, Japan and is categorized into a composite volcano whose active vents are Shinmoe-dake and Ohachi. The latest eruptive activity of Shinmoe-dake started on August 22, 2008. Subsequently, it erupted on March 30, April 17, May 27, June 27 and 28, and July 5 and 10, 2010. In 2011, the eruption started on January 19 included subplinian and vulcanian explosions. and was followed by sub-Pulinian eruption on 27 January. Eruptive activity gradually ceased since February 2, and moved to Vulcanian activities. It erupted on October in 2017 and on March in 2018. Eruptions continued until June 27. Tajima et. al (JpGU 2019) show volcanic ashfall volumes for each eruption in 2018 and we discuss the relation of ashfall volumes and durations of eruptions that is characterized by the power law: ashfall volume is proportional to durations to the second power.

Keywords: vulcanian eruption, volcanic tremor, ashfall volumes, Shinmoe-dake volcano

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Fig. 1

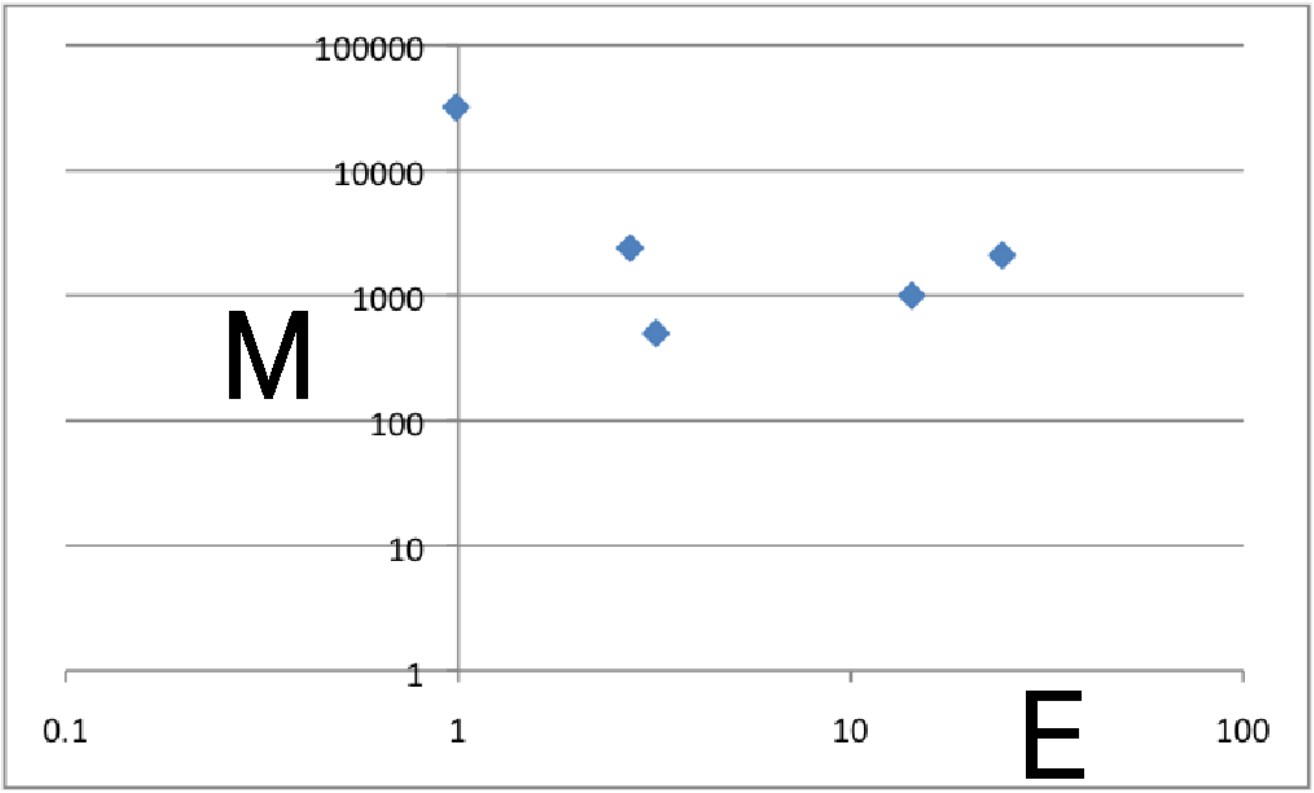
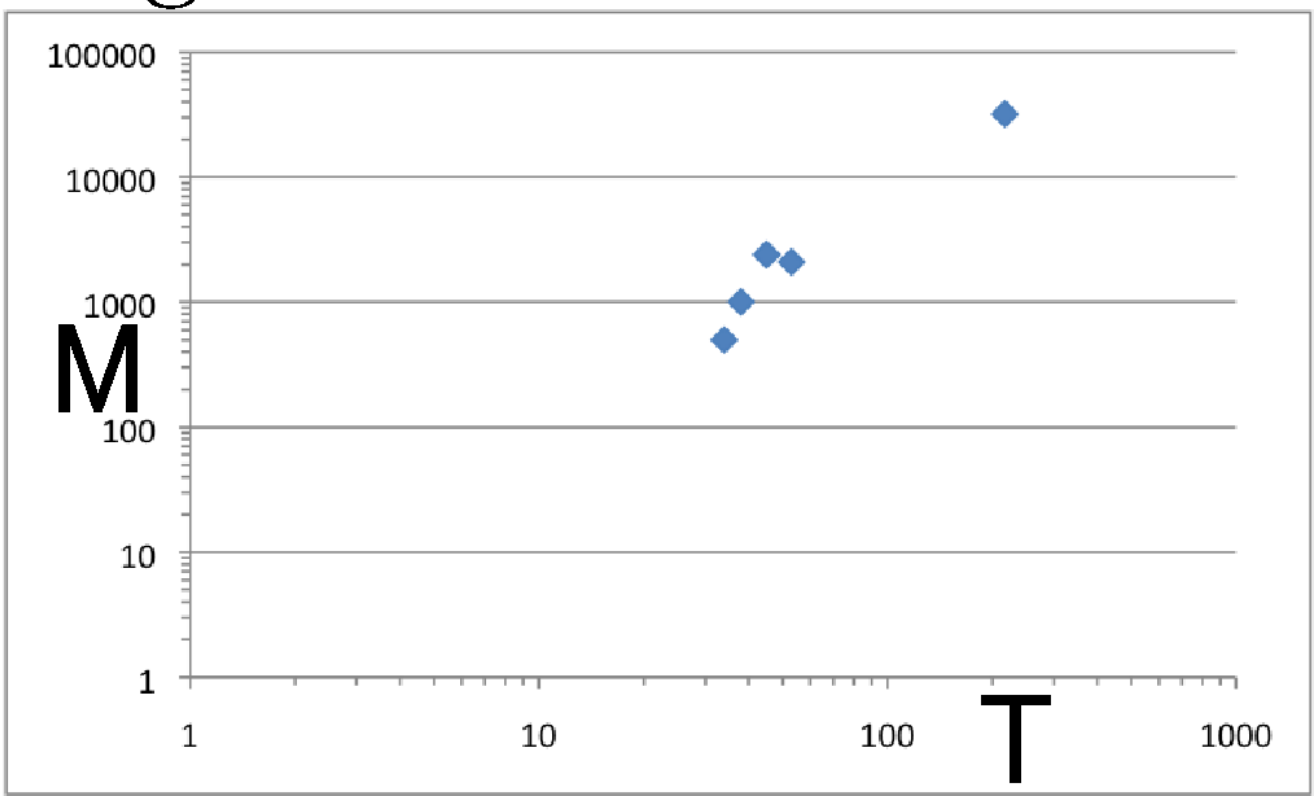


Fig. 2



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Crustal deformation around the Kirishima Volcano Group detected by GNSS and SAR observation after 2018 eruption.

*Hiroshi Yarai[1], Tomokazu Kobayashi[1], Satoshi Fujiwara[1], Tomokazu Kobayashi[1], Hiroshi Munekane[1], Masaki Honda[1], Kyonosuke Hayahsi[1], Satoshi Kawamoto[1], Atsuko Oowaki[1]

1. GSI of Japan

Since July 2017, GNSS Earth Observation Network (GEONET) maintained by Geospatial Information Authority of Japan (GSI) has observed elongation at the baseline surrounding the Kirishima volcano group. Sharp shortening occurred at the eruption of Shinmoedake volcano in March, 2018, after which elongation was observed again. Similar crustal deformations are also observed during the Shinmoedake eruption in 2011, and at that time expansion and contraction of magma reservoir of about 6 to 7 km northwest of Shinmoedake is presumed (for example, Kobayashi et al., 2012) . In addition, in the Iwo-yama located in the northwest of Kirishima-yama, expansive crustal deformation centered the Iwo-yama was captured by analysis of Daichi 2 (ALOS-2) SAR data. In April 2018, an eruption took place in Iwooyama for the first time in 250 years.

Detailed investigation of crustal deformation of the Kirishima volcano group is important in grasping the situation of volcanic activity. In this research, we investigated the crustal deformation of the Kirishima volcano group including Shinmoe-dake and Iwo-yama after the eruption of Shinmoedake and Iwozan in 2018, using GNSS observation and ALOS-2 (Daichi 2) SAR data analysis.

Keywords: Kisihisma volcano Group, Shinmoe-dake, Iwo-yama, crustal deformation, GNSS, SAR

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Harmonic tremor during 2011 eruption at Shinmoedake, Japan

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1. Earthquake Research Institute, University of Tokyo

Volcanic tremor is a continuous seismic signal that is observed near active volcanoes and is often accompanied by evidence of subterranean movement or pressure fluctuation due to a physical or chemical process inside the volcano. However, the source of volcanic tremor is still poorly understood. Most existing tremor’ s models, except for Julian’ s nonlinear channel flow model (Julian, 1994), consider an acoustic resonance in the magma channels, but mechanism to excite this resonance has not been identified until now.

During 2011 eruption at Shinmoedake, Japan, we observed a series of volcanic tremors including harmonic tremor which exhibits a set of narrow, evenly spaced frequency peaks. Natsume *et al.*(2018) perform non-linear time-series analysis on a harmonic tremor recorded near the crater. They found that the stable oscillation of the harmonic tremor is predominantly a limit cycle, implying that the harmonic tremor is generated by self-sustained oscillation. In this paper, I propose a new model of harmonic tremor and reproduce the topological characteristics of observed harmonic tremor using the new model. I formulate a lumped-parameter model of incompressible viscous fluid flow through a partially constrictive path, which seems to be realistic modeling in a shallow part of conduit. I consider inertias and resistances in the upstream and in downstream pipes. The upstream pipe is connected to a large chamber with pressure of Po. Lengths and radiuses of the pipes and the constrictive path could be set flexibly in this model. This model leads to a third-order system of nonlinear ordinary differential equations with functions of area of throat, fluid velocities in upper stream and in downstream. The equations of the model are as follows:
Mass conservations in upstream and in downstream of the constricting path; Conservation of momentum in upstream and in downstream of the constricting path; Equations of motion in upstream pipe and in downstream pipe; Elastic law of the constrictive path;
Typical frequency of the harmonic tremor is 1~2Hz and the wavelength seems to be hundreds meter, so these signals were recorded within a distance of one wavelength, being little affected by wave propagation. Therefore, assuming that these observed signals represent only linear transformations of one parametric function of the nonlinear tremor model, we can compare topological characteristics of observed and simulated signals to evaluate validity of the new model. When the resistance of downstream is larger than that of upstream, a self-sustained oscillation starts in a suitable parameter range. For different driving pressure (Po), numerical solutions exhibit steady flow, simple limit-cycle oscillation, limit-cycle oscillation with double-loops or with quadruple-loops, and a chaotic oscillation. Changing Po in time, I succeed in simulating a harmonic tremor which has same topological characteristics with the observed harmonic tremor in several portions of time series (see Figure 1).

Keywords: volcanic tremor, nonlinear oscillation, chaos

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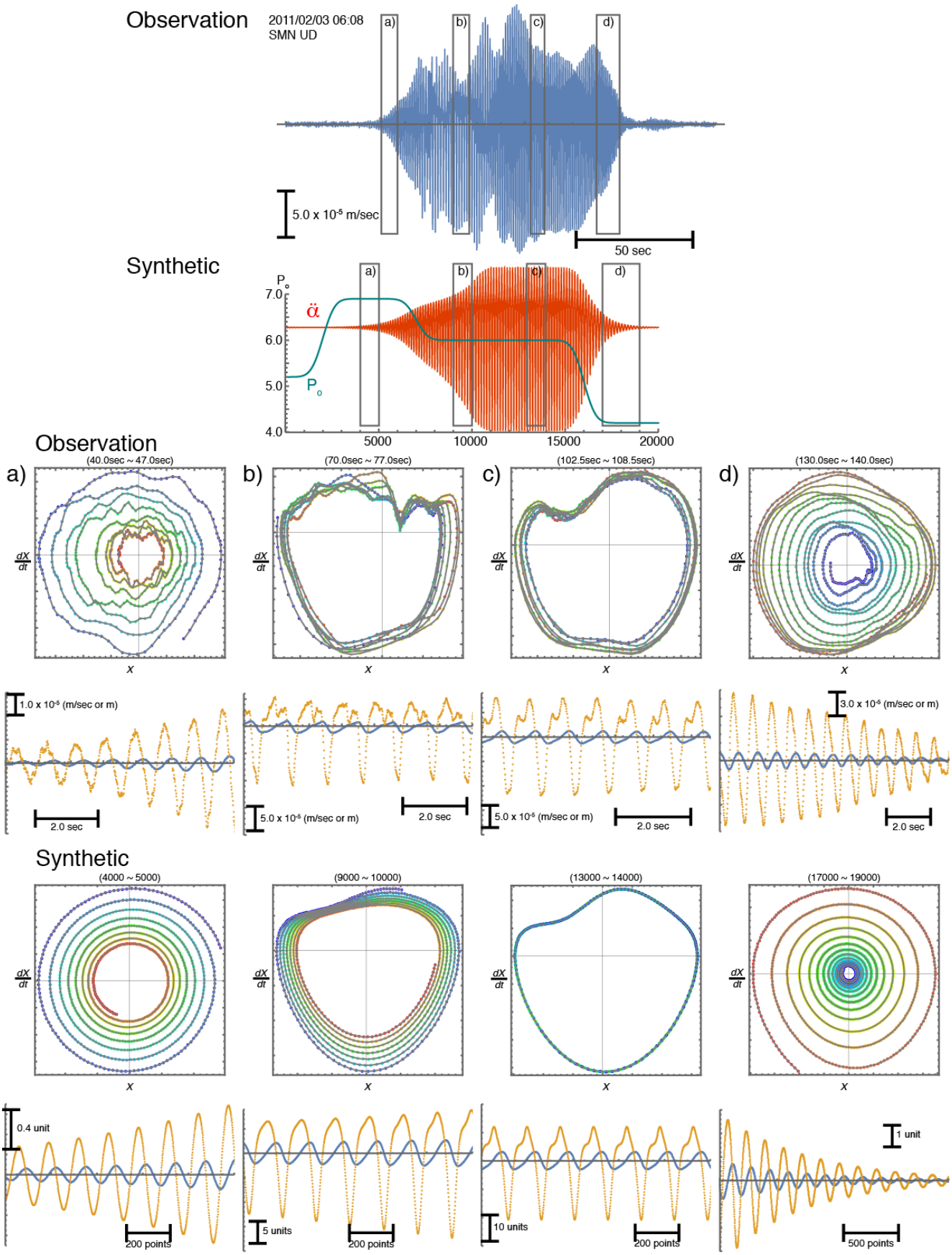


Figure 1

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Forecasting Volcanic Eruption of Sakurajima Volcano Based on Magma Intrusion Rate

*Masato Iguchi[1], Takeshi Tameguri[1], Jun-ichi Hirabayashi, Haruhisa Nakamichi[1]

1. Sakurajima Volcano Research Center, Disaster Prevention Research Institute, Kyoto University

In order to find an empirical event branch logic from abnormal phenomena to following volcanic activity for forecasting scale and type of eruption, the magma intrusion rate prior to eruptions of Sakurajima volcano is examined using ground deformation mostly from observation data and partially based on legends, for eruptions after the 20th century: the 1914 eruption starting with plinian eruption followed by effusion of lava, the 1946 eruptions with lava effusion, eruptions at the summit crater of Minamidake during the period from 1955 to 2005, and vulcanian eruptions at Showa crater east of the summit from 2006 to 2017. Prior to the 1914 eruption, it is estimated that the magma intrusion rate attained a level of approximately 10^8 m^3/day and was on the order of 10^6 m^3/day during the effusion of lava in the 1946 eruption. During the eruptive period of Minamidake summit crater, three types of eruption occurred: vulcanian eruption, strombolian/lava fountain and continuous emission of volcanic ash. In cases of intrusion of magma forming a new conduit, the intrusion rate immediately before the 1914 eruption exceeded 10^8 m^3/day, but only 10^6m^3/day in the dyke-forming event of August 15, 2015. Magma intrusion rate into a pre-existing conduit prior to eruptions at Minamidake summit crater are ordered as follows: vulcanian eruption ($1x10^5$ to $8x10^5$ m^3/day) > continuous emission of volcanic ash (approximately $1x10^5$m^3/day) > strombolian/lava fountain ($0.2x10^5$ to $2x10^5$ m^3/day). The magma intrusion rate prior to vulcanian eruptions at Showa crater is smaller (approximately 10^4m^3/day) than for eruptions at Minamidake summit crater. However, the rate reached an order of 10^5m^3/day prior to lava fountain on August 22, 2017. Magma intrusion rates well correspond to the scale and type of eruption. In the case of magma intrusion under detection, the change of volcanic gas and increase in the heat discharge rate are available for the empirical event branch logic.

Keywords: magma intrusion rate, Sakurajima, volcanic earthquake, vulcanian eruption, strombolian eruption, plinian eruption

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Tilt and strain change before and after the explosion at Minami-dake, Sakurajima, in 2017

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A deformation source associated with each eruption at Sakurajima have been estimated beneath Minami-dake [Ishihara, 1990; Iguchi et al., 2013]. Deformation sources for mid-long-term magma intrusion event were estimated beneath Aira caldera, Kita-dake and Minami-dake; and the deformation source beneath Kita-dake was found to act as a buffer of mid-long eruptive activity at Sakurajima [Hotta et al., 2016].

On November 13, 2017, an explosion with an infrasound occurred at Minami-dake at 22:07. Ground deformation was accompanied and kept for approximately five hours. For the period of 22:07–22:10 (period I), a large strain change at Arimura observation tunnel, which is the nearest tilt/strain station from Minami-dake crater and operated by Ministry of Land Infrastructure, Transport and Tourism, was detected whereas no significant change in tilt/strain was detected at other tilt/strain stations. For the period of 22:10–22:50 (period II), tilt/strain change was detected at all tilt/strain stations associated with violent eruptive activity. At around 23:00, style of eruption shifted from Vulcanian to Strombolian. For the period of 22:50–3:00 of the next day (period III), a pattern of tilt change at Japan Meteoritical Agency (JMA)-A station, which located on western area of Sakurajima, and tilt/strain gradually stopped.

We modeled the detected tilt/strain change using a finite spherical source model [McTigue, 1987]. Because of the poor constraint of the radius of the source, we assumed the radius of the source as 20 m for period I and 200 m for periods II and III. A shallow deflation source was located at a depth of 0.1 km above sea level beneath Minami-dake for period I. A deeper deflation source was located at a depth of 5.9 km below sea level beneath Minami-dake for period II. Then, a deflation source was located at a depth of 5.9 km below sea level beneath Kita-dake for period III. Deformation sources beneath Minami-dake for periods I and II are corresponding to the deformation sources previously found for each eruption at Sakurajima. Meanwhile, the deformation source beneath Kita-dake for period III is corresponding to the deformation source beneath Kita-dake which was found during mid-long eruptive activity. Each eruption at Sakurajima revealed to cause deflation of not only Minami-dake source but also Kita-dake one, which considered to repeat inflation/deflation during mid-long eruptive activity at Sakurajima. Temporal development of deflation accompanied by the eruption on November 13, 2017, will be revealed in our future study.

Keywords: Sakurajima Volcano, Explosion at Minami-dake, Ground deformation, Tilt and strain

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Pyroclastic Flow Accompanied with an Eruption on June 16, 2018 at Sakurajima Volcano

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At Sakurajima volcano, the explosive eruption has repeated at the summit crater since 1955. The eruption resumed for the first time in 58 years in the Showa crater on the eastern flank of the mountain, and the eruption activity was particularly active from 2009. The eruption activity has been transitioning again from the Showa crater to Minamidake summit crater since 2018. Characteristics of the explosive eruption include ejection of volcanic bombs, generation of shock waves, the release of sudden volcanic ash and gases. Besides, although the frequency is small, the explosive eruption of the Minamidake summit crater and Showa crater produces small pyroclastic flows. The pyroclastic flow is one of the most dangerous phenomena of volcanic eruption, with pyroclastic flow of high temperature and volcanic gas flowing down the flank at high speed, prediction of the pyroclastic flow occurrence is important for volcanic disaster prevention.
Seven pyroclastic flows have been confirmed with the eruption at Minamidake summit crater between 1967 and 1985 (Kamo and Ishihara, 1986). Furthermore, 37 pyroclastic flows have been reported to occur in the Showa crater from 2006 to 2014 with the eruption by the Japan Meteorological Agency. Travel distance of the pyroclastic flows from the Minamidake and Showa craters were less than 2 km. Although it is Sakurajima which continues active eruption activity, pyroclastic flow is minor phenomenon and the mechanism of pyroclastic flow generation in Sakurajima has not been elucidated. In the future, when the eruption activity becomes active, it is necessary to consider the occurrence of a large pyroclastic flow, and it is important to understand the occurrence mechanism of the pyroclastic flow. In this study, we will clarify the characteristics of precursory seismic activity and ground deformation data on the pyroclastic flow occurred in the Mimamidake and Showa craters between 2012 and 2018. In addition, we investigate whether it is possible to predict the scale and travel distance of the pyroclastic flow from the data of the precursory earthquakes and ground deformation.
In the explosive eruption at Minamidake summit crater that occurred on June 16, the volcanic ash reached to 4700 m and the pyroclastic flow went down 1.3 km from the crater in the southwest direction. The expansion of the ground deformation was observed about 18 hours before the occurrence of the eruption. The precursory earthquake sporadically occurred about 1 hour before the eruption, but it was not a clear activity compared to the eruption of the Showa crater. The pictures of the pyroclastic flow shows that the ejected material dropped from the plume flowed down the slope about 1 minute after the eruption started to rise. The pyroclastic flow does not occur simultaneously with the eruption, which has the same characteristics as the pyroclastic flow that occurred during the Minamidake activity period (Kamo and Ishihara, 1986). Amount of ejecta by the eruption is estimated to be 280,000 m3 from the ground deformation data. Not all of the ejecta will be pyroclastic flow. It is necessary to estimate the amount of pyroclastic flow out of the ejecta in order to predict the flow down distance. Estimate the amount of ejecta that became a pyroclastic flow from the calculation of fall volcanic ash using weather radar.

Keywords: Sakurajima volcano, pyroclastic flow

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[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

Tue. May 28, 2019 1:45 PM - 3:15 PM JST | Tue. May 28, 2019 4:45 AM - 6:15 AM UTC | IC 2F

[S-VC38] Active Volcanism

convener:Yuta Maeda(Nagoya University), Takahiro Miwa(National research institute for earth science and disaster prevention), Takeshi Nishimura(Department of Geophysics, Graduate School of Science, Tohoku University), Chairperson:Hiroshi Aoyama, Satoshi Miura

This session discusses various aspects of active volcanisms including, but not limited to, recent and historical eruptions, various phenomena associated with the volcanic activities, underground structures of the volcanoes, and developments of new instruments based on geophysical, geochemical, geological, and multidiscipline approaches. We also welcome studies on understanding and predicting the transitions of the eruptive activities from observational, theoretical, and experimental approaches.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SVC38-18] Ground deformation observed at the crater area of Tokachidake volcano

*Hiroshi Aoyama[1], Takeshi Hashimoto[1], Ryo Tanaka[1], Hiromitsu Oshima[1], Koichiro Saito[2], Tsuyoshi Michishita[2], Satoshi Okuyama[2], Volcanic Observation and Warning Center Sapporo Regional Headquarters[2] (1.Institute of Seismology and Volcanology, Faculty of Science, Hokkaido University, 2.Japan Meteorological Agency)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SVC38-19] Moment tensor inversion of very-long-period seismicity at Stromboli volcano based on a very-near-field observation

*Shunsuke Sugimura[1,2], Maurizio Ripepe[2], Giorgio Lacanna[2], Denis Legrand[3], Sébastien Valade[4], Takeshi Nishimura[1] (1.Department of Geophysics, Graduate School of Science, Tohoku University, 2.Department of Earth Sciences, University of Florence, Italy, 3.UNAM University, Mexico, 4.GFZ-German Research Centre for Geosciences, Potsdam, Germany)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SVC38-20] Pressure source estimation of tilt changes associated with small explosions at Stromboli volcano

*Ayumu Ishikawa[1], Takeshi Nishimura[1], Hiroshi Aoyama[2], Ryohei Kawaguchi[3], Eisuke Fujita[4], Takahiro Miwa[4], Taishi Yamada[4], Maurizio Ripepe[5], Riccardo Genco[5] (1.Graduate school of science, Tohoku university, 2.Faculty of science, Hokkaido university, 3.Meteorological Research Institute, 4.National Research Institute for Earth Science and Disaster Resilience, 5.University of Florence)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SVC38-21] Seismic and acoustic waves excited by volcanic explosion: analyses of energy ratio and source spectra

*Mohammad Hasib[1], Takeshi Nishimura[1], Hisashi Nakahara[1] (1.Department of Geophysics, Graduate School of Science, Tohoku University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SVC38-22] Field survey report on Zao Volcano (2012−2018)

*Akio Goto[1], Noriyoshi Tsuchiya[2], Nobuo Hirano[2], Miwa Kuri[3], Tetsuya Matsunaka[4], Kengo Sawayama[2] (1.Center for Northeast Asian Studies, Tohoku University, 2.Graduate School of Environmental Studies, Tohoku University, 3.International Research Institute of Disaster Science, Tohoku University, 4.Institute of Nature and Environmental Technology, Kanazawa University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SVC38-23] Inflation Event of Zao Volcano in 2015

*Satoshi Miura[1], Mare Yamamoto[1], Masahiro Ichiki[1], Tomotsugu Demachi[1] (1.Graduate School of Science, Tohoku University)

Ground deformation observed at the crater area of Tokachidake volcano

*Hiroshi Aoyama[1], Takeshi Hashimoto[1], Ryo Tanaka[1], Hiromitsu Oshima[1], Koichiro Saito[2], Tsuyoshi Michishita[2], Satoshi Okuyama[2], Volcanic Observation and Warning Center Sapporo Regional Headquarters[2]

1. Institute of Seismology and Volcanology, Faculty of Science, Hokkaido University, 2. Japan Meteorological Agency

Tokachidake is an active volcano that repeated magmatic eruptions in 1926, 1962 and 1988. Prior to these eruptions, phreatic eruptions had been confirmed from several years ago. Although there has been no magmatic eruption in the last 30 years, long-term expansion centered around the 62-2 crater has been observed since around 2006. One of the GNSS stations near the crater moved more than 50 cm in total till the end of 2017. Coinciding with this expansive crustal deformation, long-term demagnetization under the 62-2 crater has also been observed.

Repetitive GNSS observations around the crater for more than 10 years suggested the fluctuation of deformation area centered around 62-2 crater and Taisho crater. Analysis of the temporal change of the motion vector assuming an isotropic deformation source at these two places revealed that the two inflation sources expanded at a substantially constant rate as a whole while changing the rate complementarily. Since the assumed fluctuation source is extremely shallow and flowing out of hot muddy water at the bottom of the 62-2 crater has occasionally been observed, we consider that this long-term deformation reflects the mechanical response of the shallow hydrothermal system.

Geodetic observation revealed that the long-term expansive deformation turned into stagnation in the period from the end of 2017 to the beginning of 2018. Almost at the same time, the total magnetic force data showed change in its trend of demagnetization. Also, in the Furikozawa fumaroles, an expansion of the geothermal area and an increase in fumarolic activity have been reported since around 2017.

Under such circumstances, number of volcanic earthquakes and tremors temporarily increased from late May 2018. A volcanic tremor on May 29th which activated seismicity was accompanied by a tilt motion showing a stepwise subsidence in the crater direction. Therefore, we visually examined the tiltmeter record from January 2018 which were obtained at the station MTKW (about 650 m west of the crater). Although there were few tilt events until around the end of March, occurrence frequency of such event increased thereafter, and it further increased on May 29th. A total of 117 events were identified by the end of August, 10 events by the end of March, 30 events in April and May and 77 events by August. Tilt events generally show a stepwise subsidence in the crater direction, but careful examination of each event revealed that there are various types of events: tilt change following a small preceding phase, inflation –deflation pattern, gradual change more than a few minutes, and events associated with VLP-like seismic signals, etc. Examining the direction of the tilt motion vector at MTKW about these 117 events, almost 90 % shows subsidence in the crater direction of N120 –135°E. For the event on May 29th, a preliminary analysis using tilt data around the crater showed that the tilt motion can be roughly explained by an isotropic deflation source of 130 m^3 located at 1300 m above sea level slightly south of the 62-2 crater.

Summarizing the shallow activities of Tokachidake volcano, expansion of the geothermal area and increase in fumarolic activity appeared almost at the same time with the latest stagnation of long-term expansive deformation and demagnetization for over 10 years. Volcanic earthquakes and tremors

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accompanying stepwise subsidence in the crater direction increased around the same time with the deflation of the crater area. We can roughly consider two hypotheses for the latest deflation: one is a decrease in the amount of hot water supplied from the deep part, and the other is a change in supply / release balance due to an increase in discharge amount from fumaroles. Expansion of the fumarolic area, increase of the fumarolic activity, and increase of the tilt event strongly suggest the possibility of the latter hypothesis, although it is difficult to discuss the amount supplied from the deep part.

Keywords: Volcano, Earthquake, Crustal Deformation, Hydrothermal System, Phreatic Eruption

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Moment tensor inversion of very-long-period seismicity at Stromboli volcano based on a very-near-field observation

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In recent decades, moment tensor inversion of very-long-period (VLP, 2-100 s) earthquakes associated with explosive/non-explosive activities has been applied to estimate the optimal source location and mechanism. Source mechanism of VLP associated with explosions at Stromboli volcano has been interpreted as the pressure source of opening/closing cracks embedded in the volcanic medium (Chouet et al., 2003). However, the nearest temporal station is 300 m away from the craters so that the source mechanism might have not been constrained well to discuss the detail processes of the magma motion in the conduit. In this study, we analyze broadband seismic data observed in the very-near-field condition, only 100-300 m away from the active craters, to obtain a more precise source mechanism solution.

We use the seismic data recorded at eight broadband seismic stations including temporary and permanent networks. Infrasonic array analyses show that the explosive eruptions mostly occurred at the north-east (NE) crater during the observation period in the end of September 2016. We apply a moment tensor inversion method to VLP (0.05-0.2 Hz) signals associated with the largest explosion occurring at the NE crater. The result shows that the optimal centroid is located at 200 m southwest of, 160 m beneath the NE crater. The source mechanism is greatly dominated by the vertical component of the moment tensor (Mzz), although the polarity inverts with other two diagonal components (Mxx, Myy). The squared error between the observed and synthetic waves (Ohminato et al. 1998) is only 11%.

We note that the squared errors less than 20 % are widely distributed around the optimal location: 300 m ×300 m in horizontal distances and 250 m in the vertical direction. For example, the solution obtained at a depth of 160 m beneath the NE crater shows the error of 18 %, which is within the confidence interval 95 % range of the residual at the optimal location. At this location, the inverted source mechanism is dominated by three diagonal components with a same polarity. This is much different from the best solution.

To examine why such different source mechanisms are obtained for nearby source locations, we calculate a model resolution matrix using the Green’ s functions computed from a point source at the optimal location and investigate how well the moment tensors can be resolved. The minimum singular value in the model resolution matrix is assumed to be 2.1 % of the maximum. We replace this value with zero and consider the pseudoinverse. The model resolution matrix for the pseudoinverse shows that the resolution of the diagonal components of moment tensors is lower than deviatoric ones. This suggests that the amplitudes of diagonal components are not well constrained from the moment tensor inversion even using near-by stations in our temporal observations. These results will be indispensable for discussing the spatial distribution of the volumetric change in the conduit or magma chamber accompanying the explosions.

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Keywords: moment tensor inversion, source mechanism, VLP, Stromboli volcano, very-near-field, model resolution matrix

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Pressure source estimation of tilt changes associated with small explosions at Stromboli volcano

*Ayumu Ishikawa[1], Takeshi Nishimura[1], Hiroshi Aoyama[2], Ryohei Kawaguchi[3], Eisuke Fujita[4], Takahiro Miwa[4], Taishi Yamada[4], Maurizio Ripepe[5], Riccardo Genco[5]

1. Graduate school of science, Tohoku university, 2. Faculty of science, Hokkaido university, 3. Meteorological Research Institute, 4. National Research Institute for Earth Science and Disaster Resilience, 5. University of Florence

Stromboli volcano is characterized by continuous activities of Strombolian explosions (small explosions) at summit craters. A lot of studies have investigated volcanic processes by multi-parameter observations. However, pressure source determination by geodetic measurements, which is indispensable to understand shallow magma reservoir which is a key for understanding magma dynamics, have not yet been well conducted because of insufficient geodetic observation network. In the present study, we analyze tilt records at 3 temporal and 2 permanent stations located closely to the summit craters to determine the locations and size of pressure source by comparing the observed tilt vectors with the theoretical ones that are calculated by using finite element method.
Temporal stations CPL, PZZ, RFR were equipped with Applied Geomechanics 701-2A, and installed at a distance of <500 m from the active craters. Continuous stations LFS, OHO, LSC, operated by University of Florence, were equipped with Pinnacle 5000T. We analyze continuous tilt records of 5 stations during July 1 to July 15 when small explosion activity was high. We extract uplift and subsidence tilt signals associated with each of small explosion and classify them in 4 stages: (A) Gradual uplift prior to small explosions, (B) Rapid uplift just before small explosions, (C) Rapid subsidence after small explosions, (D) Small uplift after (C). Tilt azimuths and amplitudes are almost same for the stages of (A) –(C), although LFS show about 30 degrees difference. We use the tilt vectors averaged for 680 events in the following analyses. We suppose that the pressure source is represented by an ellipsoidal cavity at (1) beneath the summit craters or (2) VLP source (Chouet et al., 2003; 200 m NW from the summit craters). We searched optimal source model which could explain the observed tilt vectors by changing the size and shape of the ellipsoidal cavity. The results show that simple shape sources such as a sphere cannot explain the observed tilts both for the locations of (1) and (2). A spheroidal source that is modeled from the VLP source mechanism do not explain the observed tilts, either. By changing the size and directions of ellipsoidal cavity, we find that the ellipsoidal cavity with a size of 300×150×600 m at 400 m depth beneath the summit craters can well explain the observed tilts. The pressure applied during the episode (A) is estimated to be about 1 kPa.
The size and position of the estimated ellipsoid is basically consistent with the picture of shallow magma reservoir inferred from an analysis of temporal evolution of flank lava effusion in 2007(Ripepe et al., 2015). The mass and volume of magma supplied for conduit during a small explosion that are estimated from the obtained pressure change, appropriate conduit radius and magma density is comparable to the ejected mass and volume of one small explosion estimated from the observations of surface phenomena.

Keywords: Strombolian eruption, Tilt, FEM

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Seismic and acoustic waves excited by volcanic explosion: analyses of energy ratio and source spectra

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1. Department of Geophysics, Graduate School of Science, Tohoku University

Volcanic eruptions generally accompany both seismic and acoustic signals, and these signals are used to understand volcanic fluid motions in the conduit and/or its effusion process from active vents. In the present study, we compare these two kinds of signals observed at three volcanoes in Japan, systematically examining the temporal changes of radiated energy. We further examine the basic spectral characteristics of seismic and acoustic signal radiations during large and small Vulcanian explosions at Sakurajima volcano. We use seismic and acoustic records at seismic-acoustic stations operated by Japan Meteorological Agency (JMA).

We first examine the energy ratio between seismic and acoustic signals of volcanic explosions at Sakurajima, Kirishima, and Kuchinoerabu-jima volcanoes. We calculate the time series of energy ratio of acoustic signals to three-component seismic signals by calculating their envelopes at the frequency band of 1-5 Hz. To obtain averaged characteristics, we stack the energy ratios of seismic and acoustic signals of about 900 explosions at Sakurajima and 8 explosions Shinmoe-dake (Kirishima) volcanoes, respectively. We analyze only one eruption at Kuchinoerabu-jima. The results at Sakurajima and Shinmoedake (Kirishima) show the following characteristics in the temporal changes: the ratio of seismic energies to acoustic energies rapidly decreases at the beginning and reaches the minimum in about 10 s -20 s; then the ratio gradually increases for 20 s - 40 s; the seismic signals continue after the acoustic energy decreases down to the noise level. Although we can analyze one eruption data for Kuchinoerabu-jima volcano (18 December 2018), similar characteristics are recognized. These results suggest that the volcanic fluid motions are strong in the shallow parts in the beginning, and the active zone gradually becomes deep.

Next, we investigate the source spectra of acoustic signals of volcanic explosions. Applying the spectral ratio method that has been often used for seismic signals, we clarify the difference of source spectra between large and small acoustic signals. We stack the spectral ratios of acoustic signals according to their maximum amplitudes, and classify them into Classes IV, III, II, and I from the largest to the smallest. The maximum amplitude of the largest event is about 10 Pa, while the smallest is about 2.5 Pa. Since the wind around the volcano may disturb the wave propagations, we only select the acoustic signals excited by volcanic explosions occurring during a low wind speed (< 3.3 m/s) condition, using the assimilation wind data recorded by ECMWF (European Centre for Medium-Range Weather Forecasts). We observe that the spectral ratios of acoustic signals are similar among different stations both for direct and coda waves. This means that the spectral ratio method is applicable for the acoustic signals of volcanic explosions during low wind speeds. All pair of the observed source spectral ratios of acoustic signals (Class IV/I, III/I, II/I) are characterized by almost flat amplitudes at the frequency range of about 0.2 -10 Hz. The difference between the classes is the amplitude. This characteristic is much different from the seismic signals excited by Vulcanian explosions (Hasib et al., 2018), in which a flat amplitude at low frequency range (about 0.5 - 2 Hz), a gradual decrease with frequency at an intermediate frequency range (about 2–3.5 Hz), and a flat amplitude at high frequency range (about 3.5 –10 Hz). These differences suggest the differences in the generation mechanisms between seismic and acoustic signals, which may reflect the difference of excitation region: the seismic waves are in the volcanic conduit beneath the vent, while the

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acoustic waves are at the orifice of the conduit.

Acknowledgements: We used JMA seismic and acoustic signal records.

Keywords: Seismic wave, Acoustic wave, Energy ratio, Source spectra, Volcanic explosion

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Field survey report on Zao Volcano (2012–2018)

*Akio Goto[1], Noriyoshi Tsuchiya[2], Nobuo Hirano[2], Miwa Kuri[3], Tetsuya Matsunaka[4], Kengo Sawayama[2]

1. Center for Northeast Asian Studies, Tohoku University, 2. Graduate School of Environmental Studies, Tohoku University, 3. International Research Institute of Disaster Science, Tohoku University, 4. Institute of Nature and Environmental Technology, Kanazawa University

We have been conducting field surveys on Zao volcano since 2012, such as temperature monitoring and water sampling on Maruyama-sawa geothermal area, ruin of Niizeki hotspring and Okama crater lake, based on the expectation that Zao volcano may be activated by 2011 Great East Japan Earthquake. Geophysical observation network by Japan Meteorological Agency, which has started 24-hour monitoring in September 2010, detected volcanic tremor in January 2013 for the first time, and a tremor and preceding tilting occurred in April (JMA, 2013). Since then Zao volcano sustains its higher activity than usual. Volcanic warning, Level 2: Do not approach the crater, were issued in April 2015 due to the increase in volcanic earthquake and in January 2018 due to the occurrence of volcanic tremor with largest-ever amplitude and continuous tilt motion. In harmony with these activities our field surveys also detect some changes in surface activities. Here we review our field survey results since 2012, especially focusing on the 2017-2018 results which has not reported yet.

Temperature of over 20 fumaroles has been measured repeatedly on Maruyama-sawa geothermal area, where small phreatic explosion occurred in 1940 (Toraishi and Tominaga, 1940; Anzai, 1941). The highest temperature exceeded 102 ˚C in 2012, but decreased over 7 ˚C within four months in 2013; fumarole temperature overall fell lower than 95 ˚C by 2014. After the first volcanic warning in 2015, the highest fumarole temperature reached nearly 100 ˚C temporarily, and then overall temperature rise occurred in 2016. In 2018, after volcanic warning was issued for the second time in January, the highest fumarole temperature exceeded 100 ˚C in June and reached 104 ˚C in July, which is the highest record in our survey since 2012.

We have paid attention to ruin of Niizeki hotspring, where high temperature and high concentration hotsprings gushed as a result of activization in the past, but no activity was recognized between 2012 and 2014. In September 2015, five months later from the first volcanic warning, we found that Niizeki hotspring resumed welling up with multiple hotsprings at around 32˚C. But in 2016 surveys, Niizeki hotspring had only a few weak cold-water springs, and no remarkable activity was recognized after the second volcanic warning in 2018.

In contrast with Maruyama-sawa and ruin of Niizeki hotspring, no thermal activity has been recognized on Okama crater lake thus far. The bottom temperature was around 4 ˚C in late May and early June (2014 and 2016), and around 7 ˚C in early September (2014, 2015, 2017 and 2018). We installed thermocouples in 2017 and 2018 on the bottom of Okama crater lake to record the temperature change one hour interval. We found that 3-4 ˚C temperature rise occurred in early October in 2017 and 2018, which is probably not be the results of thermal activity of Zao volcano but seasonal variation, because the degree of temperature change and the time of the year were identical. In 2018 other research group conducted topography survey of Okama crater lake bottom using a multiple-frequency sonar system and detected vertically extending reflection over a small mound on the center of the lake bottom, which may be caused by a chain of rising volcanic gas bubbles or hot water plume (Yamasaki et al., 2018). One of our

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thermocouple is set within 10 m from the reflection source. Our thermocouple may catch the temperature change if thermal activity occurs there.

Keywords: Zao volcano, surface activity

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Inflation Event of Zao Volcano in 2015

*Satoshi Miura[1], Mare Yamamoto[1], Masahiro Ichiki[1], Tomotsugu Demachi[1]

1. Graduate School of Science, Tohoku University

Volcanic earthquakes and tremors have been occurring beneath Zao volcano located in the northern Honshu, Japan since 2013, following the increase in the number of deep low frequency earthquakes from around 2012. Tohoku University has deployed some new seismological, geodetic, and geomagnetic stations to enhance rather poor observation network prior to the activity. On account of a burst of volcanic earthquakes initiated in April 2015, the Japan Meteorological Agency announced a warning of eruption, however, the number of events gradually decreased for the next two months and the warning was canceled in June 2015. In the same time period, minor expansive deformation was observed by GNSS. Small-scale volcanic earthquakes and tremors are occasionally occurring, and long-period earthquakes have taken place sometimes accompanied by static tilt changes. In this talk, We report the outcome obtained from the five-year observational research to monitor the preparatory process going under the volcano for evaluation of the eruption potential.

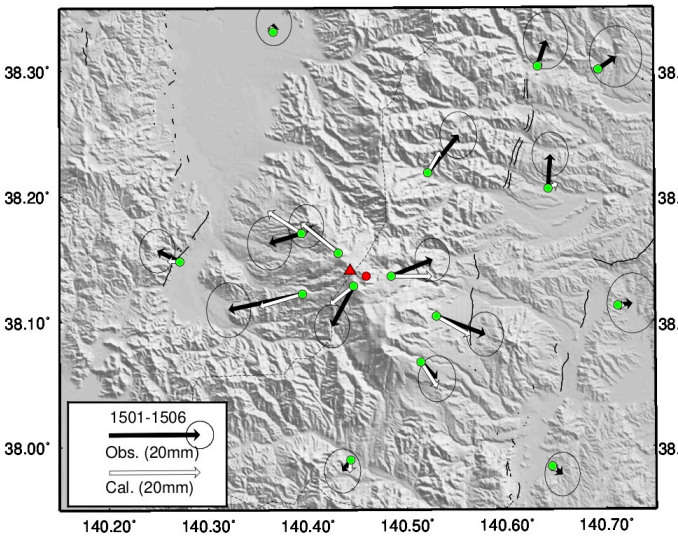
Figure 1 demonstrate the horizontal and vertical movement around Zao, respectively, from Jan. to Jun. of 2015. The black arrows show the observed ground movement. The radial pattern of movement around the summit of the volcano is clearly seen and the upheaval indicated by the black bars also centered around the summit. These characteristics of deformation can be modeled by a infinitesimal pressure source underground (so called Mogi model). We tried inversion analyses to find its location and magnitude. It is located about 0.8 km east of the crater lake with depth of about 5.6 km, and the volumetric change equivalent to the pressure change is $3.8 \times 10^{6} m^{3}$. The calculated displacements are shown in the figure by white arrows and bars.

Comparing the hypocenter map, the pressure source is located just above the deep low frequency earthquakes cluster. This suggests that the pressure source might be activated by geothermal heat supplied by magma or fluid. Ogawa et al. (2014) found a conductive zone beneath Zao volcano deeper than about 5km and this may support our result.

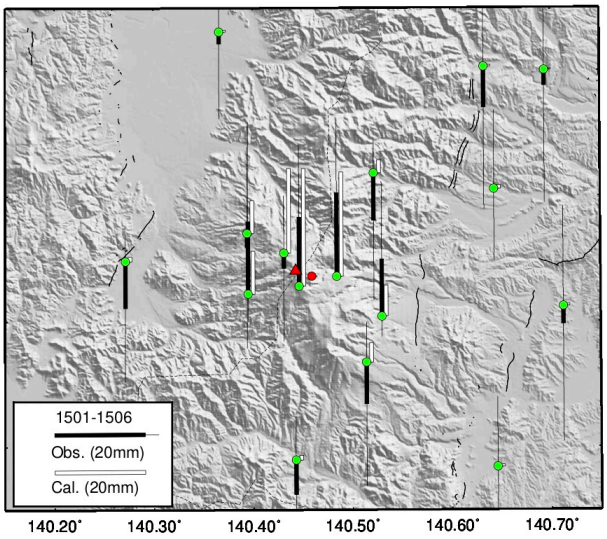
Keywords: Volcano, deformation, Pressure source

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(a) 水平変動 (2015年1月～6月)



(b) 上下変動



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[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

Tue. May 28, 2019 3:30 PM - 5:00 PM JST | Tue. May 28, 2019 6:30 AM - 8:00 AM UTC | IC 2F

[S-VC38] Active Volcanism

convener:Yuta Maeda(Nagoya University), Takahiro Miwa(National research institute for earth science and disaster prevention), Takeshi Nishimura(Department of Geophysics, Graduate School of Science, Tohoku University), Chairperson:Mare Yamamoto, Yuta Maeda(Nagoya University)

This session discusses various aspects of active volcanisms including, but not limited to, recent and historical eruptions, various phenomena associated with the volcanic activities, underground structures of the volcanoes, and developments of new instruments based on geophysical, geochemical, geological, and multidiscipline approaches. We also welcome studies on understanding and predicting the transitions of the eruptive activities from observational, theoretical, and experimental approaches.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SVC38-24] A machine-learning-based estimation of large amplitude regions for monitoring volcano seismicity

*Yuta Maeda[1] (1.Nagoya University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SVC38-25] Development of a technique for automatic determination of volcanic earthquakes with unclear onsets - Application to Mt. Asama -

*Takao Ohminato[1], Shigeki Horiuchi[2] (1.Earthquake Research Institute, Tokyo University, 2.Home Seismometer Corporation)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SVC38-26] Amplitude source location method with depth-dependent scattering and attenuation structures for volcano-seismic signals

*Hiroyuki Kumagai[1], John Makario Lonodno[2], Alvaro Esteban Acevedo Rivas[2], Yuta Maeda[1] (1.Graduate School of Environmental Studies, Nagoya University, 2.Colombian Geological Survey)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SVC38-27] Seismic interferometry at active volcanoes in Japan: Analyses of seismic records of JMA for the period from 2012 to 2018

*Takeshi Nishimura[1], Tomoya Takano[1], Takashi Hirose[1], Hisashi Nakahara[1] (1.Department of Geophysics, Graduate School of Science, Tohoku University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SVC38-28] Empirical relation for Q factors of crack resonances and its use to estimate source properties of volcanic LP events

*Kimiko Taguchi[1], Hiroyuki Kumagai[1], Yuta Maeda[1], Roberto Torres[2] (1.Nagoya University Environmental Studies, 2.Colombian Geological Survey)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SVC38-29] A study on the radiation pattern for resonating fluid-filled crack

*Mare Yamamoto[1] (1.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University)

A machine-learning-based estimation of large amplitude regions for monitoring volcano seismicity

*Yuta Maeda[1]

1. Nagoya University

The seismic network of Mt. Ontake has improved after the 2014 eruption, producing one of the most dense observational networks in the world composed of 9 stations within 1 km of the summit, 17 within 4 km, and 29 within 10 km. This network has recorded long-period (LP) events and tremors which had been considered quite rare at Mt. Ontake (Maeda et al., 2018, JPGU). These signals are attributed to movements and volume changes of shallow volcanic fluids according to studies of similar signals at other volcanoes; thus they are important markers to understand the state and behavior of the fluids. However, despite finding several events, the entire activity of them are not known at Mt. Ontake; it is not easy to manually create an event catalog because of abundance of spurious events (i.e., local wind noise) and difficulty of distinguishing them from real volcano-seismic signals. This is partly related to a difficulty of comparing the records at many stations with a sufficient temporal resolution using a small number of figures. A new strategy to extract useful information from the large number of stations is thus needed.

In this study, we developed a method to investigate a spatiotemporal distribution of large amplitude regions to easily monitor the activities of earthquakes and tremors. The amplitudes could be a measure to monitor the seismicity including those without clear initial motions, but could be affected by local structures beneath the stations. To reduce this effect, we used information of whether the amplitudes are significantly larger than the normal level. We determined a threshold to distinguish significantly large and normal amplitudes from every 5-min-long window of each data trace, based on an idea that Gaussian and non-Gaussian portions of the frequency distribution of the amplitudes are normal and significantly large parts, respectively. This idea is implemented by creating a cumulative frequency distribution of absolute amplitudes in the 5-min-long window using only the smallest N data samples; calculating the fitting error between this distribution and an error function; and searching for an optimal N which minimizes the fitting error. The amplitude corresponding to this optimal N was regarded as the threshold. We then computed the ratio of large amplitude samples in every 1-sec-long window of each trace. We used the spatial distribution of this ratio as the input to a machine learning of a neural network model to investigate the large amplitude region for the 1-sec window. In this way, the spatial distribution of the large amplitude region is investigated for every 1-sec window, which could be used to distinguish true volcano-seismic signals from spurious ones.

We applied this method to the continuous records in November and December 2017 at Mt. Ontake. For most earthquakes occurred in the analysis domain, the large amplitude region distributed within a narrow area around the epicenter or spread with time from the epicentral area to a wider region. For distant earthquakes and local noise, the large amplitude region extended over the entire analysis domain with a small probability. These different patterns of the large amplitude regions were useful to distinguish the true volcano-seismic signals from spurious ones, although there were some missing detections of small earthquakes and tremors. Using the large amplitude region, only one figure is needed for each second, enabling a seismicity monitoring easier than detailed evaluations of continuous waveform records. We are now trying the 2nd stage of the machine learning to automatically detect earthquakes and tremors, which uses the spatiotemporal distribution of the large amplitude as the input, giving 93% success as a preliminary result.

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Keywords: Volcano seismology, Machine learning, Mt. Ontake

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Development of a technique for automatic determination of volcanic earthquakes with unclear onsets - Application to Mt. Asama -

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Some of volcanic earthquakes have clear P and S-wave onsets, and other has unclear onsets. In the traditional classification of volcanic earthquakes, the former is called A-type, VT, or HF earthquakes, and the latter is called B-type, LP, or LF earthquakes. The source process of the former is thought to be the rock rupture due to the stress changes in the volcanic edifice. For the latter, various source processes involving volcanic fluids such as gas, hot water or magma, have been proposed.

Numerous B-type earthquakes are often detected by the seismic network near the active volcanic vent of a volcano even if the activity level of the volcano is not high. In addition, a sharp increase in the number of B-type earthquakes is often observed when volcanic activity increases. Because shallow B-type earthquakes reflect the state of the magma plumbing system or the shallow hydrothermal system, constant monitoring of their activity is important. However, since B-type earthquakes are numerous and it is difficult to read their onset by human eyes, manual processing is not easy. Therefore, it is necessary to develop a automatic method to detect the event and to determine the hypocenter location. For events with unclear onsets, various methods, such as obtaining travel time differences by using waveform correlation, using particle motion, using spatial distribution of amplitude, etc., have been proposed so far. In particular, methods using waveform amplitude are widely used for hypocenter determination of B-type earthquakes due to their excellent performance.

In this study, we first examine how effective the Horiuchi et al. (2010)'s method for hypocenter determination of volcanic earthquakes with unclear onset. This method has been used in hypocenter determination of non-volcanic earthquakes. The basic idea of this method is, first, to define an evaluation function that imitates the comprehensive judgment of experienced human beings, then, to optimize the parameters of the evaluation function automatically so that the results of automatic readings approach the human readings. Furthermore, the influence of noise is reduced by giving a higher score values to observation stations where the difference between the theoretical and the observed travel times is smaller and by choosing a solution with the sum of the score values of all observation stations is maximum. In order to further improve signal-to-noise ratio, S-waveforms are appropriately rotated before reading S-arrival.

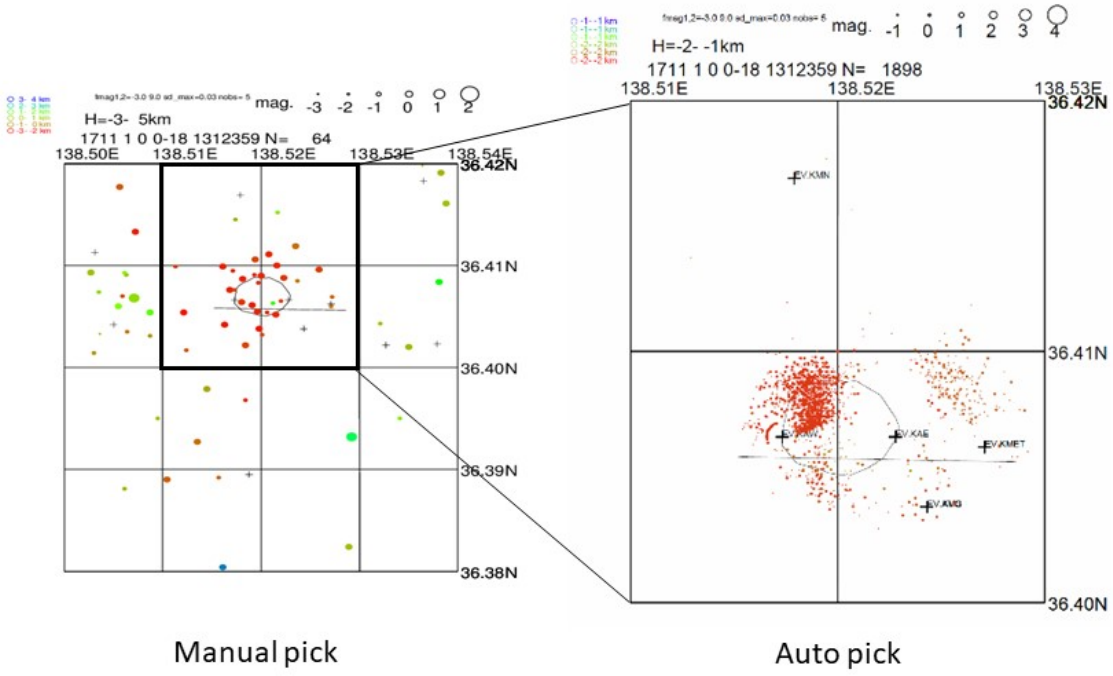
When we applied the method in its original form to Mt. Asama data, the accuracy of the result was poor. Possible reasons would be, in addition to difficulty in onset reading itself, the influence of various factors such as poor human readings which are the basis of parameter optimization, and high noise level of the data. In order to improve the performance of the method, we have tried various remedy such as improving onset reading, utilizing amplitude, reducing noise, etc. and have finally reached the stage where automatic determination is satisfactory. The measures we have taken and their results are as follows.
1) If the conventional automatic reading method is applied as it is, the accuracy of S-reading is not good enough. We examined a method in which an approximate hypocenter location is determined first using the waveform amplitude, then the S-wave arrival is read using the correlation. In order for improving the accuracy of S-reading, we used the correlation of the S-waveform envelope. We then computed the hypocenter location by using both the amplitude and the travel time. But the high accuracy of the

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S-reading was not reached. We abandoned this approach.
2) The hypocenters were determined by using both the automatic reading of S-arrival and amplitude, but accuracy was not satisfactory.
3) We performed following four remedy first: "To avoid reading noisy waveforms", "To discriminate between distant earthquakes and local volcanic earthquakes", "Not to use readings with low signal-to-noise ratio", "To remove amplitude data with inconsistent S-arrival". We then carried out hypocenter determination by using waveform amplitude alone. The results obtained by this procedure were most satisfactory.

When we apply above-mentioned improved method to the data for three months from November 2017 to January 2018, we could determine hypocenters of about 1900 events near the summit of Mt. Asama. The number of events that was determined manually during the same period was less than 100 events. Although we need to investigate more about the accuracy of the obtained hypocenter location, we believe that the improved version of this method is fairly promising.

Keywords: volcanic earthquakes, hypocenter determination, amplitude of waveforms, unclear onset



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Amplitude source location method with depth-dependent scattering and attenuation structures for volcano-seismic signals

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1. Graduate School of Environmental Studies, Nagoya University, 2. Colombian Geological Survey

The amplitude source location (ASL) method has been used to locate seismic events and tremor at various volcanoes. It has been indicated that the far-field and isotropic radiation equation for *S* waves used in the ASL method is valid in highly scattering wavefields. A constant *Q* value in the far-field and isotropic radiation equation has been commonly used in previous studies. This implicitly assumes homogenous distributions of scattering characteristics represented by the mean free path (l_0) and intrinsic attenuation (Q_i) beneath volcanoes. Wegler (JGR, 2004) and Kumagai et al. (JGR, 2018) showed that highly heterogeneous structures at volcanoes only exist in a surface thin layer with a thickness of about 1 km, below which less heterogeneous layers comparable to those in the normal crust exist. To evaluate the effects of such layered structures for ASL determinations, we performed synthetic tests using envelope waveforms simulated with the Monte Carlo method of Yoshimoto (JGR, 2000) for a two layer model based on the l_0 and Q_i structures at Nevado del Ruiz volcano (NRV) estimated by Kumagai et al. (2018). Our results indicated that the input source locations were estimated by the ASL method when appropriate values of *Q* values for the two layered model were used in the far-field and isotropic radiation equation. When a constant *Q* value was used, the estimated locations were largely deviated from the input locations especially in the depth direction. We then determined ASLs of volcano-tectonic (VT) earthquakes at NRV, which were compared with their hypocenters determined by the onset arrival times. Our results indicated that the differences between the ASLs and hypocenters of VT earthquakes became smaller when using a two layer *Q* model than those using a constant *Q* model. Our estimated ASLs of long-period (LP) events and tremor at NRV using the two layer *Q* model were more sharply clustered beneath the SW flank compared to those using the constant *Q* model. These locations corresponded to high *P*-wave to *S*-wave velocity ratio regions (Londono and Kumagai, JVGR, 2018), suggesting that the LP events and tremor were generated by fragmentation processes in a shallow magma storage region. These results indicate that use of appropriate *Q* values in the ASL method accommodating a thin surface heterogeneous layer is important to estimate precise source locations.

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Seismic interferometry at active volcanoes in Japan: Analyses of seismic records of JMA for the period from 2012 to 2018

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We analyze the seismic records of JMA stations deployed at active volcanoes in Japan, to examine the basic characteristics of daily variations of seismic velocity changes in the shallow medium. About 20 active volcanoes are systematically analyzed at the frequency range of 0.5-4 Hz. Temporal changes of the seismic velocity changes calculated from comparison of 7 years averaged cross-correlations and 5-days ones show long-period changes with periods of a year and/or a few months. The frequency distributions of seismic velocity changes at each station pairs roughly follow the normal distributions with a standard deviation of about 0.2 to 1 percents. Several phreatic eruptions occurred at Kuchinoerabu-jima, Ontake, Hakone and Aso volcanoes during the observation period, but no significant change is observed in the seismic velocity changes. On the other hand, seismic velocity changes due to the strain changes by volcanic pressure sources, moderate and large earthquakes, and/or dike intrusion are observed at, for example, Sakurajima, Miyakejima, Izu-Ohshima, Azuma and Tarumae volcanoes.

Keywords: Seismic interferometry, active volcanoes, seismic velocity change

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Empirical relation for *Q* factors of crack resonances and its use to estimate source properties of volcanic LP events

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1. Nagoya University Environmental Studies, 2. Colombian Geological Survey

Long-period (LP) seismic events are thought to arise from the oscillations of a fluid-filled resonator. The resonator geometry and fluid properties of LP sources have been estimated by comparing observed frequencies and *Q* factors to those calculated from a crack model (Chouet, *J. Geophys. Res.*, 1986). Taguchi et al. (*J. Geophys. Res.*, 2018) developed a method based on an analytical formula for the crack resonance frequencies proposed by Maeda and Kumagai (*Geophys. J. Int.*, 2017). This method enables us to estimate all the parameters of crack geometry and fluid properties. But the comparison of *Q* factors was conducted by numerical simulations of the crack model, which took extensive computational time, especially for LP events with large *Q* factors. So we systematically investigated the relation between *Q* factors and the crack model parameters by numerical simulations. It is known that *Q* factors of the crack resonances are proportional to α/a, where α is the *P* wave velocity of the solid and *a* is the sound speed of the fluid in the crack (Kumagai and Chouet, *J. Geophys. Res.*, 2000). We additionally found an empirical relation, indicating that the proportional constant depends on $\log(W/L)$, where *L* and *W* are crack length and width, respectively. To test the applicability of this empirical relation, we used it to analyze LP events at Galeras volcano, Colombia, in January 1993. These LP events have been thought to be generated by resonances of the crack filled with dusty gas. Our estimates of the crack model parameters displayed decreasing trends in both crack volume (*V*) and gas-weight fraction of water vapor (*n*) in the crack. These trends are similar to those shown by Taguchi et al. (2018). We further analyzed LP events at Galeras in May 1993 and December 2006 with the empirical relation for *Q* factors assuming dusty gas as the fluid in the crack. Because of their large *Q* factors, the determinations of crack geometry and fluid properties for these LP events with numerical simulations of the crack model were computationally expensive. The empirical relation for *Q* factors enables us to estimate all the crack model parameters for these LP events easily, and we found similar decreasing trends in both *V* and *n* to those in January 1993. This similarity implies that these variations during the individual periods of LP events were caused by the similar processes at this volcano.

These results demonstrate that the empirical relation obtained in this study is applicable to estimate all the parameters of LP sources, and may contribute to improved monitoring of fluid states under volcanoes and better understanding of LP source processes.

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A study on the radiation pattern for resonating fluid-filled crack

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Volcanic earthquakes observed around active volcanoes often exhibit harmonic characteristics having multiple spectral peaks, and thus the oscillation of fluid inclusions beneath volcanoes have been considered as one of the most plausible source models of these signals. As examples of such resonator model, the resonance of fluid inclusions whose shapes are sphere, cylinder, and crack have been proposed and successfully applied to the analyses of observed signals to explain the spectral characteristics of volcanic earthquakes. In recent years, it becomes more common that we have dense seismic observation close to the source of volcanic earthquakes, and we often observe varieties of spectral shapes showing different amplitude pattern between spectral peaks and between stations. To utilize the amplitude information of observed spectral peaks, in this study, I model the radiation pattern for a resonating fluid-filled crack, and discuss about the possibility to estimate the orientation and size of the fluid-filled crack.

In this study, the radiation of elastic waves from a resonating thin fluid-filled crack in 3-D infinite medium is considered. First, I compute the oscillation of fluid-filled crack, and compute the wave radiation from the crack by numerically integrating the elastic waves generated by the tensile dislocation on the crack surface. By computing the energy at each direction, the radiation pattern is then obtained as a function of distance from the crack. Because Yamamoto and Kawakatsu (2008) showed that the distribution of the tensile dislocation on the crack surface can be described by small numbers of Chebyshev polynomials as far as we consider the low-frequency oscillation of the crack, for the sake of comparison, I also calculate the wave propagation using this analytical expression. If we consider only far-field compressional wave, the model setting is same as that discussed in Chouet (1986). In contrast, in this study, I use analytical Green’s function including both near- and far-field terms for P and S waves to study the radiation pattern for the resonating fluid-filled crack.

In the case of the crack containing hydrothermal fluids, which have rather large acoustic velocity contrast between inside and outside of the crack, the radiation pattern of each resonant mode becomes almost comparable to that obtained only with far-field compressional term at distance larger than about 50 times of the crack size. On the other hand, the radiation pattern in short distance range is severely distorted due to the contribution of near-field term and the interference of waves emitted from different point of the crack. In addition, there exists the difference between even- and odd-modes of the resonant mode. These results can be explained by considering the following mainly two points: the wavelength of radiated elastic waves is same order of the crack size, and thus the distant range in which the contribution of near-field term dominates is proportional to the wavelength of each resonant mode; the distribution of tensile dislocation have different symmetry for odd/even modes, and thus the effect of the interference of waves emitted from different point of crack surface depends on the direction, as already pointed out by Kumagai et al. (2002). It also becomes clear that there exists the distant dependency of amplitude ratio between resonant modes.

These results indicate the possibility to estimate the orientation and size of fluid-filled crack beneath volcanoes by observing amplitude ratio between stations and between spectral peaks. Because the

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spectral amplitude ignoring phase information is less affected by the wave scattering caused by small-scale heterogeneity in shallow volcanic edifice compared to the waveform itself, the methodology has an advantage in practical data analyses. These results also suggest the importance of near-field dense observation to understand the detailed source mechanism and source process of volcanic earthquakes.

Keywords: Volcanic earthquakes, Fluid-filled crack, Source mechanism

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Tue. May 28, 2019 10:45 AM - 12:15 PM JST | Tue. May 28, 2019 1:45 AM - 3:15 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-CG54] Rheology, fracture and friction in Earth and planetary sciences

convener:Miki Tasaka(Shimane University), Osamu Kuwano(Japan Agency for Marine-Earth Science and Technology), Ichiko Shimizu(Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University), Hidemi Ishibashi(Faculty of Science, Shizuoka University), Chairperson:Osamu Kuwano(Japan Agency for Marine-Earth Science and Technology (JAMSTEC)), Ichiko Shimizu

The aim of this session is to join people from various research area in the earth and planetary sciences and to stimulate discussion beyond the boundaries of each research area. Our goal is to deepen our understanding of dynamics in geosciences by looking over whole areas in the earth and planetary sciences from the viewpoint of PHYSICS OF DEFORMATION, FLOW, AND FRACTURE. We welcome any field (e.g., earthquake, volcano, earth surface, crust, mantle and the core, and other planets and satellites) and any approach (e.g., laboratory experiments, numerical simulations, field observations, and theories).

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SCG54-01] Rheology of granular materials near the jamming transition under oscillatory shear

★Invited Papers

*Michio Otsuki[1], Hisao Hayakawa[2] (1.Graduate School of Engineering Science, Osaka University, 2.Yukawa Institute for Theoretical Physics, Kyoto University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SCG54-02] The real-scale numerical sandbox experiments for understanding stress state in accretionary prisms

*Mikito Furuichi[1], Arthur Bauville[1], Daisuke Nishiura[1], Takane Hori[1], Osamu Kuwano[1] (1.Japan Agency for Marine-Earth Science and Technology)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SCG54-03] Numerical analysis on the fracture of Maxwell fluid by phase field models

*Masaharu Kameda[1], Keita Yamanishi[1], Akinori Yamanaka[1], Mie Ichihara[2] (1.Department of Mechanical Systems Engineering, Tokyo University of Agriculture and Technology, 2.Earthquake Research Institute, The University of Tokyo)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SCG54-04] Diagenesis- and earthquake-driven transformations of carbonaceous materials and their implication for frictional strength and earthquake rupture dynamics in carbon-bearing plate-subduction faults

*Shunya Kaneki[1], Tetsuro Hirono[1] (1.Graduate School of Science, Osaka University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SCG54-05] Viscous behavior of chert during frictional melting

*Ginta Motohashi[1], Kiyokazu Oohashi[2], Kohtaro Ujiie[1] (1.University of Tsukuba, 2.Yamaguchi University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SCG54-06] Effect of friction and comminution on the optically-stimulated luminescence of quartz grains

*Kiyokazu Oohashi[1], Koji Akasegawa[2], Yuki Minomo[1], Noriko Hasebe[3], Kazumasa Miura[4] (1.Graduate School of Sciences and Technology for Innovation, Yamaguchi University, 2.Daiwa Exploration & Consulting Co., Ltd., 3.Institute of Nature and Environmental Technology, Kanazawa University, 4.Graduate School of Natural Science & Technology, Kanazawa University)

Rheology of granular materials near the jamming transition under oscillatory shear

*Michio Otsuki[1], Hisao Hayakawa[2]

1. Graduate School of Engineering Science, Osaka University, 2. Yukawa Institute for Theoretical Physics, Kyoto University

Amorphous materials consisting of repulsive and dissipative particles such as granular materials, colloidal suspensions, foams, and emulsions behave like liquids below a critical value of the packing fraction, while they behave like solids above that value. This sudden change is known as a jamming transition [1]. In this talk, we present our recent numerical results on the rheological properties of granular materials near the jamming transition under oscillatory shear. It is confirmed that the shear modulus depends on the amplitude of the initial oscillatory shear before the measurement [2]. Even at densities below the transition point, where isotropic jamming occurs without shear, the initial oscillatory shear can induce the finite shear modulus. This behavior is consistent with a transition known as shear jamming. We also discuss the yielding transition above the jamming point under sufficiently large strain.

[1] M. van Hecke, J. Phys.: Condens. Matter 22, 033101 (2009).
[2] M. Otsuki and H. Hayakawa, arXiv:1810.03846.

Keywords: Rheology, Granular materials, Jamming transition

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The real-scale numerical sandbox experiments for understanding stress state in accretionary prisms

*Mikito Furuichi[1], Arthur Bauville[1], Daisuke Nishiura[1], Takane Hori[1], Osamu Kuwano[1]

1. Japan Agency for Marine-Earth Science and Technology

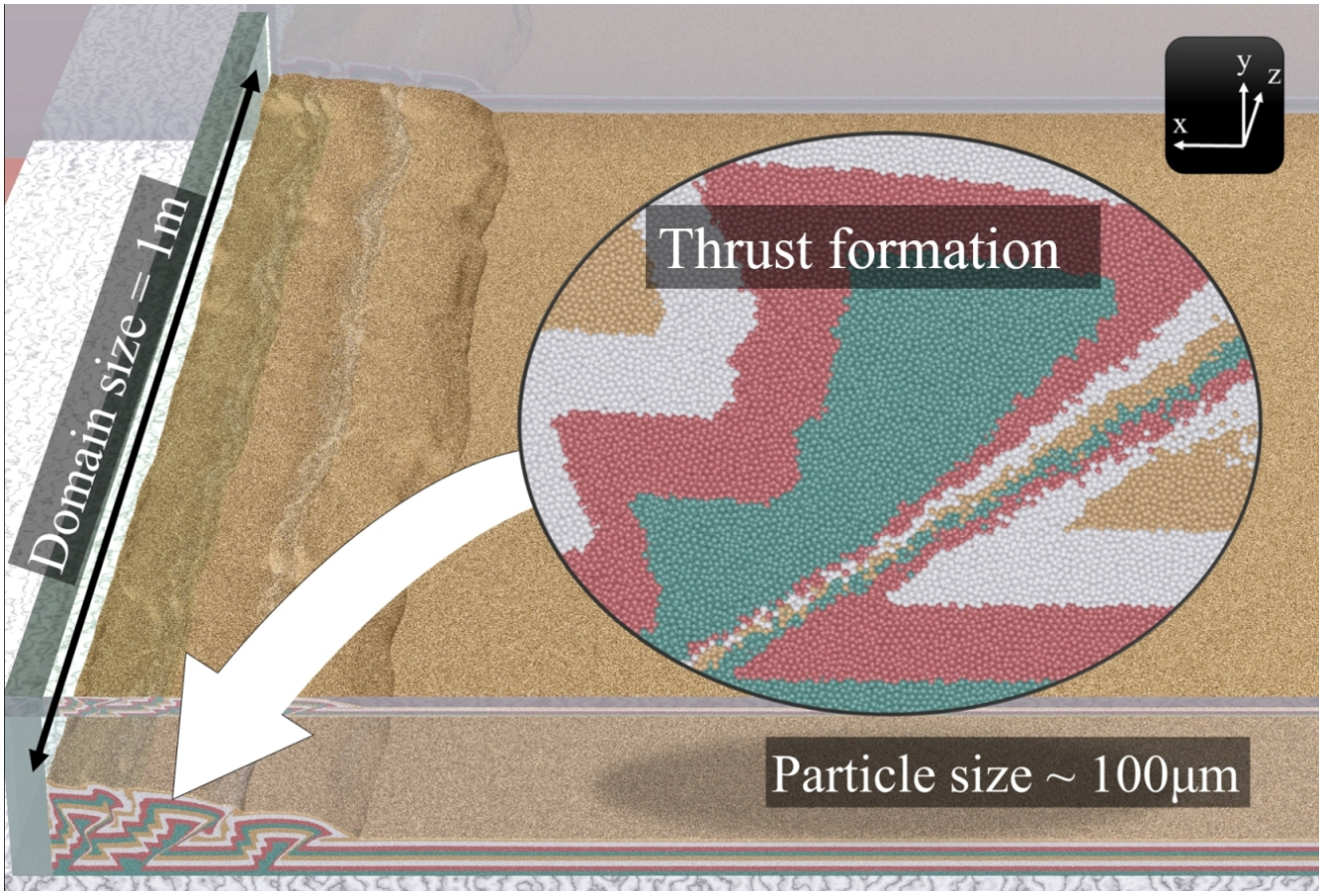
The sandbox experiment is known as a scaled physical analog model of accretionary prisms. Thus, understanding the stress state inside the sand layer is the interesting challenge of the geology. However, measuring stress states in laboratory sandbox experiments is still practically infeasible. Here we performed real-scale numerical sandbox experiments using the Discrete Element Method (DEM) to understand the 3D stress state in the accretionary prism. The critical bottleneck of DEM was the limited number of particles acceptable for practical computation time and it was difficult to simulate a system with a huge number of particles required by such as our target sandbox test with realistic particle size. We had overcome this issue by developing the dynamic load balancing technique for the DEM codes and run the real-scale numerical sandbox simulation using up to 2.4 billion particles [Furuichi et.al. 2017]. We also performed the large-scale stress chain analysis. One of the interesting findings was that the simulation of the horizontal shortening of the granular layer showed undulated margins similar to those observed in accretionary prism, despite the nearly uniform initial conditions. The 3D stress chain analysis that is practically infeasible for the laboratory experiment studies, revealed that arcuate faults emerge from micro-scale perturbations owing to the formation of the stress arch [Furuichi et.al. 2018]. Furthermore, analyses demonstrate that the in-situ stress orientation from borehole data can be a signal of either the regional direction of plate convergence or the local stress orientation associated with such a stress arch. The results may greatly enhance the outcome of long-term monitoring in areas, such as the Nankai Trough. In this contribution, we also investigated the stress state associated with a seamount (indenter) entering the accretionary prisms. The role of indenter was significant as a frictional heterogeneity to control the tomography (taper angle), material transport and stress chain distribution. Especially, amount of sediment covering the indenter was transported inward without deformation. This mechanism potentially constructs the thick low-velocity zone into the plate boundary, the subduction channel. In this presentation, we discuss the detail mechanism of these observed compressional events inside the sand layers.

[Furuichi et.al. 2017] M. Furuichi, D. Nishiura, Comput. Phys. Comm. (2017) DOI:10.1016/j.cpc.2017.05.015

[Furuichi et.al. 2018] M. Furuichi, D. Nishiura, O. Kuwano, A. Bauville, T. Hori, H. Sakaguchi, Scientific Reports (2018), DOI:10.1038/s41598-018-26534-x

Keywords: Accretionary prism, Stress, DEM

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Numerical analysis on the fracture of Maxwell fluid by phase field models

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Brittle fragmentation of vesicular magma is a key process in explosive eruption. Recent estimation on the decompression time in real explosive events indicates that the style of fragmentation is to be “brittle-like fragmentation” (Kameda et al. JVGR 2013). The solid-like fracture of the material occurs even if the bulk rheological properties is close to fluid state. We also found the fact that the spatial inhomogeneity of bubble distribution is a major source of crack development that lead to brittle-like fragmentation (Kameda et al. Sci. Rep. 2017).

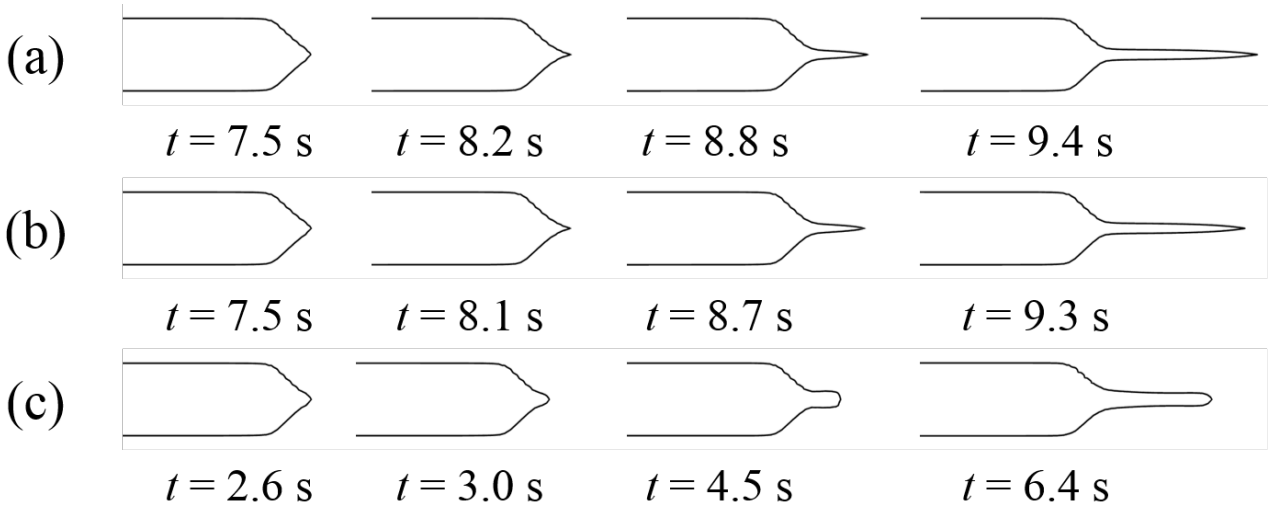
In order to model our findings by numerical approach, we propose a continuum description of fracture in viscoelastic fluid using the phase field fracture model developed by Kuhn et al. (Comput. Mat. Sci. 2015). The phase-field modes with sharp interfaces consist in incorporating a continuous field variable so-called “order parameter,” by which the magma and the bubbles (or the cracks) are distinguished. The evolution of fracture is obtained implicitly by solving the coupled mathematical models formed by the phase field fracture model and the dynamics of the material. A commercial multiphysics solver (COMSOL) is used as the platform of numerical simulation. The phase field fracture model is solved using PDE solver of COMSOL. The dynamics of the material is calculated using conventional finite element analysis (FEM) prepared in the solver, in which the rheology of unbroken magma is assumed to be a linear Maxwell fluid.

First, we simulated crack propagation in a two-dimensional notched plate in a tensile test at a constant extension rate. We obtained the extension of crack with a sharp tip in pure elastic body (Fig. 1(a)) or viscoelastic body with sufficiently high viscosity (Fig. 1(b)). On the contrary, in the viscoelastic liquid with moderate viscosity the blunted tip occurs after the crack extension starts (Fig. 1(c)). Subsequently, the crack propagates again due to further extension.

Second, we simulated crack initiation and propagation in a porous material, which is a sphere including a large bubble at the center. Additionally, we placed two satellite bubbles nearby the large bubble. The pressure at the outer surface of the material was reduced to generate the non-uniform stress field in the material. As a result, the plane crack was generated between the satellite bubbles. The crack reached outer boundary, then a sharp crack was opened. The computed time scale in the crack propagation was equivalent to the scale observed in the experiment (Kameda et al. Sci. Rep. 2017). This time scale is much smaller than the scale simulated with another phase field fracture model proposed by Karma et al. (Phys. Rev. Lett. 2001).

Keywords: Magma, Fracture, Phase field model

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Diagenesis- and earthquake-driven transformations of carbonaceous materials and their implication for frictional strength and earthquake rupture dynamics in carbon-bearing plate-subduction faults

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Various physicochemical reactions on fault-forming materials, such as illitization of smectite and crystallization of amorphous silica, have been suggested as possible controls on frictional strength of rocks and thus on earthquake dynamics in plate-subduction zones. Carbonaceous material is one of the universal materials that exist in and around both active plate-boundary and inland faults, and previous studies suggest that transformation of carbonaceous material may affect its frictional strength during frictional slip. However, there is currently no systematic study attempting to investigate the relationship of maturity of carbonaceous material to its frictional strength, and thus how diagenesis- and earthquake-driven transformations of carbonaceous material can affect frictional strength and rupture dynamics of carbon-bearing faults, still remains unknown. We conducted high-velocity friction experiments together with elemental analysis, transmission electron microscope observation, X-ray diffraction analysis, and infrared and Raman spectroscopies, on four grades of carbonaceous material in the form of lignite, bituminous coal, anthracite, and graphite. Our experimental results clearly show that an increase in maturity and crystallinity of carbonaceous material results in a decrease in the peak friction coefficient at the initial stage of slip, from 0.5 (lignite) to 0.2 (graphite). We also infer from our results of spectroscopic analyses that low- (lignite and bituminous coal) and intermediate-grade carbonaceous material (anthracite) increases its maturity by high-velocity frictional slip, but friction applied to high-grade carbonaceous material (graphite) induces an opposite trend. Furthermore, by considering systematic decrease and increase in fracture energy and stress ratio with increasing maturity of carbonaceous material, both of which strongly affect rupture propagation process during earthquake, both diagenesis- and earthquake-driven transformations of carbonaceous material can strongly affect the frictional strength of carbon-bearing faults, potentially affecting the depth-dependences of not only frictional strength but also rupture dynamics on plate-subduction faults.

Keywords: Earthquake, Carbonaceous material, Thermal maturation, Friction coefficient, Plate subduction zone, Rupture dynamics

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Viscous behavior of chert during frictional melting

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1. University of Tsukuba, 2. Yamaguchi University

Pelagic chert is one of the major lithology in accretionary complexes. Thus, frictional properties of chert at seismic slip rates are important for understanding of earthquake faulting in subduction zones. Here, we conducted high-velocity friction experiments on chert collected from the Jurassic accretionary complex in central Japan at a slip rate of 1.3 m/s and normal stresses of 5–13 MPa under room humidity conditions. The results show that initial slip weakening was followed by slip strengthening and subsequent second slip weakening toward a steady-state shear strength. Slip strengthening resulted from the formation of a silica-rich melt layer (experimentally generated pseudotachylyte) at lower melting temperatures than expected. The chemical composition of the pseudotachylyte matrix suggests the frictional melting of quartz with a small amount of illite, which may contribute to reduce melting temperatures. The second slip weakening occurred despite an increasing shear strain rate because of the thinning of the melt layer, implying that the viscosity of the melt layer decreased with slip. The estimated temperatures before and after the second slip weakening and microstructural and chemical features of experimentally generated pseudotachylytes suggest that the viscosity decrease during the second slip weakening is not due to a change in the chemical composition of melt layer, but rather a temperature increase in the melt layer.

Keywords: frictional melting , chert, high-velocity friction experiments

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Effect of friction and comminution on the optically-stimulated luminescence of quartz grains

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Optically-stimulated luminescence(OSL) dating is considered to be applicable for fault dating owing to its instability even for short-time heating such as frictional heating. However, fault zone material may experience not only heat but also friction and comminution with coseismic faulting. If the OSL signal becomes small or disappear due to friction and comminution that is also accompanied by stable sliding (fault creep), OSL signal zeroing in natural fault zone can not be simply attributed to earthquake event. Here we report an increment of OSL signal of quartz during a low- to intermediate-velocity frictional sliding. The increments of OSL signal intensities were found from finely ground recovered sample (<75 μm). We also recognized an increment of fast to medium component of OSL with increasing sliding velocity. These results can be explained by (1) trapping of electron on newly-formed mineral surface, (2) rate-dependent emission of electron, such as triboemission, at asperity contact.

[Acknowledgements] This work was supported by grants from the Nuclear Regulation Authority (FY 2015–2018).

Keywords: Optically stimulated luminescence, Friction experiment, BET specific surface area, Triboluminescence

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Tue. May 28, 2019 1:45 PM - 3:15 PM JST | Tue. May 28, 2019 4:45 AM - 6:15 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-CG54] Rheology, fracture and friction in Earth and planetary sciences

convener:Miki Tasaka(Shimane University), Osamu Kuwano(Japan Agency for Marine-Earth Science and Technology), Ichiko Shimizu(Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University), Hidemi Ishibashi(Faculty of Science, Shizuoka University), Chairperson:Miki Tasaka(島根大学), Hidemi Ishibashi(Shizuoka University)

The aim of this session is to join people from various research area in the earth and planetary sciences and to stimulate discussion beyond the boundaries of each research area. Our goal is to deepen our understanding of dynamics in geosciences by looking over whole areas in the earth and planetary sciences from the viewpoint of PHYSICS OF DEFORMATION, FLOW, AND FRACTURE. We welcome any field (e.g., earthquake, volcano, earth surface, crust, mantle and the core, and other planets and satellites) and any approach (e.g., laboratory experiments, numerical simulations, field observations, and theories).

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SCG54-07] Frictional behaviors of smectite clay: constraints for the mobility of slow-moving landslides in the cold season

★Invited Papers

*Tatsuya Shibasaki[1], Sumio Matsuura[2] (1.Japan Conservation Engineers and Co., Ltd, 2.DPRI, Kyoto University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SCG54-08] Strength of a deep fault zone along the Median Tectonic Line: Influence of chrolite friction

*Ichiko Shimizu[1], Ayumi S. Okamoto, Andre R. Niemeijer[2], Christopher J. Spiers[2], Shun Arai[3], Toru Takeshita[4] (1.Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University, 2.Faculty of Geosciences, Utrecht University, 3.Tohoku University, 4.Hokkaido University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SCG54-09] Changes in seismic wave velocity during brittle deformation of gabbro and peridotite

*Yuya Akamatsu[1], Ikuo Katayama[1] (1.Hiroshima University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SCG54-10] Dislocation textures in shock-compressed MgO and their formation mechanisms

*Kiyoshi Fujino[1], Xun Liu[2], Tsutomu Mashimo[2] (1.Geodynamics Research Center, Ehime University, 2.Institute of Pulsed Power Science, Kumamoto University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SCG54-11] Development of rotational diamond anvil cell and large strain deformation experiments of lower-mantle materials

★Invited Papers

*Shintaro Azuma[1,2], Ryuichi Nomura[3,4], Kentaro Uesugi[5], Yu Nishihara[4], Doi Shunta[4], Takeshi Arimoto[4], Tetsuo Irifune[4] (1.Tokyo Tech., 2.Kyushu Univ., 3.Kyoto Univ., 4.Ehime Univ., 5.Japan Synchrotron Radiation Research Institute (JASRI))

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SCG54-12] Rheology of hcp-iron

*Yu Nishihara[1], Doi Shunta[1], Noriyoshi Tsujino[2], Daisuke Yamazaki[2], Yuji Higo[3] (1.Geodynamics Research Center, Ehime University, 2.Institute of Planetary Materials, Okayama University, 3.Japan Synchrotron

Radiation Research Institute)

Frictional behaviors of smectite clay: constraints for the mobility of slow-moving landslides in the cold season

*Tatsuya Shibasaki[1], Sumio Matsuura[2]

1. Japan Conservation Engineers and Co., Ltd, 2. DPRI, Kyoto University

In Japan, reactivated landslides are distributed on gentle clayey slopes in specific geological settings, such as Neogene soft sedimentary rock areas and hydrothermally altered rock areas around active and inactive volcanoes. These strata are typically composed of smectite-bearing high-plasticity soils. Of all the clay minerals, smectite shows an extremely low residual friction angle. Therefore, landslides consisting of these soils can easily become unstable and be reactivated on very gentle slopes. In many cases, such landslides are likely to be reactivated during certain seasons every year, moving slowly with typical velocities ranging from 0.01 to 0.1 mm/min. According to behavioral data of landslides in the Niigata Prefecture, a well-known landslide-prone area in Japan, some landslides begin to move during the early cold season (late autumn or early winter). Some landslides are activated during the winter, and display continuous movement, while others are activated predominantly during the snow-melting period. These various behaviors cannot be explained solely by fluctuations in pore-water pressure (ground water levels), and this therefore raises the question of what the key controlling mechanisms are. Shallow landslides, less than 10 m deep, are sometimes activated in the early cold season. We inferred that the change in ground temperature may play a key role in activating landslides. In order to verify this, we investigated the effect of temperature on residual shear strength of various clayey soils. Reversal box shear experiments and ring shear experiments were performed on undisturbed slip-surface soils and reconstituted soil samples, respectively. The test results revealed that the shear strength of smectite-rich soils decreases with decreasing temperatures under slow shearing rates of lower than 0.1 mm/min. This finding implies that seasonal fluctuation in ground temperature can influence slope instability, especially for shallow, slow-moving landslides. It is also evident that the effect of temperature on residual strength changes with the shearing rate. We infer that the velocity-dependent characteristic is strongly regulated by the fabric of smectite particles along the shearing plane.

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1) Shibasaki T., Matsuura S., and Okamoto T. (2016): Experimental evidence for shallow, slow-moving landslides activated by a decrease in ground temperature. Geophysical Research Letters, 43, 13, 6975-6984. doi.org/10.1002/2016GL069604
2) Shibasaki T., Matsuura S., and Hasegawa Y. (2017): Temperature-dependent residual shear strength characteristics of smectite-bearing landslide soils. Journal of Geophysical Research: Solid Earth, 122, 2, 1449-1469. doi.org/10.1002/2016JB013241

Keywords: Landslide, Smectite, Residual strength, Temperature dependency

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Strength of a deep fault zone along the Median Tectonic Line: Influence of chrolite friction

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To explore the fault strength at the middle crustal levels, we conducted high-pressure hydrothermal experiments using natural fault rocks exposed along the Median Tectonic Line (MTL), focusing on the role of chlorite in fault weakening. Chlorite is a hydrous mineral commonly observed in basic metamorphic rocks and fault zones, and is known to have low friction coefficients around 0.3–0.4 at room temperature water saturated conditions (Behnsen and Faulkner, 2012), and about 0.3 at hydrothermal conditions (Okamoto et al., *in review*).

The experiments were performed on powdered samples of cataclasite and protomylonite, which are originated from tonalite or basic rocks in the Ryoke belt on the northern side of MTL. Cataclasites contain ~30 wt.% mica and clay minerals. Among them, chlorite-rich cataclasite (Chl-cataclasite) contains ~14 wt.% chlorite, and mica-rich cataclasite (Ms-cataclasite) contains ~14 wt.% white mica. Chlorite geothermometer (Bourdelle *et al*., 2013, CMP) yields a bimodal distribution (230–240˚C and 290–340˚C) for the protomylonite sample. The low-temperature chlorite occurs as blobs with the diameter of ~1–2 mm, which contain lamella of white mica. These chlorite grains are considered as pseudomorphs of biotite. The high-temperature chlorite filled fractures and interstice of grains. We therefore interpreted that brittle deformation first occurred at a temperature around 300˚C and subsequent hydrothermal alteration occurred at 230–240˚C. Chl-cataclasite also shows a bimodal temperature distribution (180–220˚C and 240–300˚C), although no clear relationships between temperatures and microstructures were found.

To simulate the deformation conditions at depth, friction experiments were conducted at temperature of 300˚C, normal stress of 300 MPa, and pore fluid pressures of 120 MPa and 240 MPa, using the hydrothermal ring shear apparatus at Utrecht University. Sliding velocities were varied from 0.001 mm/s to 0.1 mm/s. The steady-state friction coefficients obtained for protomylonite were ~0.68, whereas those for Ms- and Chl-cataclasites were ~0.65 and ~0.56 at 120 MPa, and ~0.87 and ~0.66 at 240 MPa, respectively. Velocity stepping tests yielded velocity-weakening or neutral behaviours, although existing laboratory data for pure chlorite gouges mostly show velocity-strengthening behaviours. Our results indicate that fault strengths and sliding behaviours in the middle crusts are not drastically changed by the presence of phyllosilicates even if chlorite contents in fault zones are relatively high (<14 wt.%).

Keywords: friction, fault strength, high-PT experiments

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Changes in seismic wave velocity during brittle deformation of gabbro and peridotite

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1. Hiroshima University

The Moho is defined as a discontinuity of seismic wave velocity and often interpreted to be the crust-mantle boundary. The oceanic crust is continuously created by magma system at the mid ocean ridge; consequently, the discontinuity of seismic wave velocity and/or sharp seismic reflection at the Moho is expected to be laterally uniform. However, recent seismic observations reported regional variations of the Moho reflectivity (e.g., Mutter and Carton, 2013; Ohira et al., 2018). As seismic wave velocity is greatly influenced by nucleation and growth of microcracks, such seismic anomaly at the Moho can be influenced by microcracks. We found that minor amounts of dilatancy in peridotite relative to mafic rocks based on strain measurements during triaxial deformation tests using these rocks (Akamatsu et al., 2019). This contrasting dilatant behaviors possibly lead to different evolution of seismic wave velocity between crust and mantle, and potentially cause the regional seismic anomaly in the oceanic plate. In this study, we measured elastic wave velocities of gabbro and peridotite during triaxial deformation experiments, and discussed how brittle deformation influences on the seismic velocity and reflectivity.

We used gabbro collected from the Oman ophiolite, and peridotite collected from the Horoman Complex. Triaxial deformation experiments were performed with intra-vessel deformation and fluid flow apparatus at room temperature, a constant strain rate of ~10^{-6} s^{-1}, and a constant confining pressure of 20 MPa. Compressional and shear waves traveling in a direction normal to the loading axis were measured during deformation, where shear waves were polarized normal and parallel to the loading axis. Seismic wave velocities were determined by a pulse transmission method, in which travel times of seismic waves through the sample were measured.

In gabbros, both Vp and Vs markedly decreased (Vp: ~40%, Vs: ~30%) as the samples approache failure. Crack density inverted from the velocities showed anisotropic crack orientation, where microcracks parallel to the loading axis (axial microcracks) were dominantly created. These results correspond to strain data and microstructural observation of recovered samples after deformation (Akamatsu et al., 2019). On the other hand, in peridotites, a small decrease in Vp and Vs (<20%) were observed up to the maximum stress, and inverted crack density showed no significant increase in axial microcracks. This indicates that microcracks developed in peridotites were mainly “mode II” shear microcracks, corresponding to strain data and microstructural observation. These contrasting evolutions of seismic wave velocity and crack density between gabbro and peridotite during brittle deformation can modify the seismic discontinuity and reflectivity at the Moho, and contribute to the variation of the Moho in the oceanic plate.

Keywords: Peridotite, Gabbro, Seismic wave velocity, Brittle deformation, Dilatancy, Microcrack

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Dislocation textures in shock-compressed MgO and their formation mechanisms

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Deformation phenomena under high-pressure in Earth and planetary science occur under the shock compression as well as under the static or quasi-static compression. However, the studies on dislocation textures of materials under the shock compression are very limited, compared to those under the static or quasi-static compression. To fill such gap, the shock compression experiments on MgO were carried out and the dislocation textures of the recovered samples were examined under TEM to consider the formation mechanisms of those dislocation textures.

The shock compression experiments of single-crystal MgO were performed with a powder gun at the Institute of Pulsed Power Science, Kumamoto Univ. The shock compression experiments were done along the <100> and <110> directions. The recovered MgO samples were examined under 200 kV TEM at the Geodynamics Research Center, Ehime University.

In the previous studies, the Burgers vector of MgO is always $(\boldsymbol{a}_1 + \boldsymbol{a}_2)/2$ and the slip planes are mostly {110} and {100}. The present TEM examination showed that the sample under the <100> compression has dislocations of only the {110} slip plane, while under the <110> compression the sample has dislocations of only the {110} slip plane at low pressure but has dislocations of both {110} and {100} slip planes at higher pressure, indicating that the slip plane changes from {110} to {100} with increasing pressure. In addition to these results the dislocation textures which are usually not observed in the static or quasi-static compression, were also observed. In the presentation, the formation mechanisms of the observed dislocation textures are also discussed.

Keywords: shock compression, MgO, TEM observation, slip system of dislocation

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Development of rotational diamond anvil cell and large strain deformation experiments of lower-mantle materials

*Shintaro Azuma[1,2], Ryuichi Nomura[3,4], Kentaro Uesugi[5], Yu Nishihara[4], Doi Shunta[4], Takeshi Arimoto[4], Tetsuo Irifune[4]

1. Tokyo Tech., 2. Kyushu Univ., 3. Kyoto Univ., 4. Ehime Univ., 5. Japan Synchrotron Radiation Research Institute (JASRI)

The rheological properties of lower-mantle materials are key to understanding the dynamics and evolution in the Earth’ s interior. However, the pressure range of deformation apparatuses which can achieve large strain is limited to ~30–40 GPa due to a technical reason. We developed the rotational diamond anvil cell (rDAC) which can conduct deformation experiments with large strain under ultra-high pressure conditions, corresponding to those of core-mantle boundary [Nomura et al., 2017]. The rDAC can apply the torsional deformation to sample with constant strain rate by a gearbox and diamond anvils with grooves [Azuma et al., 2018]. However, the stress measurement and high temperature conditions has not been achieved in rDAC. To solve these problems, the vacuum chamber newly designed for rDAC was installed and the stress measurements using X-ray Diffraction (XRD) were applied to deformation experiments in rDAC at SPring-8 (Japan). In this presentation, we will present the preliminary results of stress measurements, high temperature techniques in rDAC, and the results of deformation experiments of lower-mantle materials.

In this study, the mixture of bridgmanite $(Mg,Fe)SiO_3$ and ferropericlase (Mg,Fe)O, which was synthesized from San Carlos olivine, was deformed under torsion geometry using the rDAC. The experimental conditions are ranging 26–130 GPa, 300–673 K. Starting material was grooved by FIB and the groove was deposited by Pt as a strain-marker. Recovered samples were cut by FIB to observe the deformation microstructures in each cross-section. Deformation experiments were conducted at BL47XU, SPring-8 (Japan) and 3D visualization of strain marker within samples was performed every rotation angle of upper anvil of 5–30 degree using X-ray laminography technique [Nomura and Uesugi, 2016]. Stress was measured by collecting X-ray diffraction pattern at twelve different azimuthal angles, Ψ= 0º, ±30º, ±60º, ± 90º, ±120º, ±150º, and 180º. Testing of the new vacuum chamber was also performed at SPring-8. The vacuum chamber has a removable Kapton window for incident and diffracted X-ray, and can keep the vacuum state (<~10 Pa) to prevent the diamond anvils from oxidation during high-temperature deformation experiments. Platinum wires were used as a resistance heater surrounding the sample and Rhenium gasket.

The geometry of strain-marker in cross-section of deformed samples show nearly simple shear (or general shear). Deformed microstructure of recovered samples was observed using FE-SEM and we determined the 2D surface area of ferropericlase and aspect ratio of bridgmanite. The deformation microstructures of the recovered samples showed that ferropericlase highly deformed and formed an interconnected weak layer. On the other hand, the aspect ratio of bridgmanite did not change with the strain, indicating that bridgmanite has high viscosity compared with ferropericlase. These results imply that ferropericlase dominates the deformation in the regions where large shear strain occurs under relatively low-temperature conditions in the lower mantle (e.g., mantle portion in subducted slabs).

Stress in bridgmanite was estimated by using diffraction peaks (110) and (112) at P = 50 GPa and T= 673 K. Shear stress in bridgmanite was relatively constant values, whereas uniaxial stress changed during

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deformation experiments. This preliminary experiment was performed under low-temperature and high-pressure conditions, thus the equivalent stress in bridgmanite was about three times higher than that in previous studies [Girard et al., 2016].

In heating experiments using new vacuum chamber, temperature was monitored by Pt/Rh thermocouple placed close to the sample and and we succeeded in increasing temperature up to ~1000 K. However, the resistance heater (Pt) was unstable in vacuum. In the future, high-temperature deformation experiments using rDAC will be conducted in reducing atmosphere produced by inactive gas or internal heating system should be developed for rDAC.

Keywords: Lower mantle, Rotational diamond anvil cell, Deformation

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Rheology of hcp-iron

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Seismic observations have revealed presence of axi-symmetric anisotropy with respect to polar direction in the Earth’ s inner core which consists of solid metal, where a P- wave propagating along the polar direction is ~3% faster than that along the equatorial direction. Although many hypotheses have been proposed for origin of seismic anisotropy in the inner core, there is no general consensus for its origin. Lasbleis and Deguen (2015) discussed that dominant mechanism of the inner core dynamics depends on the inner core age and viscosity, and there are several candidate mechanisms which includes anisotropic growth model (Yoshida et al., 1996) and thermal convection model (Jeanloz and Wenk, 1988). Since the inner core is considered to consist of hexagonal close-packed iron(hcp-iron), information of viscosity of hcp-iron is a key for the understanding of the inner core dynamics. In this study, we have studied rheology of hcp-iron based on high-pressure and high-temperature deformation experiments.
Uniaxial deformation experiments were carried out using a D111-type apparatus installed on a beamline NE7A at PF-AR, KEK and a deformation-DIA apparatus installed on a beamline BL04B1 at SPring-8. Using polycrystalline bcc-iron as a starting material, deformation experiments were carried out at pressure of 16.9-22.6 GPa, temperature of 423-873 K, and strain rate of $0.2–5.2\times10^{-5}$ s^{-1}. Stress and strain during deformation were determined based on two-dimensional X-ray diffraction and X-radiography, respectively, using monochromatized synchrotron X-ray with energy of 60 keV.
A preliminary analysis of the observed data suggests that power-law dislocation creep with stress exponent of ~5 is dominant at >700 K whereas power-law breakdown occurs at lower temperatures. Extrapolation of the data based on homologous temperature scaling suggests that viscosity of hcp-iron at the inner core conditions is ~10^{21} Pa s or higher.

Keywords: hcp-iron, inner core, rheology

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Tue. May 28, 2019 9:00 AM - 10:30 AM JST | Tue. May 28, 2019 12:00 AM - 1:30 AM UTC | Convention Hall A 2F

[S-CG61] Dynamics in mobile belts

convener:Yukitoshi Fukahata(Disaster Prevention Research Institute, Kyoto University), Toru Takeshita(Department of Natural History Sciences, Graduate School of Science, Hokkaido University), Hikaru Iwamori(Geochemical Evolution Research Program, Japan Agency for Marine-Earth Science and Technology), Chairperson:Keisuke Yoshida(東北大学大学院理学研究科 地球物理学専攻), Masaoki Uno(東北大学)

The dynamic behaviours of mobile belts are expressed across a wide range of time scales, from the seismic and volcanic events that impact society during our lifetimes, to orogeny and the formation of large-scale fault systems which can take place over millions of years. Deformation occurs on length scales from microscopic fracture and flow to macroscopic deformation to plate-scale tectonics. To gain a physical understanding of the dynamics of mobile belts, we must determine the relationships between deformation and the driving stresses due to plate motion and other causes, which are connected through the rheological properties of the materials. To understand the full physical system, an integration of geophysics, geomorphology, and geology is necessary, as is the integration of observational, theoretical and experimental approaches. In addition, because rheological properties are greatly affected by fluids in the crust and fluid chemical reactions, petrological and geochemical approaches are also important. After the 2011 great Tohoku-oki earthquake, large-scale changes in seismic activity and regional scale crustal deformation were observed, making present-day Japan a unique natural laboratory for the study of the dynamics of mobile belts. This session welcomes presentations from different disciplines, such as seismology, geodesy, tectonic geomorphology, structural geology, petrology, and hydrology, as well as interdisciplinary studies, that relate to the dynamic behaviours of mobile belts.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SCG61-13] Deciphering dynamics of thermal events at lithosphere-asthenosphere boundary from peridotite xenoliths of Ichinomegata maar, NE Japan

*Yuto Sato[1], Kazuhito Ozawa[1] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SCG61-14] Experimental investigation of reaction-induced stress and permeability evolution in $MgO–H_2O$ system

*Masaoki Uno[1], Hisamu Kasahara[1], Atsushi Okamoto[1], Noriyoshi Tsuchiya[1] (1.Graduate School of Environmental Studies, Tohoku University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SCG61-15] Fluid-Flow, Resistivity and Elastic Wave Velocity Simulation of Digital Rock Fracture and Comparison with Experimental Data

*Kazuki Sawayama[1], Fei Jiang[2], Takuya ISHIBASHI[3], Takeshi Tsuji[4], Yasuhiro Fujimitsu[4] (1.Department of Earth Resources Engineering, Graduate school of engineering, Kyushu University, 2.Department of Mechanical Engineering, Faculty of Engineering, Yamaguchi University, 3.Fukushima Renewable Energy Institute, National Institute of Advanced Industrial Science and Technology, 4.Department of Earth Resources Engineering, Faculty of engineering, Kyushu University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SCG61-16] Fluid distribution in the crust – inference from seismic velocity and electrical conductivity

*Tohru Watanabe[1], Kenta Yoshida[2] (1.Gradudate School of Science and Engineering, University of Toyama, 2.Research and Development Center for Ocean Drilling Science, Japan Agency for Marine-earth Science and Technology)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SCG61-17] The seismological structure about fault zone extending to the lower crust in the northern Kinki district, southwestern Japan

*Shinya Kato[1], Yoshihisa Iio[1], Takuo Shibutani[1], Hiroshi Katao[1], Masayo Sawada[1], Kazuhide Tomisaka[1] (1.Disater Prevention Research Institute, Kyoto University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SCG61-18] Inland repeating earthquakes in the vicinity of low frequency earthquakes around Hakodate, Hokkaido

*Keisuke Yoshida[1], Akira Hasegawa[1], Shinako Noguchi[2], Keiji Kasahara[2] (1.Tohoku University, 2. Association for the Development of Earthquake Prediction)

Deciphering dynamics of thermal events at lithosphere-asthenosphere boundary from peridotite xenoliths of Ichinomegata maar, NE Japan

*Yuto Sato[1], Kazuhito Ozawa[1]

1. Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo

Mantle xenoliths are fragments of mantle materials almost instantaneously transported to the surface by alkali basalt or kimberlite magmas (Nixon, 1987). They are unique in that they record temporal changes of mantle processes in chemical zonings and microstructures of constituent minerals. Thus, such information can potentially constrain time-dependent dynamic processes occurring in the lithosphere-asthenosphere boundary (LAB) zone, where mechanisms of heat and material transfer drastically change (Sleep, 2005, 2006). In this regard, Takahashi (1980) and Koyaguchi (1986) achieved key contributions. They examined chemical zonings of olivine and pyroxenes in spinel peridotite xenoliths from Ichinomegata, a latest Pleistocene andesitic-dacitic maar located in the back-arc side of NE Japan arc (Katsui et al., 1979). They clarified a variety of thermal history that the xenoliths underwent, but processes responsible for the diversity is not resolved yet because the derivation depth was not constrained. We have conducted very careful geothermobarometry of spinel peridotite xenoliths from Ichinomegata maar and successfully reconstructed the thermal, chemical, and rheological structures of the LAB zone beneath NE Japan arc at the time of Ichinomegata maar formation (80-60 ka) (Sato and Ozawa, 2017, 2018, JpGU meeting; Sato and Ozawa, 2016, 2017, AGU fall meeting; see our companion presentation in this meeting). We examined temporal changes of the structures through analyses of chemical zonings of pyroxenes in 9 plagioclase and spinel peridotite xenoliths from Ichinomegata.

In our previous study, the depths and temperatures of 8 of the 9 xenoliths just before the xenolith extraction are estimated to range 28-55 km and 828-1081 ˚C. The mantle beneath Ichinomegata consists of shallow (28-32 km), low temperature, granular (less strained), and amphibole-bearing zone and deep (41-55 km), high temperature, porphyroclastic (strained), and amphibole-free and melt-bearing zone. We identified the shallower zone as lithospheric mantle, the deeper zone as LAB zone, and that their boundary was controlled by wet solidus.

We obtained Ca, Al, Cr, and Ti zonings of large clinopyroxene and orthopyroxene using EPMA at the University of Tokyo and analyzed them with a diffusion model. The zoning patterns of Ca, Al, and Cr of pyroxenes allow us to identify 4 different thermal histories from 4 types of chemical zonings for orthopyroxene (O1-O4) and 3 types for clinopyroxene (C1-C3) as summarized in Table 1. They are (1) continuous cooling at a cooling rate of ~$1x10^{-4}$ ˚C/y over the time scale of ~1-10 million years from ~1000 to ~830 ˚C (constrained from O1 and C1), (2) cooling followed by weak heating at ~900 ˚C over the time scale of ~10-100 thousand years (from O2 and C1), (3) cooling followed by strong heating at ~1050 ˚C over the time scale of ~1-100 thousand years (from O3 and C2), and (4) prolonged cooling and heating at ~1000 ˚C (from O4 and C3). There is a systematic depth variation of thermal histories as summarized in Table 2. It is notable that the shallow lithospheric mantle is characterized by simple cooling or cooling followed by weak heating and the deep LAB zone by cooling followed by strong heating. This systematic depth variation requires a thermal perturbation of asthenospheric mantle beneath the deeper LAB zone, most plausibly asthenospheric upwelling.

The age of the Japan Sea opening is comparable to the time scale of cooling estimated from O1 and C1, and the continuous cooling at the shallow lithospheric mantle is attributable to the cooling of the

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back-arc basin lithosphere, The timescale of the heating event in the deep LAB zone is too short to be explained by LAB-fixed heat conduction model. Effective heat transportation mechanisms are necessary, either partial crystallization of melt generated in the asthenosphere that passed through the LAB zone as advocated by Takahashi (1980) or extensive lithosphere thinning.

Keywords: lithosphere-asthenosphere boundary zone, spinel peridotite xenolith, thermal history, chemical zoning

Table 1. Patterns of chemical zonings in orthopyroxene and clinopyroxene.

Zoning type	Patterns of zoning profiles from core to rim		
	Ca	Al	Cr
Orthopyroxene			
O1	simple decrease	simple decrease	
O2	decrease followed by weak increase	decrease followed by weak increase	
		decrease followed by weak increase	simple decrease
O3	decrease followed by intense increase	decrease followed by intense increase	
O4	faint increase	faint decrease	
Clinopyroxene			
C1	simple increase	simple decrease	
C2	simple decrease	simple increase or decrease followed by intense increase	
C3	flat	faint decrease	

Table 2. Depth variations of chemical zoning types of pyroxenes and thermal hisotry.

Sample name	Pressure (GPa)	Depth (km)	Temperature (°C)	Chemical zoning of pyroxenes	
				Types	Decoded thermal history
HK64081206g	0.72 ± .52	28 ± 16	829 ± 23	O1 & C1	Simple cooling.
HK64081206c	0.80 ± .70	30 ± 21	828 ± 30	O1 & C1	Simple cooling.
HK64081206d	(0.82)	(31)	(875)	O2 & C1	Cooling followed by weak heating.
HK66031502	0.85 ± .42	32 ± 13	905 ± 19	O2 & C1	Cooling followed by weak heating.
IC81-5	1.16 ± .29	41 ± 9	1017 ± 15	O4 & C3	Cooling and long heating.
HK64081205a	1.29 ± .24	45 ± 7	1050 ± 12	O3 & C2	Cooling followed by strong heating.
IC81-8	1.46 ± .37	50 ± 11	1052 ± 19	O3 & C2	Cooling followed by strong heating.
HK66031501	1.51 ± .36	52 ± 11	1057 ± 18	O3 & C2	Cooling followed by strong heating.
HK64081205b	1.62 ± .44	55 ± 13	1081 ± 23	O3 & C2	Cooling followed by strong heating.

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Experimental investigation of reaction-induced stress and permeability evolution in MgO–H_2O system

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Crustal and mantle hydration reactions at subduction zones accompany large solid volume change as much as several vol.% to several tens of vol.%. Such large solid volume change can generate stress and fractures, accelerate reactions and fluid migrations (e.g., Kelemen and Hirth, 2012), and potentially influence the fluid transport in the crust and mantle (e.g., Jamtveit et al., 2000). Field observations of serpentinization and peridotite carbonation suggest fracture generation and permeability enhancement by such “reaction-induced stress” (e.g., Jamtveit et al., 2008; Plumer et al., 2012). However, the permeability enhancement during hydration reaction have not been reproduced by experiments, and the mechanisms and conditions of permeability enhancement by volume-increasing reactions remain largely unknown.

To understand the controlling mechanisms of fluid flow during hydration reactions, we show one of the first experimental trial to measure the permeability evolution during hydration reactions. We use MgO–H_2O system, where periclase (MgO) react with H_2O to produce brucite ($Mg(OH)_2$). The reaction involves solid volume increase of as much as +119%. Our earlier experiments have revealed that the reaction-induced stress in this system are controlled by the competition of reaction rate and stress-dependent deformation rate, and exceeds 40 MPa in this system which well exceeds the tensile strength of crustal rocks.

In this presentation, we have conducted flow thorough experiments to reveal the permeability evolution during hydration reactions. Experiments were conducted with sintered MgO with 4–14 vol.% porosity, under 100–300˚C with 5–50 MPa confining pressure and 5–15 fluid pressures. Preliminary experiments showed rapid permeability decrease in 2–3 orders, and finally the stainless sleeve broke by the reaction-induced expansion. The rate of permeability decrease is a function of the confining pressure, suggesting that the deformation of the reactant (brucite) has significant control over the permeability evolution during hydration reactions. We will present further experiments with various reaction rate/deformation rate ratios, and discuss the controlling factors of permeability enhancement/reduction during hydration reactions.

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Keywords: Reaction-induced stress, Reaction-induced fracturing, permeability

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Fluid-Flow, Resistivity and Elastic Wave Velocity Simulation of Digital Rock Fracture and Comparison with Experimental Data

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Fluid-flow in the fracture plays a key role to evaluate the mechanism of earthquake and fractured reservoirs (e.g., geothermal and shale) since fracture flow constrains the fluid-flow behavior and rock strength under the ground. To predict the fluid-flow and its distribution under the ground, geophysical explorations (seismic and electromagnetic methods) have been broadly applied. However, there is no established rock physical model to estimate the fluid-flow properties (e.g., permeability) in the fracture from resistivity or elastic wave velocity, and thereby fluid-flow behavior in the fracture are difficult to be precisely interpreted by geophysical explorations. For the better interpretation of these exploration data, more detailed investigation about the effect of fluid-flow behavior on resistivity and elastic wave velocity of fractured rocks is required. In this study, in order to discuss this effect, we measured and calculated them by using fractured rock samples which have different apertures.

We conducted laboratory fluid-flow testby using fractured Inada granite (50 mm in a diameter, 80 mm in a length) which have single tensile fracture with different aperture. For the numerical model, we digitalized this real rock fracture (0.1 mm grid resolution) to calculate fluid-flow, resistivity and elastic wave velocity under the same condition with experiment. Three dimensional fracture flow was simulated by using Lattice Boltzmann Method and we applied Finite Element Analysis to calculate resistivity and elastic wave velocity after this fluid-flow simulation.

As a result, permeability decreases with pressure increase under laboratory experiment and calculated permeability also shows the decrease as the aperture increases. This agreement suggests that fracture permeability is constrained by aperture closure due to the pressure effect. From the permeability matching approach, we found that permeability dramatically decreases after the fracture contact area exceeds ~80%. At this threshold value, fluid-flow path, resistivity and elastic wave velocity show inflections. Our results suggest that permeability change caused by aperture closure could be estimated by seismic and electromagnetic explorations.

Keywords: digital rock physics, elastic wave velocity, resistivity, fracture flow, Lattice Boltzmann Method

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Fluid distribution in the crust –inference from seismic velocity and electrical conductivity

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Aqueous fluids must play important roles in crustal dynamics including seismicity. Geophysical mapping of fluids will thus give us insights into crustal dynamics. Electrical conductivity profiles have suggested that fluids exist pervasively in the crust. However, the fluid distribution has not been quantitatively constrained. It must be due to our poor understanding of pores that govern seismic velocity and electrical conductivity under high pressures.

In order to understand pores governing physical properties under pressures, simultaneous measurements of elastic wave velocities and electrical conductivity were conducted on a brine saturated granitic rock (Aji granite) under pressures up to 150 MPa and microstructure of pores was observed by X-ray micro CT and SEM with ion-milling and FIB. X-ray micro CT images show that many grain boundaries are open at atmospheric pressure. Elastic wave velocity increases and electrical conductivity decreases with increasing confining pressure. Most of grain bouundary cracks are closed under high pressures (>100 MPa). The electrical conductivity is, however, still much higher than that of the solid phase. The brine must be interconnected under high pressures. SEM images suggest that wide aperture parts in grain boundaries are open even at high pressures and form conduction paths.

There should be cracks with various sizes in the crust: from grain boundaries to large faults. Though cracks are closed under pressure, there must be a variation in the aperture. Wide aperture parts may form conduction paths even under high pressures. The influence of wide aperture parts on physical properties can be evaluated by tube model. Electrical conductivity is proportional to the fluid volume fraction. A change in conductivity by 4 orders of magnitude requires a change in fluid volume fraction by 4 orders of magnitude. However, seismic velocity for tube model is insenstive to fluid volume fraction. Seismic velocity will thus show relatively small decrease for a large change in fluid fraction. Observed large variation in conductivity and relatively small variation in seismic velocity (e.g., Ogawa et al., 2001; Matsubara et al., 2004) are consistent with tube model. The variation in fluid fraction must reflect that in the amount of wide aperture parts, which is attributed to the variation the amount of cracks.

Keywords: seismic velcoity, resistivity, fluid

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The seismological structure about fault zone extending to the lower crust in the northern Kinki district, southwestern Japan

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The “water-weakened lower crust model” has been proposed to explain the mechanism of stress concentration on faults of inland earthquakes (Iio et al. 2002). According to this model, it is necessary that heterogeneous structure caused by the fluid exists locally in the deeper part of fault zones in the lower crust, but it has not been clearly confirmed in previous researches. This is because we do not resolve the heterogeneous structure due to fluid in the deeper part of fault zones in the lower crust. In order to solve this problem, in this study, we tried to image the heterogeneous structure in the lower crust in detail.

We conducted S-wave reflection analysis to detect the horizontal distribution of the heterogeneous structure (reflector), and receiver function analysis to estimate the structure beneath the reflector, in the northern Kinki district, southwestern Japan. As a result of the S-wave reflection analysis, it is found that the reflector exists on the north side of the Arima-Takatsuki fault zone and does not exist on the south side of it. We consider that the distribution of the reflector is related to the Arima-Takatsuki fault zone. From a result of the receiver function analysis, it is found that reflector is a thin layer with low S-wave velocity.

It is concluded that the thin layer with low S-wave velocity exists in the lower crust of the northern Kinki region. As the origin of it, it is possible to consider fluid dehydrated from the Philippine Sea slab subducting beneath the Arima-Takatsuki fault zone. In the vicinity of the Arima-Takatsuki fault zone, it is known that fluid that seems to originate in the mantle springs out (Kazahaya et al. (2014)). In the lower crust, pores between minerals exist independently (Yoshino et al. 2002), and fractures caused by faulting is thought to be necessary for fluid movement (Mibe et al. (2000)). Furthermore, since the spatial distribution of the reflector is related to the Arima-Takatsuki fault zone, we consider that the reflector in the lower crust indicates that fluid exists in fractures caused by faulting. This result supports the water-weakened lower crust model.

Keywords: S-wave reflection analysis, receiver function analysis, lower crust, fault zone, fluid

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Inland repeating earthquakes in the vicinity of low frequency earthquakes around Hakodate, Hokkaido

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Strength reduction due to pore pressure increase plays an important role for the generation of earthquakes. Earthquake swarms in central Tohoku activated after the 2011 Tohoku-Oki earthquake are examples of this; they are estimated to be caused by the upward fluid migration due to the decrease of WNW-ESE compressional stress after the earthquake (Yoshida & Hasegawa, 2018a and b). Inland deep low frequency earthquakes are also considered to be closely related to the fluids (e.g., Hasegawa & Yamamoto, 1994), but their detailed mechanism is poorly understood. In this presentation, we introduce our recent study on earthquakes occurring in Hakodate, Hokkdaido, which are covered by a dense seismic network installed by the Association for the Development of Earthquake Prediction (ADEP) (Noguchi et al., 2017). In this area many low frequency earthquakes are occurring, shallow ones of which occur in the immediate vicinity of ordinary earthquakes. This provides a unique opportunity to investigate the relationship between the diversity of fault motions and the fluid behavior.

We start by relocating hypocenters of ordinary earthquakes and low frequency earthquakes by applying the double-difference location method (Waldhauser & Ellsworth, 2002). We used precise differential arrival time data of P- and S-waves obtained by the waveform cross-correlation following Yoshida & Hasegawa (2018), which largely improved the accuracy of relative hypocenter locations. We relocated hypocenters of 198 earthquakes for the period from 2003 to Oct. 2018, which are listed in the JMA unified catalog or in the ADEP catalog; 22 of them are ordinary earthquakes and 176 are low frequency earthquakes. Relative locations of ordinary earthquakes are very precisely determined due to the similarity of waveform, but those of low frequency earthquakes are almost controlled by the manually picked arrival time data because of the diversity of their waveforms.

Relocated hypocenters show that low frequency earthquakes are distributed in a plate shape dipping eastward with focal depths from 5 to 35 km, which are confirmed by the S-P times obtained at the stations just above their epicenters. Low frequency earthquakes occurring in the shallow part of the crust are located in the immediate vicinity of ordinary earthquakes. We found that the initial parts of P- and S-waves of these low frequency earthquakes have similar waveform characteristics with those of the nearby ordinary earthquakes. Furthermore, ordinary earthquakes occurring near the low frequency earthquakes have very similar waveforms themselves. They turned out to be inland repeating earthquakes based on the hypocenter relocations using precise differential arrival times obtained by the waveform cross-correlation. Other repeating earthquake sequences were also found based on the template matching method (Shelly et al., 2013). Some earthquakes in one of those repeating earthquake sequences occur with a time interval of about ten minutes or so. Similar repeating earthquake occurrences with such a short time interval have been found in an induced seismicity of a recent fluid-injection experiment (Lengline et al., 2014), which suggests that natural repeating earthquakes are also caused by a similar mechanism to the fluid injection induced seismicity; slips are repeatedly caused in the same locations due to successive reduction in frictional strength by the pore pressure increase.

Keywords: low frequency earthquakes, earthquake detection

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Tue. May 28, 2019 10:45 AM - 12:15 PM JST | Tue. May 28, 2019 1:45 AM - 3:15 AM UTC | Convention Hall A 2F

[S-CG61] Dynamics in mobile belts

convener:Yukitoshi Fukahata(Disaster Prevention Research Institute, Kyoto University), Toru Takeshita(Department of Natural History Sciences, Graduate School of Science, Hokkaido University), Hikaru Iwamori(Geochemical Evolution Research Program, Japan Agency for Marine-Earth Science and Technology), Chairperson:Bunichiro Shibazaki, Daisuke Sato

The dynamic behaviours of mobile belts are expressed across a wide range of time scales, from the seismic and volcanic events that impact society during our lifetimes, to orogeny and the formation of large-scale fault systems which can take place over millions of years. Deformation occurs on length scales from microscopic fracture and flow to macroscopic deformation to plate-scale tectonics. To gain a physical understanding of the dynamics of mobile belts, we must determine the relationships between deformation and the driving stresses due to plate motion and other causes, which are connected through the rheological properties of the materials. To understand the full physical system, an integration of geophysics, geomorphology, and geology is necessary, as is the integration of observational, theoretical and experimental approaches. In addition, because rheological properties are greatly affected by fluids in the crust and fluid chemical reactions, petrological and geochemical approaches are also important. After the 2011 great Tohoku-oki earthquake, large-scale changes in seismic activity and regional scale crustal deformation were observed, making present-day Japan a unique natural laboratory for the study of the dynamics of mobile belts. This session welcomes presentations from different disciplines, such as seismology, geodesy, tectonic geomorphology, structural geology, petrology, and hydrology, as well as interdisciplinary studies, that relate to the dynamic behaviours of mobile belts.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SCG61-19] Modeling strain concentration and mountain building processes in central Japan considering heterogeneous rheological structure

*Bunichiro Shibazaki[1] (1.International Institute of Seismology and Earthquake Engineering, Building Research Institute)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SCG61-20] Inelastic strain rate and deviatoric stress field of the seismic gap in west part of Kyushu, Japan, estimated from seismic and geodetic data

*Yuhei Yuasa[1], Satoshi Matsumoto[2], Shigeru Nakao[3], Takeshi Matsushima[2], Takahiro Ohkura[4] (1.Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2.Institute of Seismology and Volcanology, Faculty of Sciences, Kyushu University, 3.Department of Earth and Environmental Sciences, Graduate School of Science and Engineering, Kagoshima University, 4.Aso Volcanological Laboratory, Institute for Geothermal Sciences, Graduate School of Science, Kyoto University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SCG61-21] Persistent and time-dependent crustal deformation in northern Fossa Magna and its tectonic implications

*Takeshi Sagiya[1], Koki Kumagai[2], Angela Meneses-Gutierrez[3], Nobuhisa Matsuta[4], Daisuke Hirouchi[5], Kenjiro Matsuhiro[2], Takashi OKUDA[2] (1.Disaster Mitigation Research Center, Nagoya University, 2.Graduate School of Environmental Studies, Nagoya University, 3.Disaster Prevention Research Institute, Kyoto University, 4.Graduate School of Education, Okayama University, 5.Faculty of Education, Shinshu University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SCG61-22] Unexpected relationship between ΔCFF and the strain-rate paradox: separation of plastic strain from inelastic strain

*Yukitoshi Fukahata[1], Angela Meneses-Gutierrez[1], Takeshi Sagiya[2] (1.Disaster Prevention Research Institute, Kyoto University, 2.Disaster Mitigation Research Center, Nagoya University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SCG61-23] Active period of inland earthquakes based on numerical simulation of megathrust earthquake cycle incorporating viscoelasticity

*Tsukasa MITOGAWA[1], Takuya NISHIMURA[2] (1.Graduate School of Science, Kyoto University, 2.Disaster Prevention Research Institute, Kyoto University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SCG61-24] Influence of viscoelastic relaxation on estimated interplate coupling along the Nankai Trough, southwest Japan

*Takuya NISHIMURA[1], Fred F Pollitz[2] (1.Disaster Prevention Research Institute, Kyoto University, 2.U.S. Geological Survey)

Modeling strain concentration and mountain building processes in central Japan considering heterogeneous rheological structure

*Bunichiro Shibazaki[1]

1. International Institute of Seismology and Earthquake Engineering, Building Research Institute

Recent analysis of crustal deformation using GEONET data has revealed the existence of several strain concentration zones in the Niigata–Kobe Tectonic Zone (Sagiya, et al., 2000), in the Ou backbone range (Miura et al., 2004), in Kyushu, and San-in (Nishimura et al., 2018), etc. Many large inland earthquakes have occurred in the strain concentration zones. Elucidating the mechanism of strain concentration leads to understanding generation processes of large inland earthquakes. We develop a model of strain concentration and mountain building in the island-arc crust of central Japan, where several high mountain ranges have been formed by active crustal deformation. We use the finite element code with nonlinear viscoelasticity and plasticity based on Mohr-Coulomb criterion (e.g. Shibazaki et al., 2016). We consider gravitational force as a body force because the plasticity and the flow law depend on absolute stress.

Based on dense geothermal gradient data from Hi-net (Matsumoto et al., 2007) and the Geological Survey of Japan (Tanaka et al., 2004), we develop a thermal structure. We also consider a thick sedimentary layer where the friction coefficient is low based on the J-SHIS deep subsurface structure (NIED). Numerical results show that under the compressional tectonic setting, mountains are reproduced along high geothermal gradient regions. We can reproduce the Hida mountain range, Chikuma mountain, Echigo mountain range, and others, where a geothermal anomaly exists. Our model can also reproduce strain concentration in the Hida region. Furthermore, we can reproduce a strain concentration zone by setting the frictional coefficient to be low in the basement of the Niigata region.

However, the model cannot reproduce the strain concentration zone in the Atotsugawa and Kinki regions where strike slip faulting is dominant; therefore, we consider the boundary condition that yields the stress state of the strike-slip faulting and the effect of water distribution or rheology of partial melting based on seismic velocity anomalies (Nakajima and Hasegawa, 2007). We can reproduce strain concentration along the seismic velocity anomalies. Our results suggest that the Niigata-Kobe strain concentration zone is developed by several factors: thermal anomaly, pre-existing rift structure, and the presence of fluid and partial melting in the crust and the upper mantle.

Keywords: Central Japan, Strain concentration zone, Mountain building, Finite element method, Nonlinear viscoelasticity , Plasticity based on Mohr-Coulomb criterion

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Inelastic strain rate and deviatoric stress field of the seismic gap in west part of Kyushu, Japan, estimated from seismic and geodetic data

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An earthquake is a phenomenon that differential stress loading on the Earth’ s crust is released. Thus, we need to know state of stress in the crust to understand the earthquake generation mechanism. The state in the crust has been investigated in many studies, based on data of the focal mechanisms and seismic moment tensors (e.g., Michael 1984; Horiuchi et al. 1995; Terakawa & Matsu’ ura 2008). However, information on the stress fields in non-active seismic areas is insufficient because accurate stress estimation requires the data from a number of earthquakes. A key factor for acquiring knowledge of the stress field in an aseismic zone is the inelastic strain, which is related to the deviatoric stress based on the flow rule in plasticity theory (Matsumoto 2016). Thus, the strain rate due to inelastic deformation source needs to be separated from the total strain rate measured via geodetic observation. Here, we propose a new method for estimation of the deviatoric stress field through inelastic strain analysis that combines the seismic moment tensor and geodetic data. In this method, the deformation source of inelastic strain in the upper crust is estimated from short wavelength component of the observed total strain rate field, and the inelastic source tensor yields tensor shape of deviatoric stress field based on the flow rule. This method is applied to data for a region in and around the aseismic zone of Amakusa located at west part of Kyushu Island, Japan. It was found that the inelastic deformation in the seismic gap exhibits either normal-fault or strike-slip type. Furthermore, the deviatoric stress field estimated from the inelastic deformation has same trend as the surroundings. In addition, the estimated stress explained slip vectors of event rarely occurring there. These results might provide us with important information regarding the origin of the seismic gap and stress concentration on the surrounding fault.

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Persistent and time-dependent crustal deformation in northern Fossa Magna and its tectonic implications

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In the northern Fossa Magna of the northern Nagano Prefecture, GNSS observations over last two decades identified a rapid E-W contraction around the northern Itoigawa-Shizuoka Tectonic Line (ISTL) and the Western Nagano Basin Fault (WNBF). After the 2011 Tohoku-oki earthquake, postseismic deformation with a large E-W extension occurred throughout northeast Japan. However, the northern Nagano area has been still under contraction, implying that the local contraction is a persistent deformation feature. Similar persistent deformation was identified in the Niigata area by Meneses-Gutierrez and Sagiya (2016) and around other active faults in central Japan. These observations illustrate that there exists persistent localized deformation in the lower crust beneath active faults, driven by the regional stress field. This localized deformation in the lower crust is the driving force for faults in the upper crust. The persistent local crustal deformation around active faults suggests that the long-term inland deformation and resultant inland seismic activity are steady over a longer time scale than that of an earthquake cycle at subduction zones. On the other hand, after the 2014 Northern Nagano Earthquake (Mw6.3) along the northern ISTL, an acceleration of contraction along the WNBF was identified. This observation implies that the northern ISTL and WNBF are not independent but mechanically interact each other, forming an active deformation system that accommodates regional deformation. Such a complicated behavior of the fault system implies that the long-term activity of each fault in the system is not steady but time-dependent. Such a time-dependence may be a cause of irregular activity of inland faults and such a possibility should be considered for evaluation of seismic hazard.

Keywords: inland earthquake, active fault, inelastic deformation, persistent crustal deformation, fault interaction

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Unexpected relationship between ΔCFF and the strain-rate paradox: separation of plastic strain from inelastic strain

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In the field of seismic activity, the phenomena of stress shadow is well known, that is to say, the area with negative ΔCFF after an large earthquake tends to have fewer aftershocks (e.g., Toda et al. 2011, GRL). The concept of ΔCFF is also usful to understand earthquake activity for longer time scales as exemplified by Shikakura et al. (2014, JGR), which shows that large inland earthquakes that happened in western Japan recent 500 years can be very well exlpained by the change history of ΔCFF, which is mainly controled by the repeated occurrences of the Nankai earthquakes and secular increase of east-west compression.

Meneses-Gutierrez and Sagiya (2016, EPSL) have successfully separated the component of inelastic strain from the analysis of pre- and post-seismic GNSS data of the 2011 Tohoku-oki earthquake in the area around the Niigata prefecture. However, when we examine the observed GNSS data in detail, the separated inelastic strain rate is slightly but clearly faster before the Tohoku-oki earthquake. If the inelastic strain is due to viscous flow that depends only on the absolute stress, it is difficult to explain the observed GNSS data, because the stress change due to the 2011 Tohoku-oki earthquake in this area is less than 1 MPa, which is likely to be much smaller than the absolute stress.

Therefore, we consider that the concept of ΔCFF could be applicable not only to seismic activity but also to crustal deformation. In other words, we consider that the change of the inelastic strain rate is caused by plastic strain, which was active before the 2011 Tohoku-oki earthquake but ceased after the earthquake, because the stress level is dropped due to the occurrence of the 2011 Tohoku-oki earthquake, although inelastic strain due to viscous flow occurs essentially in the same manner before and after the 2011 Tohoku-oki earthquake.

If we accept this concept, the strain rate paradox of Japan is viewed differently, that is, the strain rate was exceptionally faster before the 2011 Tohoku-oki earthquake. It might also be possible to issue more effective warnings of large inland earthquakes in western Japan from detailed analyses of crustal deformation data.

Keywords: plastic strain, ΔCFF, inelastic strain, strain-rate paradox

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Active period of inland earthquakes based on numerical simulation of megathrust earthquake cycle incorporating viscoelasticity

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In the subduction zone, megathrust earthquakes may modulate shallow crustal seismicity in the overriding plate. Historical documents demonstrate that large inland earthquakes frequently occurred for 50 years before and 10 years after megathrust earthquakes along the Nankai trough, southwest Japan. Previous studies suggest that inland earthquakes cannot occur until recovering the stress reduced by a megathrust earthquake on the fault. In this study, we modeled megathrust earthquake cycle in a simple oblique subduction zone and calculated temporal evolution of the Coulomb’ s Failure Stress changes (ΔCFS) on inland right-lateral strike-slip faults. And we examined the influence of megathrust earthquake cycle on the activity tune of inland earthquake.

Sources for loading inland faults are assumed to be interseismic locking and coseismic slip on the megathrust fault, stress changes due to inland earthquake and interaction between inland earthquake, and creep on a deeper extension of the inland faults. The stress change due to the megathrust fault was computed with numerical code by Fukahata and Matsu'ura (2006), assuming a medium composed of an elastic layer overlying a Maxwell viscoelastic half-space. We focus on ΔCFS depending on the distance from the megathrust fault, not its along-strike variation. In other words, only two-dimensional stress change at the center of a sufficiently long thrust fault plane (length 2000 km) is calculated. The megathrust fault is represented by a single rectangular fault whose depth, width, strike, dip, and rake are 11 km, 108 km, 270˚, 10˚, and 117˚, respectively. We assigned 6 m of coseismic slip at an interval of 100 years and 6 cm/year of back-slip during the interseismic period on the megathrust fault.The inland faults are located at 150 km (hereafter fault A) and 300 km (hereafter fault B) away from the upper edge of the megathrust fault and their depth, length, width, strike, dip, and rake are 4 km, 30 km, 6 km, 110˚, 90˚, and 180˚, respectively. Coseismic slip of 2 m was assigned when ΔCFS at the center of the inland faults exceeded 4.4 MPa.Becuase the code of Fukahata and Matsu'ura (2006) approximates a rectangular fault by numbers of point sources, a stress change on the fault plane can’ t be calculated. Therefore, we calculated a coseismic stress change on the fault plane assuming a semi-infinite elastic medium (Okada, 1992). In addition, stress loading by creep on a deeper extension of the inland faults was given to each inland fault at a constant rate.

ΔCFS on both inland faults is negative at the megathrust earthquake. When the stress loading rate is 5 kPa/year, the inland earthquake does not occur for 42 years on fault A and 15 years on fault B after the megathrust earthquake. Our interpretation is that viscoelastic effects of megathrust earthquakes makes these quiescence periods shorter and longer for faults A and B, respectively. Also, when the stress loading rate is 0.5 kPa/year, the quiescence period is 83 and 71 years for faults A and B. It is interesting that the quiescence period is not much dependent on the distance from the megathrust fault if the stress loading rate is small, though ΔCFS on both inland faults is highly dependent on the distance at the megathrust earthquake.

Keywords: seismic cycle, coulomb stress change, viscoelasticity

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Influence of viscoelastic relaxation on estimated interplate coupling along the Nankai Trough, southwest Japan

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Viscoelastic relaxation in asthenosphere is an important factor for understanding crustal deformation in the subduction zone. Although interplate coupling on subduction interface has often been estimated from geodetic data using a purely elastic dislocation model, several recent studies (e.g., Li et al., 2015) pointed out that ignoring viscoelasticity in the medium made estimated coupling distribution biased. Pollitz and Evans (2017) developed viscoelastic block models introducing a viscoelastic correction term for earthquake cycles to estimate both interplate coupling and rigid rotation of microplates in western US. Once you subtracted the viscoelastic correction velocities from observed ones, the corrected velocities can be inverted by conventional elastic block models. The viscoelastic correction term consists of two components. One (hereafter, 1st component) is viscoelastic velocities due to interplate locking in the past, which is constant over the interseismic period. The other (hereafter, 2nd component) is total postseismic velocities of past earthquakes repeated with a certain recurrence interval, which is dependent on a time from the last earthquake. Here we examine these viscoelastic correction components for megathrust earthquake cycles along the Nankai trough.

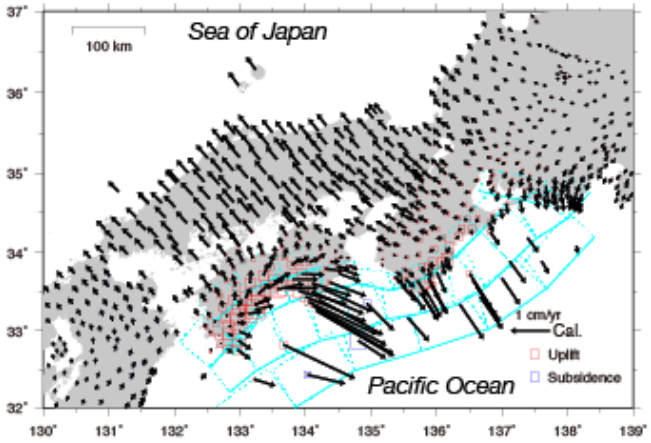
We calculated viscoelastic deformation using VISCO1D (Pollitz, 1997) and assumed a 35 km thick elastic plate overriding a Maxwell viscoelastic half-space with a viscosity of 10^{19} Pa s. Coseismic fault model for the 1944 Tonankai and 1946 Nankai earthquakes estimated by Sagiya and Thatcher (1999) is used for viscoelastic calculation. A recurrence interval of megathrust earthquakes is 117 years and slip deficit accumulated for the interseismic period is completely released by the megathrust earthquakes. Figs. A-C show 1st and 2nd components as well as the sum of them as of 2007. 1st component represent a difference between elastic and viscoelastic responses of locking that has continued since the infinite past. It reaches 2 cm/yr along the Pacific coast and several mm/yr even along the coast of Sea of Japan (Fig. A). 2nd component is generally reverse to 1st component and decays with time from the last earthquake. Amplitude of 2nd component is roughly equal to that of 1st component 30 years after the last earthquake. Therefore, total viscoelastic correction is minimized 30 years after the last earthquakes during the interseismic period. Even after 61 years of the last earthquakes, velocities of 2nd component is still comparable to those of 1st component (Fig. B). Total correction velocities, therefore, exceed 2 mm/yr only near peninsulas along the Pacific Ocean (Fig. C). 2nd component reaches several mm/yr in the last years of the interseismic period for the Nankai subduction zone and cannot be ignored for better viscoelastic correction.

We present a result of applying viscoelastic correction to the block model of Nishimura et al.(2018) which models onshore GNSS and offshore GNSS-Acoustic velocities in southwest Japan.

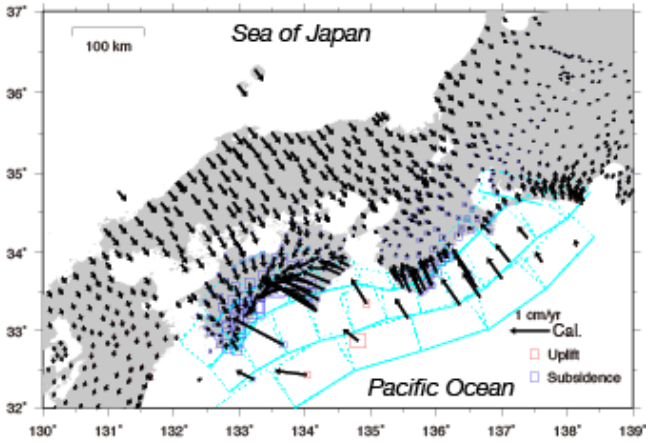
Keywords: Crustal deformation, Viscoelastic relaxation, Nankai trough, Viscoelastic block model

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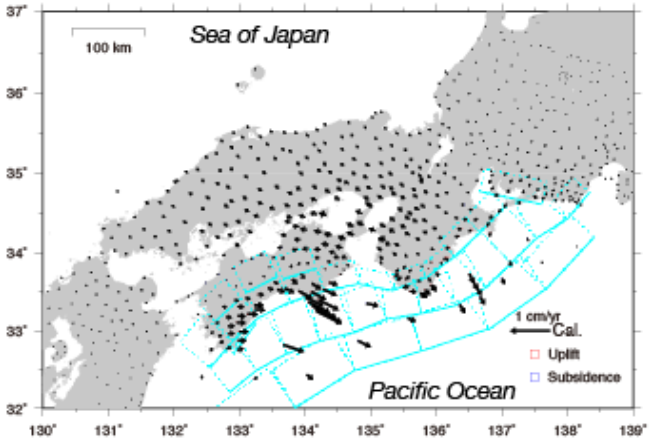
(a)Velocity for viscoelastic correction of slip-deficit



(b) Velocity for viscoelastic correction of past earthquakes



(c) Velocity for total viscoelastic correction



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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Tue. May 28, 2019 1:45 PM - 3:15 PM JST | Tue. May 28, 2019 4:45 AM - 6:15 AM UTC | Convention Hall A 2F

[S-CG61] Dynamics in mobile belts

convener:Yukitoshi Fukahata(Disaster Prevention Research Institute, Kyoto University), Toru Takeshita(Department of Natural History Sciences, Graduate School of Science, Hokkaido University), Hikaru Iwamori(Geochemical Evolution Research Program, Japan Agency for Marine-Earth Science and Technology), Chairperson:Naoki Uchida, Takeshi Iinuma

The dynamic behaviours of mobile belts are expressed across a wide range of time scales, from the seismic and volcanic events that impact society during our lifetimes, to orogeny and the formation of large-scale fault systems which can take place over millions of years. Deformation occurs on length scales from microscopic fracture and flow to macroscopic deformation to plate-scale tectonics. To gain a physical understanding of the dynamics of mobile belts, we must determine the relationships between deformation and the driving stresses due to plate motion and other causes, which are connected through the rheological properties of the materials. To understand the full physical system, an integration of geophysics, geomorphology, and geology is necessary, as is the integration of observational, theoretical and experimental approaches. In addition, because rheological properties are greatly affected by fluids in the crust and fluid chemical reactions, petrological and geochemical approaches are also important. After the 2011 great Tohoku-oki earthquake, large-scale changes in seismic activity and regional scale crustal deformation were observed, making present-day Japan a unique natural laboratory for the study of the dynamics of mobile belts. This session welcomes presentations from different disciplines, such as seismology, geodesy, tectonic geomorphology, structural geology, petrology, and hydrology, as well as interdisciplinary studies, that relate to the dynamic behaviours of mobile belts.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SCG61-25] Revisiting the Forearc Sliver Scenario Along the Southern Kurile Trench to Reconcile Interdisciplinary Observations

*Yuji ITOH[1], Kelin WANG[2], Takuya NISHIMURA[3] (1.Graduate School of Science, Kyoto University, 2.Pacific Geoscience Centre, Geological Survey of Canada, 3.Disaster Prevention Research Institute, Kyoto University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SCG61-26] Segmentation of crustal deformation area within the Sanriku coast, northeast Japan, on the basis of spatial distribution of millennial-scale crustal movements

*Yuichi Niwa[1] (1.Faculty of Science and Engineering, Chuo University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SCG61-27] Shear wave splitting east off NE Japan based on the S-net data

*Naoki Uchida[1], Junichi Nakajima[2], Ryota Takagi[1], Keisuke Yoshida[1], Takashi NAKAYAMA[1], Ryota Hino[1], Tomomi Okada[1], Youichi Asano[3], Sachiko Tanaka[3] (1.Research Center for Prediction of Earthquakes and Volcanic Eruptions Graduate School of Science, Tohoku University, 2.Department of Earth and Planetary Sciences, Graduate School of Science and Engineering, Tokyo Institute of Technology, Tokyo, 3.National Research Institute for Earth Science and Disaster Resilience)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SCG61-28] Gravity anomaly due to active faults and crustal rheology in the northeastern Japan arc inferred by fault dislocation model

*Mitsuhiro Hirano[1], Hiroyuki Nagahama[1], Jun Muto[1] (1.tohoku university)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SCG61-29] On the temporal decay of the localized strain rate in the Tohoku region after the Tohoku-Oki earthquake

*Youichiro Takada[1], Tomomi Inamatsu[2] (1.Faculty of Science, Hokkaido University, 2.Dept. Natural History Sciences, Hokkaido University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SCG61-30] Revisiting the Coseismic Slip Distribution of the 2011 Tohoku-oki Earthquake Considering Early Postseismic Deformation, Non-linear Viscoelasticity, and Heterogeneous Structure

*Takeshi Iinuma[1], Ryoichiro Agata[1], Yusaku Ohta[2], Ryota Hino[2], Takane Hori[1] (1.Japan Agency for Marine-Earth Science and Technology (JAMSTEC), 2.Graduate School of Science, Tohoku University)

Revisiting the Forearc Sliver Scenario Along the Southern Kurile Trench to Reconcile Interdisciplinary Observations

*Yuji ITOH[1], Kelin WANG[2], Takuya NISHIMURA[3]

1. Graduate School of Science, Kyoto University, 2. Pacific Geoscience Centre, Geological Survey of Canada, 3. Disaster Prevention Research Institute, Kyoto University

Forearc sliver has been proposed as a mechanism to accommodate margin-parallel component of oblique plate convergence along the southern Kurile trench. The sliver scenario was established based mostly on the presence of the margin-perpendicular Hidaka Mountain Range (HMR), graben at Bussol Strait, en echelon Kurile Islands and high temperature metamorphic and intrusive rocks exposed at HMR. Along the volcanic front, geological faults including Kamishi-Yubetsu tectonic zone with 50 km right-lateral displacement was reported. Seismic velocity tomography and refraction/reflection experiments beneath HMR show the heterogeneous crustal structure relating to collision of the Kurile forearc and Northeast Japan arc, indicating upwelling of upper mantle, sinking of crustal material and delamination of upper mantle beneath HMR, and shortening in the foreland of HMR. Anomalous deep crustal earthquakes beneath HMR such as the 1970 M6.7 Hidaka and 1982 M7.1 Urakawa-oki earthquakes show active margin-parallel compression. However, other observations cast doubt on the forearc sliver being presently active. Although some active faults are reported along the volcanic front, they are not right-lateral faults. Interseismic GNSS velocities do not show localized right-lateral shear deformation along the volcanic front, although they show active margin-normal shortening in the foreland of HMR consistent with active collision. In this study, we propose a new scenario of forearc kinematics and strain partitioning along the southern Kurile trench to reconcile these seemingly discordant observations.

A mountain like HMR pushes sideways because of gravity and acts as a buttress of the forearc sliver to impede its migration. We compared the stress field inferred from CMT solution with that predicted from a buttressed sliver model. The comparison suggests that (1) the forearc sliver is buttressed at HMR and (2) resistance to right-lateral shear along the volcanic front is very large. Therefore, we propose a scenario as follows. The forearc sliver had been increasingly buttressed as HMR rose, so that the rate of strain partitioning diminished with time. Eventually, the forearc migration became too slow to cause recurring large earthquakes and to maintain a mature active fault zone along the volcanic front. As a result, the fault zone healed with time. At present, the forearc and backarc deform together without active faulting and localized shear along the volcanic front.

We also compared Kurile with other oblique subduction zones and found that margin (trench) curvature appears to principal control forearc kinematics. At Cascadia and Nankai where the margin is concave seaward, interseismic GNSS velocities do not show discernable localized shear to define the forearc sliver but strong margin-parallel shortening towards the area of maximum margin curvature. In contrast, in southernmost Chile where the trench is approximately straight, there is little margin-parallel shortening but significant forearc sliver migration. However, at Kamchatka, although the margin is concave off-Kamchatka Peninsula, significant margin-parallel migration of Aleutian Islands is still occurring, which we speculate is due to the extreme obliquity of plate convergence here. Even in this case, significant shortening is observed at the leading edge of the forearc sliver. The concave margin has buttressed the forearc sliver and caused shortening in the area of maximum curvature in the geological time scale as well because the tectonic setting itself, such as the margin curvature and the obliquity of plate convergence, is the controlling factor of the forearc kinematics.

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Keywords: Kurile Trench, Forearc Sliver, Oblique Subduction, Hidaka Mountain Range, Strain Partitioning, Volcanic Front

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Segmentation of crustal deformation area within the Sanriku coast, northeast Japan, on the basis of spatial distribution of millennial-scale crustal movements

*Yuichi Niwa[1]

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Along the Sanriku coast, northeast Japan, discrepancies in crustal movement have been reported between uplift on a timescale of 10^5 years (Koike and Machida, 2001) and subsidence on a timescale of 10^1 –10^2 years (Kato, 1983; Ozawa et al., 2011). Some hypothetical models, which explain these discrepancies, are proposed in relation to megathrust earthquake cycle (e.g., Ikeda et al., 2012; Nishimura, 2014). These models assume that crustal movement style is same within whole part of the Sanriku coast, and show that amount of accumulation of uplift exceeds that of subsidence during one earthquake cycle. However, because of lack of age data of marine terrace except for Hachinohe to Kuji (Miyazaki and Ishimura, 2018) and of putative marine terrace along the southern part of the Sanriku coast (Koike and Machida, 2001), spatial distribution of crustal movement cannot be estimated on the basis of only feature of Pleistocene marine terrace. On the other hand, sedimentary successions in alluvial plains distributed along the Sanriku coast may offer records of millennial-scale crustal movements during the Holocene.

Recent sediment core analyses and radiocarbon dating shows sedimentary succession influenced by sea-level changes during the past 10,000 years. In the Rikuzen-takata plain, Kesennuma Okawa plain, and Onuma, on the southern Sanriku coast, a millennial-scale subsidence is inferred on the basis of height distribution of intertidal sediments which is lower than non-tectonic relative sea-level (Niwa et al., 2014, 2015; Ishimura and Miyauchi, 2017). Depositional environment estimated from a sediment core of the Tsuya plain, between Kesennuma plain and Onuma, also support a millennial-scale subsidence (Niwa et al., 2016). In the Tsugaruishi plain, on the central coast, height distribution of intertidal sediments and aggradation of delta sediments since ca. 7500 cal BP indicates subsidence on a millennial-scale (Niwa et al., 2017). On the other hand, sedimentary feature typical of subsidence area is not identified in sediment cores obtained from Omoto plain, northern Sanriku coast, suggesting no noticeable subsidence on a millennial-scale (Niwa et al., in press).

Inferred millennial-scale crustal movements shows subsidence trend on central to southern Sanriku coast and relatively uplifting trend on northern part of the coast. This spatial distribution of millennial-scale crustal movements is consistent with geodetically estimated subsidence rate on a timescale of 10^1 –10^2 years (Kato, 1983) and the amount of subsidence at 2011 Tohoku-oki earthquake (Ozawa et al., 2011), indicating that the Sanriku coast presents a variety of crustal movement styles. These results suggest that the northern and the central to southern parts of the Sanriku coast should be considered separately when assessing crustal deformation related to subduction.

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Keywords: the Sanriku coast, earthquake cycle, millennial-scale, crustal deformation area

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Shear wave splitting east off NE Japan based on the S-net data

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We estimated the anisotropy of seismic wave speed by using shear wave splitting data in the offshore area of NE Japan. The analysis was made possible by the deployment of the Seafloor Observation Network for Earthquakes and Tsunamis along the Japan Trench (S-net) by National Research Institute for Earth Science and Disaster Resilience (NIED). We used the waveforms of 421 interplate earthquakes from August 2016 to October 2018 which are selected based on the focal mechanisms of Full Range Seismograph Network of Japan (F-net) operated by NIED and located under the S-net stations (within 35 degree from the vertical). We determined the fast polarization directions and delay times between fast- and slow-shear waves by the cross-correlation method.

The results show that the shear wave splitting tends to have trench parallel fast polarization direction for the region east off Chiba to Hokkaido which is the same with the observations in the land area of the forearc. Since we used earthquakes on the plate boundary, the anisotropy must be located in mantle wedge or forearc crust. The interpretation of the polarization includes the flow-normal fast direction of B-type olivine fabric in the forearc mantle-wedge and cracks aligned in the trench parallel direction due to the present forearc stress-field or fossil structures developed during the formation of the forearc.

Acknowledgements: We used S-net data which is deployed and maintained by NIED.

Keywords: Shear wave splitting, S-net, forearc

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Gravity anomaly due to active faults and crustal rheology in the northeastern Japan arc inferred by fault dislocation model

*Mitsuhiro Hirano[1], Hiroyuki Nagahama[1], Jun Muto[1]

1. tohoku university

Short-wavelength Bouguer gravity anomaly reflects crustal structures including effective elastic thickness distribution in the northeastern (NE) Japan arc [1-3]. Moreover, earthquake epicenters and active faults tend to be located in the region of the negative gravity anomaly or high gradient in the anomaly in the NE Japan arc [1-3]. Following the relationship between gravity anomaly and active fault distributions, Yamazaki and Nagahama [4] derive an equation of static gravity change by volumetric strain due to fault dislocation, and argue that active faults contribute to Bouguer gravity anomaly in the NE Japan arc. On the other hand, seismicity and active fault distribution tend to be located in the region with high gradient of thermal gradients or along the boundary between high and low seismic wave velocity [5-7]. Thermal gradient and seismic wave velocity reflect mechanical behaviors (viscosity and elasticity) and they are indices of crustal rheology. However, relationship between gravity anomaly and the influence of the inhomogeneity in crustal rheological structures including active fault distributions have been not unknown yet. In addition, although large positive gravity anomaly is expected along the Ou-backbone Range by its pop-up structure, negative or small positive gravity anomaly zone exists along the Ou-backbone Range. So, we study relationship between gravity anomaly and rheological properties in the NE Japan arc. First, we calculated gravity anomaly due to volumetric strain by fault dislocation model in a homogeneous elastic half space. In this case, considering compressive stress field that has continued since 3 Ma in the NE Japan arc, we give total fault displacements in the 3 million years to active faults. This model calculation generates negative gravity anomaly less than 15 mGal around active faults and these generally agree with some negative areas of short-wavelength Bouguer gravity anomaly (such as the Ou-backbone Range, Yamagata Basin and the Niigata Plain). Next, we compare short-wavelength Bouguer gravity anomaly with three available datasets in the NE Japan (thermal gradient, crustal strain rate and P-wave velocity) along the two transects created normal to the arc. This comparison reveals the correlation between negative peak in the gravity anomaly and the peaks of thermal gradient and contraction, and negative peak of P-wave velocity around the Ou-backbone Range. The comparisons suggest the relationship between gravity anomaly and crustal rheology, and that contraction along the Ou Backbone Range produces negative gravity anomaly. The result also explains the relationship between gravity anomaly and seismicity and active fault distributions since both of them distribute to transitional areas of crustal rheological structures. Hasegawa et al. [8] pointed out that reverse faults and large contraction along the Ou Backbone Range reflects the heterogeneity in rheological properties in the NE Japan arc. Therefore, those comparisons imply that reverse faults and anelastic contraction produce continuous negative gravity anomaly along the Ou-backbone Range. Finally, we propose that the gravity anomaly can be an index of the heterogeneity in crustal rheology.

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Keywords: gravity anomaly, crustal rheology, fault dislocation model

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On the temporal decay of the localized strain rate in the Tohoku region after the Tohoku-Oki earthquake

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The 2011 Tohoku-Oki earthquake (Mw9.0) provides us the first opportunity to examine the responses of strain concentration zones and active faults to megathrust earthquakes with dense permanent GNSS network. Along the Backbone range in the Tohoku region, strain rate localization has been found before and after the Tohoku-Oki earthquake (e.g., Miura et al., 2004; Takada and Inamatsu, 2018). In this study, we focused on the post-seismic strain rate localization along the Backbone range, and examined its driving mechanism with GNSS data and simple FEM simulation.
We used daily coordinates obtained at GEONET stations operated by GSI. We estimated surface velocity field before and after the earthquake by removing annual and semi-annual perturbations. For post-seismic period, we estimated the velocity field for every two years to use linear approximation. From the velocities thus obtained, we calculated the strain rates following the method of Shen et al (1996). Next, we approximated the long wavelength components, which reflects the afterslip and/or the viscoelastic relaxation of Asthenosphere following the Tohoku-Oki earthquake, by polynomial function for each component, and removed it to extract the short wavelength component. Then, we found patchy distribution of localized contraction (negative dilatation rate) areas along the Backbone range with these amplitudes rapidly decreasing with time.
To examine the mechanism of rapidly decreasing strain rate, we conducted a simple numerical simulation with a finite element software COMSOL Multiphysics. There are thermally active regions with many calderas along the Backbone range (e.g., Yoshida, 2001; Takada and Fukushima, 2013). On the other hand, the thermal activity of surrounding area is not very high. Considering these points, we set a rectangular elastic body and located several ellipsoids in north-south direction that consist of low viscosity Maxwell viscoelastic medium. Then we applied gravitational body force to all the model region, and supported it from a lateral boundary. In addition, we also applied a step-wise 1 MPa stress change which represents coseismic stress perturbation due to the Tohoku-Oki earthquake. From the calculated results, we removed the long wave-length component. Then, we successfully extracted the short wave-length dilatation rate around the viscoelastic ellipsoids. Just after the step-wise stress change, whole medium responded as an elastic body. Soon after that, viscous flow starts in the ellipsoids. As differential stress decreases with time in the ellipsoids due to viscous relaxation, the surrounding elastic region becomes important to support the differential stress. Thus, the localized strain rates can be large only during the viscous relaxation in the ellipsoid. After the completion of viscous relaxation, all the differential stress is supported solely by elastic region, and the localized strain rates vanish. Thus, three dimensional connectivity of low viscosity regions play an important role when considering crustal response to an externally applied stress change.

Keywords: Tohoku-Oki earthquake, GNSS, Viscoelasticity

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Revisiting the Coseismic Slip Distribution of the 2011 Tohoku-oki Earthquake Considering Early Postseismic Deformation, Non-linear Viscoelasticity, and Heterogeneous Structure

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The 2011 Tohoku-oki earthquake produced large coseismic displacements that were detected by terrestrial and seafloor geodetic observations, namely, global navigation satellite systems (GNSS), GNSS-Acoustic (GNSS-A), and ocean bottom pressure (OBP) measurements. Previous studies constructed coseismic slip distribution models of the Tohoku-oki earthquake using the daily GNSS site coordinate time series, seafloor GNSS-A, and/or OBP data to estimate the coseismic displacements [e.g., Ito et al., 2011; Koketsu et al., 2011; Ozawa et al., 2011; Iinuma et al., 2012]. However, studies for these several years suggested that the coseismic displacements must include early postseismic deformation due to a low-viscosity zone beneath the Pacific plate that is necessary to explain terrestrial and seafloor postseismic crustal deformations [Sun et al., 2014; Freed et al., 2017; Suito, 2017]. This low-viscosity zone may not be persistent but could result in huge changes in stress resulting from the coseismic slip with reflecting non-linear rheology [Muto et al., 2018; Agata et al., 2019]. The effect of non-linear rheology is great immediately after a main shock. Therefore, coseismic displacements based on the daily site coordinate time series and GNSS-A measurements inevitably must include early postseismic deformation.

Thus, we derived “pure” coseismic displacements based on 1-Hz site coordinate time series at GNSS sites of the Geospatial Information Authority of Japan estimated by utilizing kinematic PPP (precise point positioning) analysis and based on 1-min average seafloor level time series at OBP sites. The residual displacements were obtained by subtracting the pure coseismic displacement from that based on the daily site coordinate time series. The data showed subsidence and trenchward motions in the entire Tohoku district. These broad deformations could not be explained solely by aftershocks nor by afterslip on the plate interface. Viscoelastic deformation that occurs immediately after the main shock is required to explain the displacement field. We present the results of our investigations into coseismic slip distribution and early postseismic deformation by applying Green’s function, which is calculated by considering the shapes of surface terrain and subducting slabs as well as heterogeneous thermal structures and power-law rheology.

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Keywords: The 2011 Tohoku-oki Earthquake, Postseismic deformation, Power-law rheology

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[J] Oral | B (Biogeosciences)：B-BC Biogeochemistry

Tue. May 28, 2019 1:45 PM - 3:15 PM JST | Tue. May 28, 2019 4:45 AM - 6:15 AM UTC | 201A 2F

[B-BC03] Interrelation between Life, Water, Mineral, and Atmosphere

convener:Takeshi Kakegawa(Graduate School of Science, Tohoku University), Tadashi Yokoyama(Graduate School of Integrated Arts and Sciences, Hiroshima University), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Fumito Shiraishi(Department of Earth and Planetary Systems Science, Graduate School of Science, Hiroshima University), Chairperson:Tadashi Yokoyama, Keisuke Fukushi

Life on Earth is based on a diversity of physical and chemical dynamics and processes throughout the history of the Earth. It can essentially be regarded as the history of interrelation between Life, Water, Mineral (Solid Earth) and Atmosphere. To solve this kind of complex systems problems, interdisciplinary approach, a way of thinking and communication, is necessary. This session will be a cradle for such interdisciplinary researches.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[BBC03-01] Chemical speciation analysis of the brown and black precipitates observed in the gill chamber of the vent shrimp *Rimicaris kairei*

*Masanari Hikosaka[1], Yoshio Takahashi[2], Chong Chen[3], Robert Jenkins[1] (1.Kanazawa University, 2.Tokyo University, 3.Japan Agency for Marine-Earth Science and Technology)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[BBC03-02] Experimental study on hydrogen generation during low temperature serpentinization by using natural samples

*Shunta Higashino[1], Ryohei Kawakita[1], Tsubasa Otake[2], Tsutomu Sato[2] (1.Graduate School of Engineering, Hokkaido University, 2.Faculty of Engineering, Hokkaido University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[BBC03-03] **Constraint on the origin of methane from Hakuba Happo serpentinite-hosted hot spring by using $^{14}CH_4$ and noble gas isotope**

*Konomi Suda[1], Takahiro AZE[2], Yosuke Miyairi[2], Yusuke Yokoyama[2], Yohei Matsui[3,2], Hisahiro Ueda[3], Takuya Saito[3], Tomohiko Sato[4], Yusuke Sawaki[2], Ryosuke Nakai[1], Hideyuki Tamaki[1], Hiroshi A Takahashi[1], Noritoshi Morikawa[1] (1.National Institute of Advanced Industrial Science and Technology, 2.The University of Tokyo, 3.Japan Agency for Marine-Earth Science and Technology, 4.Tokyo Institute of Technology)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[BBC03-04] Inhibition of calcium silicate hydrate formation by lignosulfonate and lignin

*Kanako Toda[1], Tsubasa Otake[1], Tsutomu Sato[1] (1.Laboratory of Environmental Geology, Faculty of Engineering, Hokkaido University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[BBC03-05] Calcium carbonate formation processes on cyanobacterial surface

*Fumito Shiraishi[1], Takeru Omori[1], Naotaka Tomioka[2], Satoko Motai[2], Hiroki Suga[3], Yoshio Takahashi[3] (1.Hiroshima University, 2.JAMSTEC, 3.The University of Tokyo)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[BBC03-06] Mineralogical and geochemical study on sedimentary rock containing microfossils from 1.9 billion years ago(Ga) Gunflint Formation, Canada

*kouhei Sasaki[1], Akizumi Ishida[1], Takeshi Kakegawa[1] (1.Graduate School of Science, Tohoku University)

Chemical speciation analysis of the brown and black precipitates observed in the gill chamber of the vent shrimp *Rimicaris kairei*

*Masanari Hikosaka[1], Yoshio Takahashi[2], Chong Chen[3], Robert Jenkins[1]

1. Kanazawa University, 2. Tokyo University, 3. Japan Agency for Marine-Earth Science and Technology

The hydrothermal vent shrimp *Rimicaris* dominates the megafaunal community in many hydrothermal vent ecosystems in the globe, including Mid Atlantic Ridge, the Central Indian Ridge (CIR), and the Caribbean Mid-Cayman Rise. *Rimicaris* harbors numerous strains of episymbiotic bacteria in its gill chamber and depends on them for most of the nutrition as adults. Probably due to the metabolism of this symbiotic bacteria, the tissues in the gill chamber were found to be encrusted with brown or black iron precipitates. The precipitates are removed by molting, but in a few days after molting, *Rimicaris* will be covered with precipitates again. Although *Rimicaris* relies on episymbiotic bacteria nutritionally, it is thought that the precipitates originated from episymbiotic bacteria disturb their swimming activity, nutrient uptake by the host. Thus, the relationship between *Rimicaris* and its epibionts seems to be different from general mutualistic relationship. To understand this symbiotic relationship correctly, it is necessary to clarify the relationship among the host, episymbiotic bacteria, and the precipitates. In this study, iron chemical speciation analysis based on XAFS were performed to black and brown precipitates in the gill chamber of *Rimicaris kairei* in order to clarify the chemical environment in the gill chamber.
Specimens of *Rimicaris kairei* were collected during the YK16-E02 cruise at two hydrothermal vent site, Edmond and Kairei on the CIR. Each tissues were fixed in 99.5 % ethanol, and embedded in Epoxy resin(Epofix, Struers), and both sides polished thin section with a thickness of about 50 μm were obtained. Thin section was subjected to μ-XRF element analysis and Fe K-edge XANES analysis at KEK PF BL-4A to investigate the element distribution and the speciation of iron around the bacteria. Fitting was carried out using a software REX 2000 (Rigaku) using ferrihydrite, goethite, magnetite, $FePO_4$, pyrite, pyrrhotite as reference materials.
By observing the freeze-dried samples by scanning electron microscope (JSM-6100, JEOL) and thin section samples by polarized microscopy, it was observed that the brown precipitates forms crusts of about 50 μm in thickness and covers entirely the inside of the branchiostegite, where black precipitates occur as submicron size microparticles in organic filmy tissues around filamentous bacteria. From the XANES fitting, it was suggested that the brown precipitates contain ferrihydrite, goethite, $FePO_4$, while the black precipitates contain ferrihydrite, goethite, $FePO_4$, and pyrrhotite. It was revealed that iron exists as Fe^{3+} in the brown precipitate, but in the black precipitate, iron exist as a mixture of Fe^{2+} and Fe^{3+}. It is estimated that the brown precipitates were formed in the aerobic environment and the black precipitates were formed in the relatively anaerobic environment. Overall, our suggested that the gill chamber environment was diverse even among the same species. We will perform next-generation sequencing of microbes in the gill chamber, and we need to investigate in detail the precipitation conditions of each mineral and the environment in which the host can grow.

Keywords: hydrothermal vent, Rimicaris kairei, biomineralization, XAFS

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Experimental study on hydrogen generation during low temperature serpentinization by using natural samples

*Shunta Higashino[1], Ryohei Kawakita[1], Tsubasa Otake[2], Tsutomu Sato[2]

1. Graduate School of Engineering, Hokkaido University, 2. Faculty of Engineering, Hokkaido University

Low temperature serpentinization, a reaction between ultramafic rocks and water under ambient conditions, generates hydrogen near Earth’ s surface environments. This reaction has been considered to play important roles in the origin of life since hydrogen may have been an important reducing gas for building blocks of life as well as early metabolisms. Furthermore, this process may be applicable for industrial hydrogen production that does not emit carbon dioxide during its production or consumption whereas the conventional method for hydrogen production essentially relies on fossil fuels. During serpentinization, hydrogen is generated by the reduction of water accompanied with oxidation of ferrous ion to ferric ion in the primary minerals of ultramafic rocks such as olivine or pyroxene. However, the amount of hydrogen produced during low temperature serpentinization is controlled by various factors, which have not been well understood, particularly, the effect of the formation of secondary minerals (Mayhew et al., 2018). Therefore, we conducted a series of experiments for hydrogen production using 10 ultramafic rock samples (dunites and harzburgites), from Japan (Horoman and Wakamatsu), Oman and Indonesia, showing various lithological features and degrees of serpentinization subjected during obduction. Mineralogical and geochemical characterizations were conducted using XRD, XRF and SEM-EDS. Experiments were then conducted by reacting the samples with water under anaerobic conditions at 90℃, for 2 weeks. After the experiments, gas, solid, and solution obtained from the experiments were analyzed by GC-RGD, XRD, and ICP-AES, respectively.

The results of experiments show that samples with lower degrees of serpentinization tend to generate larger amounts of hydrogen, and that harzburgites tend to generate more hydrogen than dunite when they are at the same degree of serpentinization. However, some highly serpentinized samples also generated large amounts of hydrogen though these results werepooly reproduced. This may have stemmed from the oxidation of trace minerals (e.g., Ni-Fe alloy) or their catalytic effects, in addition to the dissolution of Fe^{2+}-bearing primary minerals, because these minerals were heterogeneously observed by microscopy in the serpentinites. Experiments were also conducted with some additives (e.g., MgO, SiO_2, and magnetite) to investigate the effect of solution chemistry and formation of secondary minerals on hydrogen generation. The results show that hydrogen was generated the most under Si-rich conditions. Solution chemistry suggests that, olivine and pyroxene were likely dissolved more rapidly with Si-rich solutions. This is consistent with the trend that harzburgites generate hydrogen more than dunite because harzburgite contains pyroxene, which dissolved much Si compared to olivine. Moreover, thermodynamic calculations suggest that the precipitation of amorphous Mg-silicate minerals (e.g., M-S-H), which are commonly precursors of serpentine controls the solution chemistry including decreasing pH. Because the dissolution rate of the primary minerals is greater at lower pH, the precipitation of Mg-silicate minerals may have promoted the dissolution cycle of the primary minerals and therefore generation of hydrogen, especially under Si-rich conditions.

Reference

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Keywords: serpentinization, serpentine, ultramafic rock, hydrogen, amorphous Mg-silicate mineral, thermodynamic calculation

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Constraint on the origin of methane from Hakuba Happo serpentinite-hosted hot spring by using $^{14}CH_4$ and noble gas isotope

*Konomi Suda[1], Takahiro AZE[2], Yosuke Miyairi[2], Yusuke Yokoyama[2], Yohei Matsui[3,2], Hisahiro Ueda[3], Takuya Saito[3], Tomohiko Sato[4], Yusuke Sawaki[2], Ryosuke Nakai[1], Hideyuki Tamaki[1], Hiroshi A Takahashi[1], Noritoshi Morikawa[1]

1. National Institute of Advanced Industrial Science and Technology, 2. The University of Tokyo, 3. Japan Agency for Marine-Earth Science and Technology, 4. Tokyo Institute of Technology

Ultramafic rock-water interaction systems attract more interest from the perspective of study for origin of life since the discovery of the hyperalkaline hydrothermal system in the Atlantic Ocean in 2001 (Kelley et al., 2001). These serpentinite-hosted systems are generally characterized by high concentrations of methane (CH_4) and higher hydrocarbons (C^{2+}) regardless of seafloor or on-land (e.g., Schrenk et al., 2013; Etiope and Sherwood-Lollar, 2013). Previous stable carbon and hydrogen isotopic studies have suggested that hydrocarbons could be formed abiotically via polymerization process (Proskurowski et al., 2008; Suda et al., 2017). However, the following is still poorly constrained; when and where hydrocarbons are produced. In this study, to constrain the origin of methane, we determined the radiocarbon (^{14}C) content in CH_4 and the helium isotope obtained from serpentinite-hosted hot spring in Hakuba Happo.
Hakuba Happo hot spring lies on a serpentinized ultramafic rock body in the Shiroumadake area, which belongs to the Hida Marginal Tectonic Belt in central Japan. The hyperalkaline waters (pH>10), with temperatures of approximately 50˚C, are pumped from two borehole wells (Happo #1 and Happo #3). N_2, H_2 and CH_4 are main gas components (Homma and Tsukahara, 2008; Suda et al., 2014). Water chemistry and volatile component are controlled primarily by serpentinization reaction.
Sample collection was conducted in 2015-2018. Hot spring gas samples were collected by a displacement method in water from two borehole wells (Happo #1 and Happo #3). For radiocarbon (^{14}C) analysis of methane, firstly, CH_4 in gas samples was converted to CO_2 by using the custom-built flow-through vacuum line system (similar to Pack et al., 2015) at JAMSTEC. Secondly, the purified CO_2 gas was reduced to graphite by using the graphitization reactor with Fe powder and hydrogen gas, and then the ^{14}C content was determined by using an accelerator mass spectrometry (AMS) at AORI, the University of Tokyo. Noble gas isotope abundances were measured with a noble gas mass spectrometer at GSJ, AIST. The concentrations of CO and CO_2 in gas phase were determined by using a GC-methanizer-FID method, which was suitable for detection of trace amounts of CO and CO_2 (Kaminski et al., 2003). The concentration of dissolved inorganic carbon (DIC) in spring water was measured by using GasBench/IRMS system at GSJ, AIST.
In Hakuba Happo hot spring, CO and CO_2 were below detection limit (<0.0005 vol.%). DIC concentration was <28 μmol/L (upper values because of suspicion of air contamination during sampling), which was lower than dissolved methane concentration (124-664 μmol/L; Suda et al., 2014). Methane is the most abundant carbon compound in Hakuba Happo hot spring. If methane production occurs under on-site condition, the inorganic carbon compounds (CO, CO_2 and DIC) are not likely to be a carbon source for CH_4. The high helium isotope ratio ($^3He/^4He$) was observed in both well sites. The $^3He/^4He$ ratios for Happo #1 and Happo #3 were 4.10 R_{atm} and 4.47 R_{atm}, respectively (where R_{atm} is the atmospheric $^3He/^4He$ ratio of 1.4×10^{-6}). For Happo #1 site, relative contribution of air, mantle and crustal components are estimated to be 47%, 31% and 22%, respectively. For Happo #3 site, 69%, 24% and 8%, respectively. The result of AMS measurements on two CH_4 samples from Hakuba Happo reveals that ^{14}C contents are near the detectable limit, i.e., the ^{14}C ages of CH_4 is at least approximately 50,000 years before present. Radiocarbon evidence rules out a modern carbon compound (e.g., atmospheric CO_2, organics in surface

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soil) as the carbon source of CH_4 at Hakuba Happo hot spring system. The helium isotope and $^{14}CH_4$ data could be consistent with deep-derived carbon source of the Hakuba Happo CH_4. Therefore, it will be important to consider a relation between surface reaction system and deep mantle/crustal system.

Keywords: serpentinite, hyperalkaline hot spring, methane, radiocarbon, helium isotope

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Inhibition of calcium silicate hydrate formation by lignosulfonate and lignin

*Kanako Toda[1], Tsubasa Otake[1], Tsutomu Sato[1]

1. Laboratory of Environmental Geology, Faculty of Engineering, Hokkaido University

Dams and harbors have frequently dredged in order to secure the water storage capacity and shipping routes. Dredged soils are mostly treated as waste, though utilization of dredged soils for construction resources are economically and environmentally desired. Only a part of the dredged soils has been used for construction materials after mixing with steel slags due to their low physical strength. Mixture's strength development has been known to depend on utilized dredged soil. However, even under the same mixing conditions, some combinations may not be hardened. Soil composition is generally complex as it reflects the result of mineral-water-organic matter-microbe interactions occurred onto components from diverse origin. In solidification of the dredged soils to form construction materials, alkaline activators, steels slags in this case, are added, which triggers the formation of secondary phases such as calcium silicate hydrate (C-S-H). Factors affecting C-S-H formation have been reported previously (e.g., Tremblay et al., 2002; Zhu et al., 2007; Toda et al., 2018). However, inhibition mechanism of authentic organic matter in the soils and the quantitative effects of their functional groups on C-S-H formation are not fully understood.

In this context, the effects of 1) lignosulfonate and 2) lignin that contain carboxylic, sulfonic and thiol functional groups that have similar structures to soil organic matter and 3) simple organic molecule with one of carboxylic, sulfonic and thiol functional groups on C-S-H formation were investigated in this study. C-S-H was synthesized from $Ca(OH)_2$ and amorphous silica in coexistence of multiple addition ratio of lignosulfonate and lignin to expecting amount of C-S-H formed, in 100 rpm shaker at 50℃ for 10 days. After the syntheses, C-S-H were characterized by X-ray diffraction and FT-IR analysis, and chemical composition of the remaining solutions were analyzed by ICP-AES and TOC analyzer. After syntheses, solution pH were all above 12. The threshold quantity of lignosulfonate and lignin was evaluated to suppress the formation of C-S-H. Above the threshold, XRD peaks assigned to $Ca(OH)_2$ and amorphous silica could still be obtained after synthesis, without C-S-H peaks. Furthermore, below the threshold, the broad diffraction peak assigned to (001) reflection of C-S-H decreased with increasing the added amount of lignosulfonate and lignin. This suggests that lignosulfonate and lignin may suppress the dissolution of initial phases but also C-S-H crystal growth. Both of the indicated inhibition factors could occur due to the surface coverage by negatively charged functional groups in the organic matter under alkaline condition, which may be interacting with positively charged sites such as $Ca(OH)_2$ surface and CaO layer in C-S-H. C-S-H synthesis with simple organic molecule with various functional groups were also conducted to further discuss how the difference in soil organic matter structure in terms of functional group can inhibit C-S-H formation.

Keywords: dredged soils, soil organic matter, C-S-H, construction materials

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Calcium carbonate formation processes on cyanobacterial surface

*Fumito Shiraishi[1], Takeru Omori[1], Naotaka Tomioka[2], Satoko Motai[2], Hiroki Suga[3], Yoshio Takahashi[3]

1. Hiroshima University, 2. JAMSTEC, 3. The University of Tokyo

Cyanobacteria is oxygenic phototroph known to calcify under optimum ambient water chemistry. Fossils of calcified cyanobacteria are widely spread especially during the Phanerozoic, and the fluctuation in their abundance is crucial for reconstructing paleo-ocean chemistry (e.g., pH). Two major mechanisms are suggested for cyanobacterial calcification: 1) the photosynthetic increase in $CaCO_3$ saturation state, and 2) the crystal nucleation sites supplied by acidic groups of extracellular polymeric substances (EPS). Previous study based on natural samples demonstrated that acidic EPS is crucial for controlling the degree and the style of calcification. However, the influence of EPS on crystal morphology, crystal arrangement, and precursor (amorphous calcium carbonate: ACC) formation are still not well understood. The present study, therefore, examined the relationship between physical/chemical characteristics of EPS and calcification styles by using cultivated cyanobacteria.
Four cyanobacteria having different EPS characteristics (*Spirulina*, *Phormidium*, *Scytonema*, and *Leptolyngbya*) were cultivated. Acid-base titrations and lectin binding analysis indicated that all investigated cyanobacteria secreted EPS containing acidic groups. These cyanobacterial cultures were incubated in an aquarium (pH = ca. 8.5, $[Ca^{2+}]$ = 2 mM, DIC = 2 mM) with light supply to cause calcification. Microelectrode measurements (pH, O_2, and Ca^{2+}) showed that all cyanobacterial cultures induced $CaCO_3$ precipitation by photosynthesis, although the degree of precipitation was different. Observations by transmission electron microscopy (TEM) and scanning transmission X-ray microscopy (STXM) revealed that the characteristics of precipitated $CaCO_3$ were significantly different among the investigated cyanobacteria. Especially, calcite formed around *Spirulina*, *Phormidium*, *Scytonema* exhibited specific features including ACC, sub-micron-sized calcite polycrystals, and superstructures, suggesting that the nucleation occurred on acidic EPS via ACC nanoparticles. In contrast, such features were rarely observed in calcite formed around *Leptolyngbya* producing only a few amounts of EPS. From these results, $CaCO_3$ formation processes on cyanobacterial surface is suggested as follows: 1) ACC nanoparticles are formed on acidic EPS, 2) crystallization takes place inside of grown ACC particles to form submicron-sized calcite polycrystals, and 3) these polycrystals grow into calcite single crystal while ACC and polycrystals remain partly.

Keywords: CaCO3, Cyanobacteria, EPS

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Mineralogical and geochemical study on sedimentary rock containing microfossils from 1.9 billion years ago(Ga) Gunflint Formation, Canada

*kouhei Sasaki[1], Akizumi Ishida[1], Takeshi Kakegawa[1]

1. Graduate School of Science, Tohoku University

The ca. 1.9 Ga Gunflint microfossils are well studied by previous investigators. On the other hand, no agreements exist for primary producers indicated by microfossils, and their living environments. In this study, we performed geological, mineralogical and geochemical studies on samples from Schreiber and Mink Mountain regions. In addition, detailed morphologies of microfossils in stromatolite were observed. In Schreiber region, we discovered the novel microfossils of cyanobacteria colony, akinete, and endospore. Undiscovered microfossil type with radial wall ornamentation is found, indicating eukaryotic affinities. In particular, in situ analysis of microfossils by NanoSIMS discovered multilayered microstructure of cell wall and heterogeneous distribution of carbon, nitrogen and sulfur possibly associated with biological incorporation of those elements followed by later diagenetic modification. At Mink Mountain region, detailed observations and chemical analyses suggest that iron-oxidizing bacteria were dominant around stromatolites. Fe^{2+} and clays were supplied by local and shallow hydrothermal systems along the paleo-coastal lines. Such hydrothermal environments created local anoxic environments, allowing accumulation of Fe^{2+} followed by microbial oxidation. In summary, microbial life at the Gunflint age was more diverse and evolved than previously thought, cyanobacteria were primary producers in most places, but structure of microbial ecosystems in the Gunflint ocean dynamically changed with environments.

Keywords: Gunflint Formation, microfossils, stromatolite

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[J] Oral | B (Biogeosciences)：B-BC Biogeochemistry

Tue. May 28, 2019 3:30 PM - 5:00 PM JST | Tue. May 28, 2019 6:30 AM - 8:00 AM UTC | 201A 2F

[B-BC03] Interrelation between Life, Water, Mineral, and Atmosphere

convener:Takeshi Kakegawa(Graduate School of Science, Tohoku University), Tadashi Yokoyama(Graduate School of Integrated Arts and Sciences, Hiroshima University), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Fumito Shiraishi(Department of Earth and Planetary Systems Science, Graduate School of Science, Hiroshima University), Chairperson:Takeshi Kakegawa, Fumito Shiraishi(Hiroshima Univ.)

Life on Earth is based on a diversity of physical and chemical dynamics and processes throughout the history of the Earth. It can essentially be regarded as the history of interrelation between Life, Water, Mineral (Solid Earth) and Atmosphere. To solve this kind of complex systems problems, interdisciplinary approach, a way of thinking and communication, is necessary. This session will be a cradle for such interdisciplinary researches.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[BBC03-07] Secular variation of multiple sulfur isotopic compositions of sulfate and sulfide during long term incubation of *Desulfovibrio desulfuricans*

*Fumihiro Matsuura[1], Hiroko Makita[2], Ken Takai[3], Yuichiro Ueno[1,3] (1.Tokyo Institute of Technology, 2.Tokyo University of Marine Science and Technology, 3.Japan Agency for Marine-Earth Science & Technology (JAMSTEC))

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[BBC03-08] **Origins of volcanic SO_2 on Earth**

*Hiroshi Ohmoto[1] (1.The Pennsylvania State University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[BBC03-09] **Volcanism, sedimentation, and development of life in a Mesoarchaean intracratonic setting: the Dominion Group, South Africa**

*Andrea Agangi[1,2], Axel Hofmann[2], Dora Paprika[2], Andrey Bekker[2,3], Frantz Ossa-Ossa[2,4] (1.Akita University, 2.University of Johannesburg, 3.University of California, 4.University of Tuebingen)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[BBC03-10] New microbial ecology results from genome centered metagenomics studies of iron carbonate and sulfidic hot springs

*Shawn E McGlynn[1], Lewis Ward[2], Takeshi Kakegawa[3], Yuichiro Ueno[1], Mayuko Nakagawa[1] (1.Earth-Life Science Institute, Tokyo Institute of Technology, 2.Harvard University, 3.Tohoku University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[BBC03-11] Superhabitability in ultradeep rocky environments

*Yohey Suzuki[1] (1.Graduate School of Science, The University of Tokyo)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[BBC03-12] Exploring planetary habitability beneath the oceans

★Invited Papers

*Fumio Inagaki[1] (1.Japan Agency for Marine-Earth Science and Technology)

Secular variation of multiple sulfur isotopic compositions of sulfate and sulfide during long term incubation of *Desulfovibrio desulfuricans*

*Fumihiro Matsuura[1], Hiroko Makita[2], Ken Takai[3], Yuichiro Ueno[1,3]

1. Tokyo Institute of Technology, 2. Tokyo University of Marine Science and Technology, 3. Japan Agency for Marine-Earth Science & Technology (JAMSTEC)

Incubation experiments of sulfate reducing microbes have been carried out since 1950s to quantify sulfur isotope fractionation. Sulfur isotope fractionation models are constructed from the results of these experiments. These models are applicable only when steady state is accomplished in the cells; thus, most of incubation experiments targeted cells exponential growth phase. We aimed to quantify the isotope fractionation in stationary to death phase of the cells and carried out two series of incubation experiment of sulfate reducing bacteria, *Desulfovibrio desulfuricans* (DSM-642), until c.a. 2000 hours. In addition, we used glucose as electron donor to make cell specific sulfate reduction rate low. Cells grew linearly rather than exponentially until cell concentration became c.a. 2×10^7 cells/mL in the early stage of incubation. Calculated sulfur isotope fractionation increased from 13.5±3.7‰ at the earliest stage of linear growth phase to 70.5±21.0‰ at the middle of linear growth phase. The cell specific sulfate reduction rate was 1.0±0.3 fmol/cell/day when sulfur isotope fractionation became 70.5±21.0‰, consistent with the results of a previous study. In the stationary to death phase, sulfide concentration started decreasing on the contrary to our expectation. Besides, $\delta^{34}S_{sulfide}$ value increased concomitant with the decrease of $\Delta^{33}S'_{sulfide}$ value. The $\delta^{34}S'_{sulfide}$ and $\Delta^{33}S'_{sulfide}$ have good linear correlation, and that indicate a sulfide originated reaction in a closed system with a unique fractionation factor dominates sulfur cycle during stationary to death phase. The calculated enrichment factors of the reaction in the two series experiments are 10.5‰ and 30‰. These enrichment factors are large compared to those of biotic or abiotic sulfide oxidation experiments of previous studies. We checked the reaction occur without cells and infer that the reaction is caused from sulfide oxidation by oxidants containing in the medium or sulfurization of organic matter containing in the medium.

Keywords: sulfate reducing bacteria, sulfur isotope fractionation, long term incubation

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Origins of volcanic SO_2 on Earth

*Hiroshi Ohmoto[1]

1. The Pennsylvania State University

SO_2 is a principal volcanic gas today. The two important questions to be addressed are: (i). the origin of S atoms in volcanic SO_2; and (ii) whether or not SO_2 was an important volcanic gas of early Earth. I have approached these questions from: (a) thermodynamic- and kinetic analyses of various reactions involving S-bearing species in silicate melts, fluids, rocks, minerals, and aqueous solutions at T = 0-1500 ˚C and P = 1-10 kb, and (b) examinations of the chemical and S-isotopic characteristics of volcanic gases and rocks in various tectonic settings on modern Earth. Here are some of the important suggestions from these investigations:

1. All of the S-bearing species from submarine volcanic eruptions have been nearly completely trapped in oceans through reactions such as: $H_2S_{(g)} = H_2S_{(aq)}$; $4SO_{2(g)} + 4H_2O = 3HSO_4^- + H_2S_{(aq)} + 3H^+$; $S_{8(g)} = 8S_{(s)}$; and $7H_2S_{(aq)} + HSO_4^- + 4Fe^{2+} = 4FeS_{2(py)} + 7H^+ + 4H_2O$. S-bearing volcanic gases have only been emitted into the atmospheres by subaerial eruptions. Therefore, on the ocean-covered planets, possibly including the pre-3.0 Ga Earth, S-bearing gases have not been emitted into the atmospheres.

2. The fluids that originated from normal-mantle-derived-magmas (i.e., $\log fO_2$ = FMQ-2 to FMQ+0.5) were initially H_2S-rich and SO_2-poor, whereas those from subduction-related arc magmas (i.e., $\log fO_2$ = FMQ+0.5 to FMQ+3) were initially SO_2- and/or H_2S-rich.

3. H_2S-rich magmatic fluids may become SO_2-rich gas, if: (i) the fluids were derived from high fO_2 magmas (i.e., $\log fO_2$ > FMQ) and ascended slowly through conduits (i.e., diffusive eruptions) and re-equilibrated with wall-rocks at P_{H2O}<10 bars, or (ii) the fluids are oxidized by reactions with an O_2-rich atmosphere, -groundwater and/or high-fO_2 wall-rocks during and/or after the ascent through conduits. In the absence of (i) and (ii), such as the Earth prior to the oxygenation of the atmosphere, H_2S-rich magmatic fluids were not transformed to SO_2 during eruptions.

4. SO_2-rich fluids from arc magmas would remain SO_2-rich during explosive or diffusive eruptions. However, if the fluids cool down to <~700˚C, SO_2 transforms to H_2S.

5. Volcanic SO_2 from arc magmas was transformed from seawater sulfate through the following processes: (i) formation of pyrite, hematite and anhydrite by reactions between SO_4^{2-}-rich seawater and hot basalts on MORs; (ii) devolatilization of H_2O- and SO_2-rich fluids from the subducting oceanic crust; (iii) formation of oxidized- and SO_4^{2-}-rich magmas by partial melting of peridotite in the mantle wedges, and (iv) degassing of SO_2-rich fluids from these magmas. If the oceans were SO_4^{2-}-poor, volcanic gases from arc magmas would be SO_2-poor.

6. Oceanic SO_4^{2-} has been produced mostly by the oxidative weathering of pyrite on land. Therefore, subaerial volcanic gases on planets with O_2-poor atmospheres would be SO_2-poor and H_2S-rich. Then, the current paradigm concerning the origin of mass-independent-fractionations of sulfur isotopes (MIF-S) in Archean-aged sedimentary rocks (i.e., the UV photolysis of volcanic SO_2 in an O_2-poor atmosphere) becomes invalid. Consequently, the MIF-S record in sedimentary rocks is not supportive evidence for the “Great Oxidation Event” at ~2.5 Ga ago. Furthermore, the current atmospheric O_2-evolution models,

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which are based on the premise of SO_2-rich volcanic gases throughout geologic time, become invalid.

(7). The MIF-S in the Archean- and younger sedimentary rocks may have been created by the chemisorption isotope effects during thermochemical reductions of seawater sulfates by hydrothermally-generated, very reactive organic matter.

Keywords: volcanic SO2, evolution of the atmospheric oxygen, arc magmatism, origin of MIF-S

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Volcanism, sedimentation, and development of life in a Mesoarchaean intracratonic setting: the Dominion Group, South Africa

*Andrea Agangi[1,2], Axel Hofmann[2], Dora Paprika[2], Andrey Bekker[2,3], Frantz Ossa-Ossa[2,4]

1. Akita University, 2. University of Johannesburg, 3. University of California, 4. University of Tuebingen

The ca. 3 billion-years-old Dominion Group of the Kaapvaal craton, South Africa is a >2 km-thick volcano-sedimentary succession emplaced in an intracontinental setting shortly after craton consolidation. As such, it represents one of the oldest examples of volcanism and sedimentation on stable continental crust. Deposition of the Dominion Group is interpreted to have occurred largely subaerially in a failed rift. In contrast to other Palaeo- to Mesoarchaean successions of the Kaapvaal craton, the Dominion Group is little deformed and was metamorphosed at greenschist facies grade, allowing excellent preservation of rock textures and chemical composition. The succession includes a thin basal conglomerate that marks a major, craton-scale nonconformity, and is overlain by sandstone. Volcanic rocks include intercalated massive to amygdaloidal mafic lavas of tholeiitic affinity, felsic lavas, and ignimbrites with high Fe/Mg.

In the area around the town of Ottosdal, the Dominion Group is represented by felsic volcanic rocks with intercalated, thin sedimentary layers that crop out discontinuously for several km along the strike. The presence of shallow, porphyritic intrusions that developed peperitic contacts with the sediments and the intense alteration developed in sediments underlying (but not in overlying) volcanic rocks indicate deposition of these sediments in a volcanically and hydrothermally active environment, such as volcanic lakes. These sediments are composed of carbonaceous and variably sulfidic shale and minor arenite and have a distinctive aluminium-rich composition (Al_2O_3 up to 36 wt.%) and very low contents of alkaline elements, Ca, and Fe (Na_2O content from below detection limit to 0.3 wt%; Fe_2O_3 = 0.1 to 1.6 wt%). The main mineral components of these sediments are pyrophyllite, diaspore, K-mica, rutile, and pyrite. No carbonate was found.

The total organic carbon content) is up to 1.5 wt%, and bulk-sample isotope analyses indicate strongly ^{13}C-depleted composition ($\delta^{13}C_{VPDB}$ = -45 to -29‰). These isotopic values are diagnostic of biogenic carbon fixation and the lowest, best-preserved values are indicative of methanogenesis and methanotrophy in a redox and chemically stratified shallow basin. Modern examples of volcanic environments hosting methane-producing Archaea, even under low pH and high temperature conditions, are known from Kamchatka, Russia and Argentina.

Our results indicate that restricted and ephemeral lakes that developed in Mesoarchaean volcanic environments shortly after the large-scale emergence of the Kaapvaal craton fostered life and were likely niches for life diversification. This ancient environment might be a better Mars analogue than modern caldera environments on Earth where the impact of advanced biosphere is more pronounced.

Keywords: Archaean, Terrestrial life, Alteration

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New microbial ecology results from genome centered metagenomics studies of iron carbonate and sulfidic hot springs

*Shawn E McGlynn[1], Lewis Ward[2], Takeshi Kakegawa[3], Yuichiro Ueno[1], Mayuko Nakagawa[1]

1. Earth-Life Science Institute, Tokyo Institute of Technology, 2. Harvard University, 3. Tohoku University

The ability to recover microbial genomes from metagenomic datasets has revolutionized how we understand microbial inhabitants in the environment, and is a powerful way to develop detailed hypotheses of community function and evolution. In this talk, I will discuss recent genomes we have recovered from two iron rich, carbonate hot springs in Japan, and contrast these to observations in low iron, sulfidic springs. Surprisingly, despite the different chemistry, some overall trends in phylogeny and physiology are observed, however water chemistry differences such as salinity and the availability of ferrous iron does alter the observed microbial inhabitants and physiologies.
These overall results will be discussed within the context of the possible ability to recognize microbial inhabitation on Earth through time.

Keywords: metagenomics, microbial ecology, geochemistry, geobiology



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Superhabitability in ultradeep rocky environments

*Yohey Suzuki[1]

1. Graduate School of Science, The University of Tokyo

It is challenging for life to proliferate in cold rocky habitats deeply isolated from photosynthetic organic matter. Although fluid circulation is previously considered to be necessary for supplying energy sources and oxidants, it is also considered that substrates available within the rocky environment are diluted by fluid circulation. As the abundance of microbial life within the rock matrix is largely unknown, I developed nanoscale analytical procedures to unveil the distributions of microbial cells, organic matters and low-temperature minerals. As a result of applying the analytical procedures to various deep-sea and subsurface rocky environments such as deep-sea hydrothermal vents, deep-sea ferromanganese crusts and deep subseafloor basaltic rocks, it is unexpectedly unveiled that the rocky habitats are superhabitalble with cell densities locally exceeding 10^{10}cells/cm^3. The superhabitablity might be explained by the coexistence of solid silicate phases such smectite clays that play roles in concentrating nutrients from the ambient fluid.In this presentation, I will introduce the analytical procedures and main results obtained from the ultradeep rocky habitats.

Keywords: deep biosphere, nanobiogeoscience, microbial ecology

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Exploring planetary habitability beneath the oceans

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1. Japan Agency for Marine-Earth Science and Technology

Since Ocean Drilling Program (ODP) Leg 201 in 2002 off Peru and eastern equatorial Pacific, numerous geochemists and microbiologists have participated in multiple expeditions of scientific ocean drilling to explore subseafloor life and the deep biosphere beneath the oceans. The discovery of diverse microbial life in marine sediments and oceanic crusts worldwide points to a notion that subseafloor microbial ecosystems may have uniquely co-evolved with Earth's dynamics and this inevitable interrelationship has shaped environemnts for more than 3 billion years. Expanding our knowledge of the comprehensive ocean-Earth-life system through scientific ocean drilling inspires new insights into the essence of "planetary habitability"—down to the Earth’s upper mantle, which with today’s drilling technology provides the deepest yet accessible limit. The deep ocean offers windows into thick piles of ocean sediment and the Earth’s interior that has vast potentials for the development of sustainable ocean-Earth-life system in the past but also into the future, yet there is still a large insufficiency in our knowledge of the habitability extent of our own planet. Such explorations towards deep frontiers will lead us to an understanding of how and why life emerged on our planet, as well as an estimation (prediction) of the possible trajectories of life on Earth, and finally, will provide hints as to whether life persists in the other celestial bodies, and which ones are the most likely to be habitable and even inhabited.

Keywords: planetary habitability, subseafloor life, mantle drilling, deep biosphere, scientific ocean drilling

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[J] Oral | B (Biogeosciences)：B-CG Complex & General

Tue. May 28, 2019 10:45 AM - 12:15 PM JST | Tue. May 28, 2019 1:45 AM - 3:15 AM UTC | 105 1F

[B-CG08] Phanerozoic biodiversity change: Extinction and diversification

convener:Yukio Isozaki(Department of Earth Science and Astronomy, Multi-disciplinary Sciences - General Systems Studies, Graduate School of Arts and Sciences, The University of Tokyo), Yusuke Sawaki(The University of Tokyo), Chairperson:Yukio Isozaki(Department of Earth Science and Astronomy, The University of Tokyo), Yusuke Sawaki(The University of Tokyo)

Phanerozoic biodiversity is the consequence of repeated extinctions and following diversifications in the past, which were caused by large-scale environmental changes, in particular, by extremely rapid and drastic forcing that changed the environments of the biosphere. Irreversible and episodic changes in material cycling on the planet and influences of severe galactic cosmic radiation enhanced by encounter with dark cloud are nominated as major driving mechanisms for the alleged rapid, large-scale environmental perturbations. The biodiversity change in the fossiliferous Phanerozoic record is characterized by 5 major mass extinctions within the long-term trend of diversity increase. Nonetheless, each extinction event has been explained rather in ad hoc manner, without any universal explanation. Therefore, ultimate triggers that caused the Phanerozoic biodiversity still remain as unsolved issues. This session discusses the ancient environmental changes related to Phanerozoic biodiversity under a new light of the recent progress in geology.

10:45 AM - 10:50 AM JST | 1:45 AM - 1:50 AM UTC

Introduction

10:50 AM - 11:10 AM JST | 1:50 AM - 2:10 AM UTC

[BCG08-01] **The Ediacaran-Cambrian transition of North China**

★Invited Papers

*Xingliang Zhang[1] (1.State Key Laboratory of Continental Dynamics, Shaanxi Key Laboratory of Early Life and Environments, and Department of Geology, Northwest University)

11:10 AM - 11:30 AM JST | 2:10 AM - 2:30 AM UTC

[BCG08-02] The Qingjiang biota – An extraordinary new Burgess Shale-type fossil Lagerstätte from the early Cambrian of South China

★Invited Papers

*Dongjing Fu[1], Xingliang Zhang[1], Robert R. Gains[2] (1.State Key Laboratory of the Continental Dynamics, Shaanxi Key Laboratory of Early Life and Environment, Department of Geology, Northwest University, Xi'an 710069, PR China, 2.Department of Geology, Pomona College, Claremont, CA 91711, USA)

11:30 AM - 11:50 AM JST | 2:30 AM - 2:50 AM UTC

[BCG08-03] Enhanced flux of extraterrestrial ^{3}He across the Permian–Triassic boundary

★Invited Papers

*Tetsuji Onoue[1], Naoto Takahata[2], Honami Sato[4], Akira Ishikawa[3], Katsuhito Soda[1], Yuji Sano[2], Yukio Isozaki[2] (1.Kumamoto Univ., 2.Univ. Tokyo, 3.Tokyo Inst. Tech., 4.Chiba Inst. Tech.)

11:50 AM - 12:10 PM JST | 2:50 AM - 3:10 AM UTC

[BCG08-04] **End-Triassic Mass Extinction: Causes and Consequences**

★Invited Papers

*Wataru Fujisaki[1] (1.Japan Agency for Marine-Earth Science and Technology)

12:10 PM - 12:15 PM JST | 3:10 AM - 3:15 AM UTC

Discussion

The Ediacaran-Cambrian transition of North China

*Xingliang Zhang[1]

1. State Key Laboratory of Continental Dynamics, Shaanxi Key Laboratory of Early Life and Environments, and Department of Geology, Northwest University

The central mountain range, known as the backbone of China, separates the country into North China and South China, which are different from each other in geology, geography, climate, and culture. The Precambrian-Cambrian transition of South China has received much attention of world scientists for beautiful sections and numerous fantastic fossil-Lagerstätten. However, the Ediacaran-Cambrian sequences of North China have some attractive points as well. The lowermost Cambrian of North China, the Xinji Formation, unconformably overlies Precambrian rocks of various ages, from Archean to late Ediacaran. The Xinji Formation is rich in SSFs of Cambrian Epoch 2 aspects and thus the Terreneuvian is absent throughout North China. The Xinji SSF assemblage is taxonomically dominated by molluscs and hyoliths, which are represented by 26 and 12 species, respectively. A number of molluscan taxa are conspecific with Australia, Antarctic and Laurentia, and thus have biostratigraphical and paleobiogeographical values. Remarkably, shell microstructures are well preserved in molluscs and hyoliths, which demonstrate how these Cambrian animals use minute mineral crystals to build their shells. Additionally, shell microstructures shed new light on the phylogenic links between the groups. Ediacaran rocks developed in marginal regions and cratonic basins. Along the south and west margins of North China, the Dongpo/Tuerkeng Shale/Slate immediately underlies the unconformity and overlies the Luoquan/Zhengmuguan Diamictite which is poorly constrained in age. The shale/slate unit above the diamictite yields a diverse form of macroscopic, soft-bodied fossils, e.g. the annulated tubular form *Shaanxilithes*, the form of a string of beads *Horodyskia*, the WiFi symbol-like form *Palaeopascichnus*, an unnamed form resembling a string of rings (which might be a segmented organism composed of many repetitive units), and small clew-like fossils of unknown affinities. Algal fossils are abundant but simple in complexity and poor in diversity. The presence of *Shaanxilithes* and *Palaeopascichnus* suggests an age of late Ediacaran. New specimens demonstrate that *Shaanxilithes* is composed of a cone-in-cone internal tube encased in a flexible external tube with irregular cross annulations. Such a morphological reconstruction is analogous to the contemporary *Cloudina* and other tubular organisms. New findings in North China would provide new insights into the biotic evolution of the Ediacaran-Cambrian transition.

Keywords: Ediacaran, Cambrian, Biodiversity, North China

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The Qingjiang biota –An extraordinary new Burgess Shale-type fossil Lagerstätte from the early Cambrian of South China

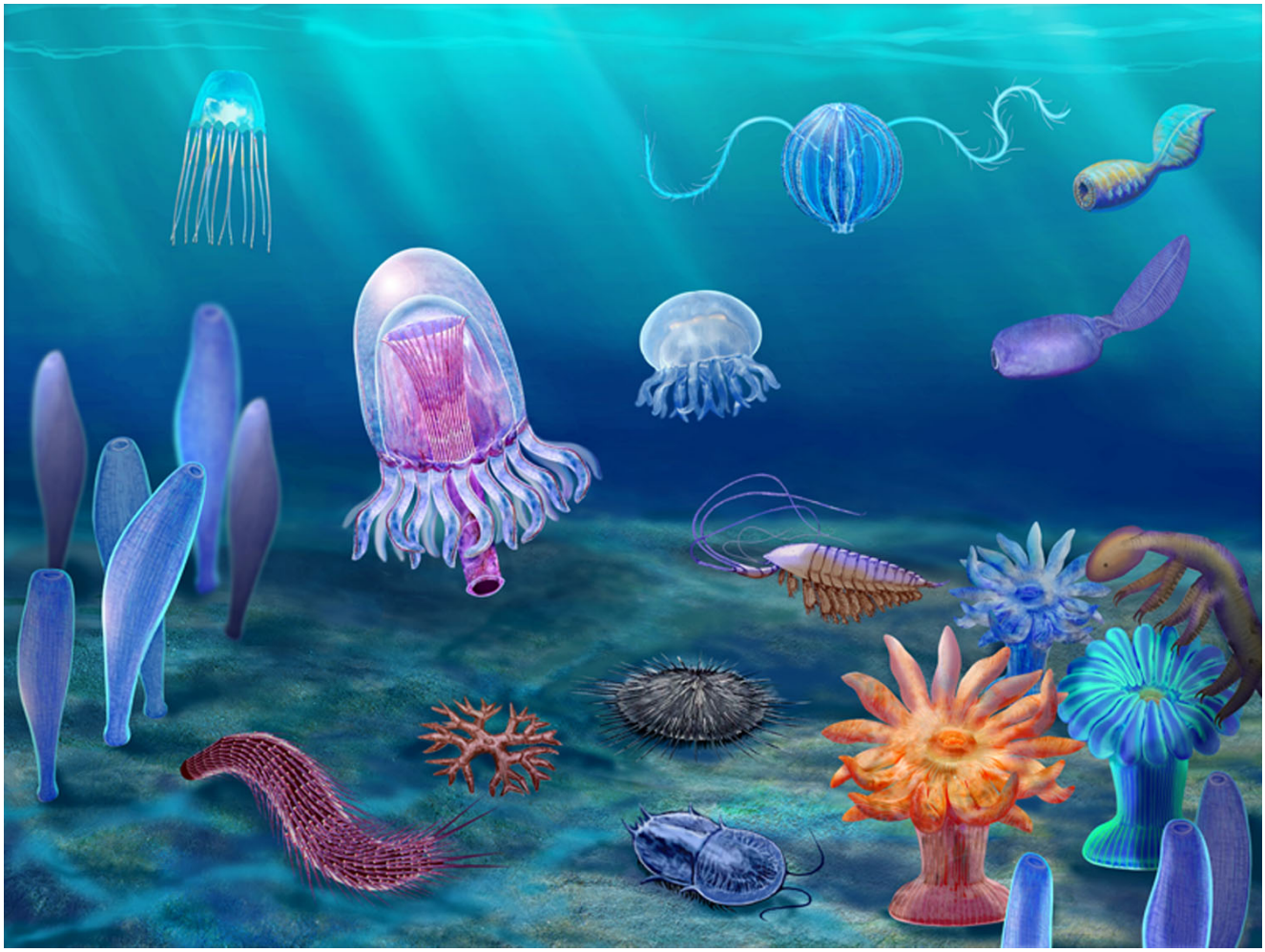
*Dongjing Fu[1], Xingliang Zhang[1], Robert R. Gains[2]

1. State Key Laboratory of the Continental Dynamics, Shaanxi Key Laboratory of Early Life and Environment, Department of Geology, Northwest University, Xi' an 710069, PR China, 2. Department of Geology, Pomona College, Claremont, CA 91711, USA

Our understanding of the Cambrian explosion and of the fundamental structure of the tree of animal life rests in large part on evidence from a dramatically enhanced fossil record, characterized by the preservation of entire assemblages of soft-bodied fossils. In the one hundred years since Walcott' s original discovery of the Burgess Shale, exceptionally preserved fossil assemblages have been reported from Cambrian strata of almost every paleocontinent. Nevertheless, only the early Cambrian Chengjiang biota of Yunnan Province has matched the Burgess Shale in total diversity of soft-bodied taxa and fidelity of exceptional preservation. Here, we report the discovery of an extraordinary new early Cambrian Burgess Shale-type (BST) fossil Lagerstätte from the Changyang area of South China, which is characterized by high taxonomic diversity (101 metazoan taxa plus 8 algal forms), an unexpectedly large proportion of new taxa (53.2%), and exquisite preservation of fine aspects of labile tissue anatomy. The taxonomic richness of soft-bodied taxa (85%) approaches the top tier of BST deposits, presently occupied only by the Burgess Shale and Chengjiang biotas. Rarefaction analyses suggest that diversity may surpass all other BST biotas. Novel aspects include high abundance of cnidarians, including both medusoid and polypoid forms, new taxa resembling extant kinorhynchs, and abundant larval or juvenile forms. While approximately coeval to the Chengjiang biota, the Qingjiang biota (518 Ma) appears to have occupied a more distal environmental setting, in which a different early Cambrian ecosystem flourished. The uniqueness of the Qingjiang biota in the taxon composition and preservation quality holds special potential to provide new insights into the evolution of early metazoans and the structuring of Cambrian ecosystems across environmental gradients.

Keywords: Qingjiang Biota, Cambrian Explosion, Exceptional Preservation, South China, Burgess Shale Type

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Enhanced flux of extraterrestrial ^{3}He across the Permian–Triassic boundary

*Tetsuji Onoue[1], Naoto Takahata[2], Honami Sato[4], Akira Ishikawa[3], Katsuhito Soda[1], Yuji Sano[2], Yukio Isozaki[2]

1. Kumamoto Univ., 2. Univ. Tokyo, 3. Tokyo Inst. Tech., 4. Chiba Inst. Tech.

The Solar System contains abundant submillimetre interplanetary dust particles (IDPs) that are enriched in ^{3}He. ^{3}He concentrations in ancient deep-sea sediments have been used to constrain the flux of IDPs onto the Earth for at least the last 100 Myr. However, the use of ^{3}He in detecting IDP flux is often compromised by the diffusional loss of ^{3}He in sedimentary rocks, with the exception of some Ordovician samples that record a period of unusually high extraterrestrial^{3}He ($^{3}He_{ET}$) flux. In this study, we report for the first time the preservation of extra-terrestrial ^{3}Hein deep-sea bedded chertfrom a continuous Permian-Triassic boundary (PTB) section at Waidani in Japan, which was deposited in the Panthalassa superocean.

High ^{3}He/^{4}He ratios (up to 150 Ra; 1Ra = the atmospheric ratio) were detected from acid-insoluble residues fromthe uppermost Permian deposits, which suggeststhe existence of extraterrestrial He hosted mainly in IDPs. The estimated extraterrestrial fraction of ^{3}He across the PTB revealsthat$^{3}He_{ET}$ concentrations are higher in the topmost ~1.5 m ofthe studied Permian deposits, which is 4–5 times greater than that measured in the overlying Triassic unit. Based on the $^{3}He_{ET}$ concentration and sedimentary mass accumulation rate of the PTB section at Waidani, we calculated $^{3}He_{ET}$ fluxacross the PTB.The data document the presence of an up to 4-fold increase in IDP flux for the last 500 kyr interval of the Permian.This unusual signal suggests a significant increase in the influx of interplanetary dust particles, likely related to an asteroid showerin the inner Solar System. High-resolution stratigraphy indicates that peak IDP flux occurred during the final 500 kyr of the Permian, concurrent with a pre-extinction decline in radiolarian diversity.

Keywords: Permian, Triassic, Bedded Chert, Helium, Interplanetary dust particle, Platinum group element

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End-Triassic Mass Extinction: Causes and Consequences

*Wataru Fujisaki[1]

1. Japan Agency for Marine-Earth Science and Technology

The biodiversity crisis across the Triassic-Jurassic boundary (TJB; *ca.* 201 Ma) is characterized by one of the largest mass extinctions in the Phanerozoic. Significant increases in the extinction rate of marine fauna, and major turnovers in terrestrial vegetation and vertebrate groups, have been well documented across the TJB. In addition to the extinction, several unique geological episodes around the TJB were recognized; i.e., the emplacement of the Central Atlantic Magmatic Provinces (CAMP) which is associated with the breakup of Pangea, carbon cycle perturbations, and widespread ocean anoxia and associated deficits of nutrients. In the last decade, based on of the numerous data-set obtained from the shallow-marine shelf sequences around the Pangea, major advances have been made in our understanding of the TJB biotic crisis, related environmental changes, and the CAMP volcanism. However, the casual relationships between the CAMP volcanism and extinction-related environmental changes of global context still remain unclear. Therefore, the deep mid-Panthalassa, which occupied major portion of the global ocean during the Triassic-Jurassic transition, is indispensable for reconstructing the global environmental changes related to the TJB biotic crisis.

Deep-sea bedded cherts in the Mino-Tanba belt in SW Japan provide critical constraints for reconstructing paleo-environmental changes because they preserve extinction-related intervals from the Middle Permian to the Early Jurassic deposited in the deep mid-Panthalassa. Most recently, the stratigraphic $\delta^{13}C_{org}$ variation using Rhaetian (Late Triassic) to Hettangian (Early Jurassic) shales interbedded within deep-sea cherts was established in the Katsuyama section in the Mino-Tanba belt. By obtaining high-resolution Rhaetian to Hettangian $\delta^{13}C_{org}$ values, three negative carbon isotopic excursions (NCIEs) were newly detected before and across the TJB. The mid-Panthalassic NCIEs are well correlated with those in many shallow-marine regions including the base Jurassic GSSP of TJB at Kuhjoch in Austria, suggesting that three NCIEs in the Tethys and mid-Panthalassa likely reflected global perturbations of the carbon cycle, rather than local phenomena. Based on the Os isotopic records correlated with $\delta^{13}C_{org}$ stratigraphic profiles, the mid-Panthalassic NCIEs can be interpreted as the consequences of the multiple emplacements of CAMP volcanism.

On the other hand, despite the oxic deep mid-Panthalassa, widespread ocean anoxia and associated deficits of nutrients around the TJB were recently identified in the Eastern Panthalassa. Since the redox conditions were quite different between shallow-marine regions and mid-Panthalassic sites, information regarding nutrient concentrations in the mid-Panthalassa is required. Oceanic fixed nitrogen is a bio-limiting component in the modern ocean, and total nitrogen isotopic composition ($\delta^{15}N_{TN}$) of sedimentary rocks is a useful tool for the reconstruction of ancient nitrogen cycles. To advance our understanding on the global nitrogen cycle, this study for the first time provides Rhaetian to Hettangian $\delta^{15}N_{TN}$ records in combined with Mo and U concentrations from the shales in the Katsuyama section. Based on the newly obtained data-set, I comprehensively discuss relative concentrations of biologically available nitrogen compounds in the mid-Panthalassa, their possible association with the redox condition, and biodiversity during the Triassic-Jurassic transition.

Keywords: Central Atlantic Magmatic Provinces (CAMP), Panthalassic ocean, Nitrogen isotopes, Redox sensitive elements, Bedded cherts, Japan

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[J] Oral | B (Biogeosciences)：B-CG Complex & General

Tue. May 28, 2019 1:45 PM - 3:15 PM JST | Tue. May 28, 2019 4:45 AM - 6:15 AM UTC | 105 1F

[B-CG08] Phanerozoic biodiversity change: Extinction and diversification

convener:Yukio Isozaki(Department of Earth Science and Astronomy, Multi-disciplinary Sciences - General Systems Studies, Graduate School of Arts and Sciences, The University of Tokyo), Yusuke Sawaki(The University of Tokyo), Chairperson:Wataru Fujisaki(Japan Agency for Marine-Earth Science and Technology)

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1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[BCG08-05] Transition of biodiversity in mobile populations and the small world in local subpopulations

*Kota Imaoka[1], Kazuhito Yamasaki[1] (1.Kobe University Graduate school of Science)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[BCG08-06] Rivision of the lowermost Cambrian SSF stratigraphy

*KONO SENA[1], Yukio Isozaki[1], Tomohiko Sato[2], Xingliang Zhang[3], Wei Liu[3] (1.The University of Tokyo School of Arts &Sciences, 2.Earth-Life Science Institute, Tokyo Institute of Technology, 3.Northwest university, China)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[BCG08-07] $\delta^{88}Sr$ and $^{87}Sr/^{86}Sr$records of the Middle-Late Permian seawater: mass extinction-relevant change in ocean Sr budget

*Tomomi Kani[1], Yukio Isozaki[2], Keiji Misawa[3], Akira Ishikawa[4], Shigekazu Yoneda[5] (1.Kumamoto University, 2.The University of Tokyo, 3.National Institute of Polar Research, 4.Tokyo Tech, School of Science, 5.National Museum of Nature and Science)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[BCG08-08] Formation of stratiform manganese deposits during the Carnian (Late Triassic) “pluvial event” in the pelagic Panthalassa

*Yuki Tomimatsu[1], Tetsuji Onoue[2], Daisuke Yamashita[3], Tatsuo Nozaki[4,5,6,7], Yutaro Takaya[8] (1.Graduate school of Science and Technology, Kumamoto University, 2.Faculty of Advanced Science and Technology, Kumamoto University , 3.Satsumasendai City Office, 4.Research and Development Center for Submarine Resources, Japan Agency for Marine-Earth Science and Technology, 5.Frontier Research Center for Energy and Resources (FRC- ER), Graduate School of Engineering, Tokyo University, 6.Department of Planetology, Graduate School of Science, Kobe University, 7.Ocean Resources Research Center for Next Generation, Chiba Institute of Technology, 8.Department of Resources and Environmental Engineering School of Creative Science and Enginerring, Waseda University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[BCG08-09] Enrichment of chalcophile elements in Cretaceous–Paleogene boundary clays

*Teruyuki Maruoka[1], Yoshiro Nishio[2] (1.Faculty of Life and Environmental Sciences, University of Tsukuba, 2.Research and Education Faculty, Kochi University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[BCG08-10] Mass extinctions: hierarchy of causes and cosmoclimatological perspective

*Yukio Isozaki[1] (1.Department of Earth Science and Astronomy, Multi-disciplinary Sciences - General Systems Studies, Graduate School of Arts and Sciences, The University of Tokyo)

Transition of biodiversity in mobile populations and the small world in local subpopulations

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Speciation is one of the factors that influences ecological biodiversity on the geological time scale (Gould 1989, Kawata, 2000). So its mechanism is the important paleontological theme that leads to learn evolution. The basic mechanism is reproductive isolation. Allopatric speciation needs geographical barriers that divide the population into two subpopulations and block the genetic flow between them of individuals (Hubbell, 2001). These isolated groups accumulate incompatible genes leading to reproductive. Sympatric speciation happens with ecological interactions in the same niche. Difference of resources and habits leads to disruptive selection and ultimately to speciation (Gavrilets, 2003). Recently, a neutral theory of speciation, without geographical barriers or ecological interactions, has been shown to predict many patterns consistent with the behaviors observed in nature, e.g. species abundance distributions and species-area relationships. This neutral speciation is driven by physical and genetic distances which are essential for assortative mating. As the condition is restricted, speciation is promoted. Such a speciation model is named 'topopatric speciation'. In addition, another factor that influences ecological biodiversity on the geological time scale is radiation (Yamasaki et al., 1999). However, many studies of topopatric speciation consider standing still populations. So we considered mobile populations and the effect of them on speciation and ecological system. Our study may show that mechanism of speciation and how populations increased their biodiversity in the past. Moreover, we considered the spatial structure of each species with networks and quantitatively showed the distribution of populations on the process of speciation. This study uses a multi agent system to simulate the neutral stochastic evolution without natural selection. We consider an initial population of diploid and genetically identical individuals. In reproduction, we extend the Dobzhansky-Muller model to the most general form contains multiple alleles. A species is defined as the concept of ring species (Irwin et al., 2001, 2005). In the simulations, we found not only the number of species in the space, but also species diversity (species abundance distributions) and genetic diversity (heterozygosity). Furthermore, we calculated average path lengths and clustering coefficients by considering individuals as nodes and linking between them which can reproduce. Our simulations showed that the number of species and species diversity, genetic diversity changed depending on the mobile speed in populations. Accordingly, the difference of mobile speed in populations influences on biodiversity. In addition, from our results we predict species abundance distributions and species-area relationships. The highest species richness was found at minimum mobile speed, then average path length is smaller and clustering coefficient is larger. So this shows that the populations have a feature of 'small world' on the network. In the small world, we can communicate quickly each other and have many strong connections. In other words, individuals can exchange genomes quickly each other and have many mates. Thus, speciation is promoted by dividing the population into local subpopulations that form the small world and accumulating genetic variation. Consequently, in mobile population, assortative mate based on isolation by physical and genetic distance without geographical barriers and ecological interactions leads to divide population and speciation.

Keywords: speciation, biodiversity, biological diffusion, Dobzhansky-Muller model, the small world

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Rivision of the lowermost Cambrian SSF stratigraphy

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The earliest Cambrian evolution of animals is marked by the appearance and rapid diversification of small shelly fossils (SSFs). We examined the litho- and bio stratigraphy of the lowermost Cambrian at the Xiaolantian and Hongjiachong sections in the Chengjiang area, eastern Yunnan, South China. By analyzing both outcrop and drilled core samples, we picked up many SSFs from the ca. 30 m-thick phosphorites (Zhongyicun Mb), and obtained the following results.1) the Zhongyicun Mb comprises 6 lithostratigraphic units, which include Unit 3 with characteristic black mudstone beds for a significant key for the mid-Zhongyicun Mb.2)SSFs were found from 26 horizons out of 83 in the Zhongyicun Mb and the overlying Dahai Mb. Five zones were discriminated. Interval 1 with*Acanthocasis orthocanthus, Spirellus* sp., *Protohertzina unguloformis* and*Protohertzina anabarica*(from uppermost of Unit 1 to lower part of Unit 2); Interval 2 with *Ocruranus finial, Purella*sp.and*Yunnanopleura biformis*(from upper part of Unit 2). This marks the first occurrence of cap-shaped SSFs. Interval 3 with *Helcionella*sp.and*Oelandiella korobkovi*(from Unit 3). Interval 4 with *Obtusoconus*sp.,*Conopoconis*sp. and*Erongia acculatus*(from lower part of Unit 6). Interval 5 with*Igorella* sp., *Bemella simplelx*and*Paragloborilus subglobosus*(from upper part of Unit 6). 3) In addition, at the Hongjiachong section, a unique interval with *Halkieria* sp.*,Pteromus* sp.and*Sinosachites delicatus*occurs between Interval 1 and 2.

These results from the Xiaolantian and Hongjiachong sections, the following 6 SSF zones are proposed here. Namely, 1)*Acanthocasis orthocanthus- Protohertzina anabarica*Zone, 2) *Halkieria- Pteromus*Zone, 3) *Ocruranus finial-Yunnanopleura biformis*Zone, 4)*Paracarinachites sinensis-Oelandiella korobkovi*Zone, 5) *Obtusoconus-Conopoconis*Zone, and 6) *Igorella -Bemella simplelx*Zone.Previously the Zhongyicun Mb was divided into two SSF assemblage zones (Steiner et al., 2007); however, the present study offers 6 zones. It is noteworthy that the key bed in the mid-Zhongyicun Mb, restricted within the*Paracarinachites sinensis-Oelandiella korobkovi*Zone,appears useful for regional correlation.

Keywords: Cambrain, SSF, Yunnan

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δ^{88}Sr and ^{87}Sr/^{86}Srrecords of the Middle-Late Permian seawater: mass extinction-relevant change in ocean Sr budget

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As Sr isotope compositions in seawater are globally homogeneous, these proxies are useful in checking marine Sr budget change in direct link to global calcium cycle. ^{87}Sr/^{86}Sr valueis mainlydriven by two input fluxes to seawater; riverine flux connected with weathering of time-integrated radiogenic old continent and hydrothermal input flux derived from less radiogenic mantle. δ^{88}Sr in seawaterreflects marine calcium carbonate input/output flux. The marine Sr budget changed dramatically, in particular, during the Guadalupian (Middle Pemian), with the lowest value of seawater ^{87}Sr/^{86}Sr in the Phanerozoic, i.e., “the Capitanian minimum”. This likely reflected a major global environmental change associated with the end-Guadalupian mass extinction. Likewise, the δ^{88}Sr started to decrease in the Early Permian, and reached the Phanerozoic lowest value at the end of Capitanian (late Guadalupian). We measured δ^{88}Sr values of the Middle-Upper Permian marine carbonates with detailed biostratigraphy by TRITONTIMS, with correction of isotope fractionation during mass spectrometry with ^{87}Sr-^{84}Sr double spike. Analyzed samples were from various localities in the world, e.g., the Akasaka paleo-atoll limestone (Japan), and shelf carbonates in S. China. These results confirmed that both in stable δ^{88}Sr and radiogenic ^{87}Sr/^{86}Sr ratios, low values remained throughout the Guadalupian, whereas they increased in the Wuchiapingian. The extremely low δ^{88}Sr value in seawater may reflect the increased dissolution of carbonates and/or reduced carbonate burial, i.e., enhanced carbonate weathering or suppression of reef building on shelf settings according to the coeval global sea-level drop.

Keywords: Permian, Sr isotope, carbonate

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Formation of stratiform manganese deposits during the Carnian (Late Triassic) “pluvial event” in the pelagic Panthalassa

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Stratiform manganese deposits have been reported from the Triassic bedded chert sequences in the Japanese accretionary complexes, which are considered to have accumulated in a mid–oceanic basin of the Panthalassa Ocean.However, their precise mineralization age and depositional environment remain poorly understood. In the present study, we investigated lithostratigraphy, conodont and radiolarian ages, and geochemistry of bedded cherts and chert-hosted manganese deposits from the Jurassic accretionary complexes (Chichibu, Mino–Tamba, and Northern Kitakami Belts) in Japan.
The studied sequences are classified into three to four lithostratigraphical units; lower bedded chert, massive chert, manganese ore (30-150 cm thick), and upper bedded chert units in ascending order. Radiolarian fossils from the lower bedded chert unit indicate the Early Carnian age, based on the occurrence of *Capnuchosphaera deweveri*and *C. triassica*, whereas the upper bedded chert unit contains Late Carnian radioralian species, including *Poulpus carcharus*and *Trialatus megacornutus*. Conodonts extracted from the upper bedded chert unit also include Late Carnian species, such as *Paragondolella praelindae*and*Metapolygnathus praecommunisti*. These occurrences of microfossils suggest that the sedimentary age of the manganese ores can be constrained from the late Early Carnian to early Late Carnian. Chemical compositions of the manganese ore are characterized by the enrichments in Mn and low concentrations of Co, Ni, and Zn. These geochemical features are similar to those in modern submarine hydrothermal manganese deposits. On the other hand, highly enrichments in V, Ni, Zn, U, and high U/Th ratio were recognized in the massive chert unit below the manganese ores, which indicate deposition under a reducing depositional environment.
Our biostratigraphic and geochemical analyses indicate that a redox state change from anoxic to oxic environments occurred in a pelagic deep seafloor in the late Early to early Late Carnian. This interval is known as a period of increased rainfall, named the Carnian Pluvial Event (CPE) in the western Tethys. CPE is characterized by the increased continental weathering which led to the increased nutrient flux and triggered the development of anoxia. It is likely that the Upper Triassic manganese deposits may have been formed during recovery from the reducing environment associated with the CPE.

Keywords: Stratiform manganese deposit, Triassic, Carnian Pluvial Event, Jurassic accretionary complex, Microfossil, Geochemistry

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Enrichment of chalcophile elements in Cretaceous–Paleogene boundary clays

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Cretaceous-Paleogene (K-Pg) boundary clays are enriched in chalcophile elements along with siderophile elements [1]. As elemental ratios of siderophile elements in the K-Pg boundary clays are very similar to chondritic values, the enrichment of siderophile elements in the K-Pg boundary clays results from the incorporation of meteorite condensates. On the other hand, it cannot be assumed that the chalcophile elements in the K-Pg boundary clays were supplied by meteorite condensates, because the ratios of chalcophile and siderophile elements in the K-Pg boundary clays, such as Zn/Ir, As/Ir, and Sb/Ir, are one to two orders of magnitude higher than those in chondrites. In this study, to elucidate the processes that could have contributed to the enrichment of chalcophile elements in the K-Pg boundary clays, we analyzed the chemical compositions of major and trace elements in the K-Pg boundary clays from Stevns Klint in Denmark.

The concentrations of major and trace elements in the K-Pg boundary clays varied among the collected samples even from neighboring outcrops. Cross plots of the concentrations of these elements suggested the mixing of three materials with different chemical compositions. The first component was enriched in all chalcophile elements and iron. The second component was depleted in chalcophile elements and enriched in calcium. The third component was enriched particularly in copper, silver, and lead. The first and third components included iridium that was obviously supplied at the K-Pg meteorite impact. Therefore, these two components were produced by phenomena related to the K-Pg meteorite impact. We propose that chalcophile elements were supplied to the K-Pg boundary clays by a combination of impact heating of the target rocks and intense acid rain following the impact.

Iron oxide/hydroxide grains with sizes of one to several tens of nanometers have been previously observed in the K-Pg boundary clays [2]. These likely condensed from the vapor plume that formed by impact heating at the K-Pg meteorite impact. These iron oxides/hydroxides could absorb chalcophile and siderophile elements from seawater. Such materials would have been converted to pyrites incorporating chalcophile elements under the reductive conditions on the seafloor. In addition, the correlations between the concentrations of chalcophile elements and soot have been observed in the K-Pg boundary clays [3]. This soot could have been produced by the impact heating of hydrocarbons in the target rocks. Bacterial sulfate reduction and subsequent pyrite production occur in reducing environments where hydrocarbon deposition occurs, thus resulting in the simultaneous accumulation of pyrite and hydrocarbons. Therefore, chalcophile elements accompanied by soot may have been released by impact heating of pyrite in the target rocks. Both chalcophile elements and iron, which were enriched in the first component, could have been provided by the impact heating of the target rocks.

Copper, silver, and lead, which were concentrated in the third component, are generally concentrated in acid soluble sulfides such as sphalerite and galena. Therefore, the third component was possibly supplied by intense acid rain after the K-Pg impact.

In summary, chalcophile elements in the K-Pg boundary clays comprises two components, one that is enriched in all chalcophile elements and another that is enriched particularly in copper, silver, and lead. These components were likely supplied by phenomena associated with the meteorite impact at the K-Pg boundary, such as the impact heating of the target rocks and intense acid rain.

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Geochim. Cosmochim. Acta 202, 231-263 [3] Gilmour and Anders (1989) Geochim. Cosmochim. Acta 53, 503-511

Keywords: meteorite impact, impact heating, acid rain

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Mass extinctions: hierarchy of causes and cosmoclimatological perspective

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This paper reviews possible causes proposed for the double-stepped extinction in regard of the current status of mass extinction studies. Causes of extinction can be grouped into four categories; from small to large scale, Caterogry 1 to Category 4. Category 1 –direct kill mechanism, Category 2 –global environmental change, Category 3 –trigger on the planet’ s surface, and Category 4 –ultimate cause. Among the Big-5 mass extinctions of the Phanerozic, two events in the Paleozoic, i.e.,the Hirnantian (Ordovician) and end-Guadalupian (Permian) events, show significant similarities in various aspects. Biological and non-biological aspects unique to these two distinct events include changes in biodiversity, isotope ratios (C, Sr *etc.*) of seawater, sea level, ocean redox state, episodic volcanism, and geomagnetism. In particular, the similar appearance of global cooling (Category 2) suggests the same cause and processes were likely responsible for the biodiversity drop. In addition to the most prevalent scenario of mantle plume-generated large igneous provinces (LIPs) (Category 3) for the end-Permian extinction, an emerging perspective of cosmoclimatology is introduced with respect to astrobiology. Galactic cosmic radiation (GCR) and solar/terrestrial responses in magnetism (Category 4) could have had a profound impact on Earth’ s climate, in particular, on extensive cloud coverage (irradiance shutdown). Furthermore, the star-burst events detected in the Milky Way Galaxy apparently coincide in timing with the cooling-associated major extinctions of the Phanerozoic and also with the Proterozoic snowball Earth episode. As an ultimate cause (Category 4) for major extinction, the episodic increase in GCR flux from the source (dark clouds derived from star-burst) against the geomagnetic shield likely determined the major climate changes, particularly global cooling in the past. The study of mass extinctions on Earth is entering a new stage with a new astrobiological perspective.

Keywords: mass extinction, global cooling, GCR, extinction cause

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Tue. May 28, 2019 9:00 AM - 10:30 AM JST | Tue. May 28, 2019 12:00 AM - 1:30 AM UTC | 303 3F

[M-IS10] Interface- and nano-phenomena on crystal growth and dissolution

convener:Yuki Kimura(Institute of Low Temperature Science, Hokkaido University), Hitoshi Miura(Graduate School of Natural Sciences, Department of Information and Basic Science, Nagoya City University), Hisao Satoh(Naka Energy Research Laboratory, Mitsubishi Materials Corporation), Katsuo Tsukamoto(Graduate School of Engineering, Osaka University), Chairperson:Yuki Kimura (Institute of Low Temperature Science, Hokkaido University)

Recent developments of observations in nano-scale opened a detail discussion concerning mechanisms of crystal growth and dissolution based on interface phenomena including dynamics. In this session, growth and dissolution mechanisms of crystals will be discussed focusing on interface phenomena of minerals in the fields of biological origin, global environment, planets and space in addition to general minerals.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[MIS10-01] Fabrication of octacalcium phosphate block through a dissolutionprecipitation reaction and its biological evaluation

*Yuki Sugiura[1], Munar L Melvin[2], Kunio Ishikawa[2] (1.National Institute of Advanced Industrial Science and Technology, 2.Kyushu University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[MIS10-02] Development of optimized incineration process of fisheries waste for synthesizing a functional heat storage material

*Hidekazu Kobatake[1], SHinji Kirihara[1] (1.Hirosaki University Institute of Regional Innovation)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[MIS10-03] “Manipulated” Organic Crystallization and Two-step Dissolution Process Attained by Plasmonic Optical Tweezers

*Hiromasa Niinomi[1], Teruki Sugiyama[2,3,4], Miho Tagawa[5], Toru Ujihara[5], Katsuhiko Miyamoto[6,7], Takashige Omatsu[6,7], Jun Nozawa[1], Junpei Okada[1], Satoshi Uda[1] (1.Institute for Materials Research, Tohoku University, 2.Department of Applied Chemistry, National Chiao Tung University, 3.Center for Emergent Functional Matter Science, National Chiao Tung University, 4.Division of Materials Science, Nara Institute of Science and Technology, 5.Institute of Materials and Systems for Sustainability (IMaSS), Nagoya University, 6.Molecular Chirality Research Center (MCRC), Chiba University, 7.Graduate School of Engineering, Chiba University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[MIS10-04] Investigation of liquid cell transmission electron microscopy combined with antisolvent crystallization

*Tomoya Yamazaki[1], Yuki Kimura[1] (1.Institute of Low Temperature Science Hokkkaido University)

10:00 AM - 10:30 AM JST | 1:00 AM - 1:30 AM UTC

[MIS10-05] DNA-guided crystallization of nanoparticles: optimization of crystallization conditions and structure analysis

★Invited Papers

*Miho Tagawa[1], Shoko Kojima[1], Hayato Sumi[1], Arisa Nishibu[1], Takumi Isogai[1], Maasa Yokomori[2], Shunta Harada[1], Toru Ujihara[1], Katsuo Tsukamoto[1] (1.Nagoya University, 2.The University of Tokyo)

Fabrication of octacalcium phosphate block through a dissolutionprecipitation reaction and its biological evaluation

*Yuki Sugiura[1], Munar L Melvin[2], Kunio Ishikawa[2]

1. National Institute of Advanced Industrial Science and Technology, 2. Kyushu University

Although octacalcium phosphate (OCP) powder and a collagen/gelatin composite demonstrate good potential as bone substitutes, an OCP block has not been fabricated to date. In this study, the feasibility of fabricating an OCP block was evaluated through a dissolution-precipitation reaction using a calcium sulfate hemihydrate (CSH) block as a precursor. When the block was immersed in a phosphate salt solution, its composition changed to that of OCP, while its structure was maintained. The diametral tensile strength (DTS) of the OCP block was 1.0 ±0.2 MPa. The macroporosity and microporosity of the OCP block were 33.4 ±4.5% and, 69.0 ±1.6%, respectively. New bone attached well to the OCP block, and this block was partially replaced by bone 2 weeks after implantation. Four weeks after implantation, the surface of the OCP block was nearly covered with new bone and ~30% of the block was replaced by new bone, while no replacement by bone was observed in the case of a hydroxyapatite (HAp) block used as a control. It is concluded that OCP blocks are potentially suitable for their use as artificial bone substitutes.

Keywords: Calcium phosphate, bone substitute, biomaterial

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Development of optimized incineration process of fisheries waste for synthesizing a functional heat storage material

*Hidekazu Kobatake[1], SHinji Kirihara[1]

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A part of fishery waste, such as scallops or oyster shells, are utilized for fertilizer, feed, soil conditioner, or fishing ground preparations, and most of the shells from aquaculture residue are incinerated as general waste at or above 1273 K using a huge amount of fuels and cost. And the most of the incineration products are used for a landfill disposal. For the establishing the sustainable fisheries industry and local community, the reduction of the incineration cost and utilization of the incineration products are indispensable. In this research, the incineration temperature of fisheries waste was examined for lowering incineration temperature. Addition to the investigation on the incineration temperature of fisheries waste, the properties of the calcium oxide derived from the fisheries waste as heat storage material was also evaluated based on the thermal analysis.

The samples used for thermal decomposition kinetics investigation are 2 species of shells (Scallop *Mizuhopecten yessoensis*, Oyster *Crassostrea gigas*), a spines of a sea urchin *Mesocentrotus nudus*, and calcite reagent (purity 99.95%). The surface deposits on these shells and spines are removed using a wire brush or tweezers, then washed by tap water. The cleaned samples were crushed in a porcelain mortar, then dried in an oven at 383 K. The dried powder particles were allied by their size using a sieve to sort in size in the range between 63 and 125 micron meter. The thermal incineration temperature was investigated using these samples.

Calcite reagent (purity 99.95%) the sorted, shells (Scallop, Oyster, Myoida *Hiatella orietalis*, and Tube worms *Dexiospira foraminosus*), and spines of Sea urchin were thermally decomposed for 1 hour at 1273 K to be converted to calcium oxide and then reacted with distilled water to prepare $Ca(OH)_2$. The thermal decomposition temperature of the $Ca(OH)_2$ of these samples was experimentally investigated for the evaluation of the incineration product as a heat storage material.

The prepared powder samples were put in a platinum container covered with Pt disk and then installed in a Differential Scanning Calorimetry. The samples were heated up with the temperature increasing rate from 5 K /min to 40 K /min in Ar atmosphere (99.9999%).

The thermal decomposition complete temperature is depending on the temperature increasing rate. As increase of the temperature increasing rate, thermal decomposition temperature of each samples became higher. The activation energy and frequency factor of the thermal decomposition were determined from the relation between thermal decomposition complete temperature and the temperature increasing rate. However, there is only 8% difference in the activation energies of thermal decomposition among the all samples. This result implies that the thermal decomposition kinetics is mainly controlled by the frequency factor.

Meanwhile the thermal decomposition temperature of the $Ca(OH)_2$ differs each other depending on the derived specimens. There is a weak positive correlation between the thermal decomposition temperature of calcite and calcium hydroxide. The shells and spines having lower thermal decomposition temperature have lower thermal decomposition temperature of calcium hydroxide. The incineration products from shells and spines have also better reaction property than that of derived from the calcite reagent.

These differences could be caused by the microstructures of the reagent, shells and spines. The adjustment of the particle size of shells during the firing can further reduce the reaction temperature and fuels and control the reaction property as a heat storage material.

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Keywords: Calcite, Shell, Thermal decomposition

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“Manipulated” Organic Crystallization and Two-step Dissolution Process Attained by Plasmonic Optical Tweezers

*Hiromasa Niinomi[1], Teruki Sugiyama[2,3,4], Miho Tagawa[5], Toru Ujihara[5], Katsuhiko Miyamoto[6,7], Takashige Omatsu[6,7], Jun Nozawa[1], Junpei Okada[1], Satoshi Uda[1]

1. Institute for Materials Research, Tohoku University, 2. Department of Applied Chemistry, National Chiao Tung University, 3. Center for Emergent Functional Matter Science, National Chiao Tung University, 4. Division of Materials Science, Nara Institute of Science and Technology, 5. Institute of Materials and Systems for Sustainability (IMaSS), Nagoya University, 6. Molecular Chirality Research Center (MCRC), Chiba University, 7. Graduate School of Engineering, Chiba University

Spatiotemporal control of crystallization from a solution is often required for detailed exploration on mechanism of early stage of crystallization because the stochastic nature of nucleation process hinders us to chase its early stage. Recently, laser trapping-induced crystallization technique has received increasing attention as a possible candidate to realize spatiotemporally controllable crystallization.[1] In the technique, the crystallization is induced by trapping molecular clusters in a solution with optical tweezers, in which dielectric tiny particles are captured by electrical field gradient force generated by tightly focusing laser light by optical lens. This technique has actually demonstrated forced nucleation of various organic molecules from an unsaturated mother solution at the focal spot. Although recent progress of nanoscience including research on nucleation dynamics demands precise manipulation of nanoscopic objects, the conventional optical tweezers, electrical field gradient force of which relies on the focusing the laser by optical lens, has a limitation of diffraction limit on focusing the light. To overcome the limit, the use of near-field generated by localized surface plasmon resonance, which is collective oscillation of free electrons on surfaces of metal nanoparticles when light impinges on the nanoparticle, has been proposed. [2] Because the near-field is confined in nanoscale, the light focusing beyond the diffraction limit can be achieved consequently, allowing us to capture the smaller particles much tightly than the conventional method. However, the plasmonic optical tweezers has never been applied to crystallization. Here we applied plasmonic optical tweezers to crystallization of acetaminophen molecule from an aqueous solution.

Figure 1 shows schematic illustration of experimental setup. Periodic Au nanolattice the unit structure of which is gammadion with the size of 500 nm was fabricated on a cover glass by electron beam lithography. An aqueous solution of acetaminophen saturated at room temperature (24^{o}C) was dropped on the Au nanolattice, and then solution thin layer supported by the nanolattice was formed by capillarity. Near-infrared continuous-wave left-handed circularly polarized laser (1064 nm, 6.4×10^{9} W/m^{2}) was focused to the nanolattice supporting the solution thin layer by passing through an objective lens equipped on an inverted polarized-light optical microscope. In-situ microscopic observation for the vicinity of the focal spot was also performed simultaneous with the laser irradiation.

Figure 2 shows time-lapse micrographs of the in-situ observation in the vicinity of the focal spot. After the laser irradiation, crystals with the size of 1000 ~ 2000 nm were precipitated 19 mm away from the focal spot in annular pattern. The position of the annular pattern moved while following the change of in-plane position of the focal spot via dissolution/precipitation process, indicating that position of the crystal is manipulatable. When the plasmon excitation by laser irradiation was stopped, the crystals were disappeared via two-step dissolution process; the crystals first transformed to dense liquid droplets, and then the dense droplet disappeared through molecular diffusion.

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Generally, large temperature gradient generates in the vicinity of the focal spot when localized surface plasmon resonance was excited, because of the heat generation through electron-phonon scattering. Thus, the large temperature gradient exerts thermophoretic force outward from the focal spot on acetaminophen molecules. Since the electrical field gradient force attracts the molecules towards the focal spot, the annular-patterned precipitation can be interpreted as the consequence of the balancing the electrical field gradient force as attractive force and the thermophoretic force as repulsive force. Therefore, our observation strongly suggested that plasmonic optical tweezers can precisely control crystallization.

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Keywords: Plasmonic Optical Tweezres, Crystallization of Organic Molecule, Two-step Dissolution Process

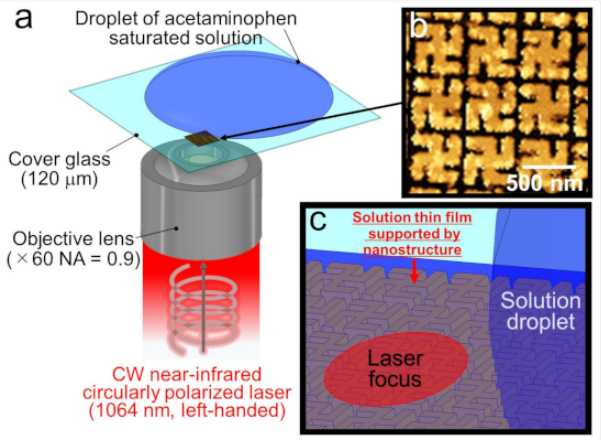


Figure 1 **a** Schematic illustration of the experimental setup **b** Atomic force microscopic image of the plasmonic Au nanolattice **c** Position of the laser focus.

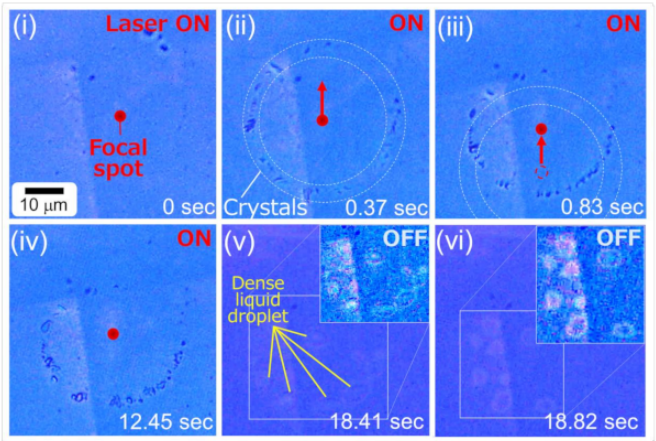


Figure 2 Time-lapse micrographs showing the dynamics of the plasmonic trapping-induced crystallization and the two-step dissolution process.

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Investigation of liquid cell transmission electron microscopy combined with antisolvent crystallization

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Crystallization of salts in solutions is a quite common phenomenon in the earth and is important not only for production of materials but also for understanding geochemical processes. However, initial stage of crystallization, called nucleation, is not fully understood and numerous studies to understand the process have been reported. Recently, multistep nucleation pathway, which formations of one or more metastable phases are required on the route to a formation of a crystalline phase, have been proposed. Liquid cell transmission electron microscopy (TEM) is a promising method for observing the nucleation process directly because the spatial resolution of this method is under nanometer scale. More recently, multistep nucleation pathways of the crystals of calcium carbonate [1] and lysozyme protein [2] have been revealed by liquid cell TEM. However, capturing a moment of a nucleation event is quite difficult because the observable area of the method is small ($< 100\ \mu m^2$) and a nucleation event is typically very rare in the tiny volume within the area. In order to observe nucleation events efficiently, a supersaturation of a sample solution should be increased with observing the solution. To create the situation, we applied the anti-solvent crystallization technique, which crystallize the solute to add the solvent with the extremely low solubility of the solute (anti-solvent), to liquid cell TEM and tried to observe the nucleation event of a salt crystal.

We used the TEM holder (Poseidon 300, Protochips Inc.) and the liquid cells of silicon chips equipped with thin silicon nitride windows. Aqueous solution of sodium chlorate under equilibrium at room temperature was enclosed in the liquid cell. The TEM holder has two injection ports of liquid, and one of the ports was filled by acetone as the anti-solvent of sodium chlorate. After starting the observation of the sample solution, acetone was injected by syringe pump for mixing the aqueous solution in the liquid cell.

Using the methods, we succeeded in observing the nucleation events of crystals. In this presentation, we will report the detailed analysis of crystals and the nucleation processes.

Acknowledgement

This work was supported partly by Grant for Basic Science Research Projects from The Sumitomo Foundation (Grant Number 170738) and JSPS KAKENHI Grant Numbers JP15H05731 and JP18J01470. T.Y. is grateful for the JSPS Research Fellowship for Young Scientists.

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Keywords: liquid cell transmission electron microscopy, crystal growth, solution growth, anti-solvent crystallization

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DNA-guided crystallization of nanoparticles: optimization of crystallization conditions and structure analysis

*Miho Tagawa[1], Shoko Kojima[1], Hayato Sumi[1], Arisa Nishibu[1], Takumi Isogai[1], Maasa Yokomori[2], Shunta Harada[1], Toru Ujihara[1], Katsuo Tsukamoto[1]

1. Nagoya University, 2. The University of Tokyo

Due to the programmability and self-assembly characteristic, DNA is a powerful tool for guiding the assembly of nanometer-sized particles into large-scale ordered structures. Recently, DNA-guided nanoparticle crystallization has been demonstrated and many types of crystal structures have been created[1-3]. By changing particle size ratio, DNA length and complementarity, particles assemble into different types of crystals. By TEM imaging after silica encapsulations, Mirkin et al. confirmed that some of DNA-guided nanoparticle crystals assembled into wulff polyhedra in solution[3]. However, it is crucially difficult to grow large-scale wulff polyhedral single crystal of DNA-functionalized nanoparticles (DNA-NPs) with size up to several microns. Herein, we demonstrate the optimization of solution composition on DNA-NP crystal growth, specifically the effect of sodium chloride concentration and polyethylene glycol (PEG) addition into DNA-NP colloidal solution.

Au nanoparticles of diameter 7 nm were functionalized with two different sequenced thiolated-DNA strands (DNAa and DNAb), respectively. These DNA-functionalized nanoparticles, DNA-NPa and DNA-NPb, were combined with linker DNA strands, which hybridize to complementary sequences of DNAa and DNAb (Figure 1). The mixed solutions were adjusted under different sodium chloride concentration (100, 300, 500, 700 and 900 mM) and by adding PEG with different molecular weights (1000, 4000 and 8000) and subsequently heated to 65 ºC and then slowly cooled back to 25 ºC. The crystal structure of assembled DNA-NP superlattices were analyzed by small angle x-ray scattering (SAXS) and imaged by scanning electron microscope (SEM).

We confirmed the crystal structure of assembled DNA-NP aggregates was bcc by analyzing peak positions of SAXS 1D curves. The differences were seen in SAXS and SEM data with different samples under different sodium chloride concentrations. Relatively large wulff polyhedral single crystals of DNA-NP superlattices were assembled in buffer solution under 500 mM NaCl. The significant differences were seen in SAXS and SEM data with different samples by adding PEG with different molecular weights. DNA-NP superlattices assembled in the buffer solution with PEG 1000 showed a clear SAXS 1D curve which indicates bcc structure (Figure 2) and a significant increase in average crystal size were confirmed by SEM (Figure 3).

We will also present the recent progress on the formation of lattice using DNA-NPs linked by DNA polyhedral constructs. DNA polyhedron has symmetrical connecting bonds and plays a determining role in the inter-particle bonding; that allows for control of particles coordination. DNA nanostructure-directed crystallization has a power of the proposed approach for assembly of complex nanoparticle lattices[4].

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Keywords: DNA, Nanoparticles, SAXS, colloidal crystallization

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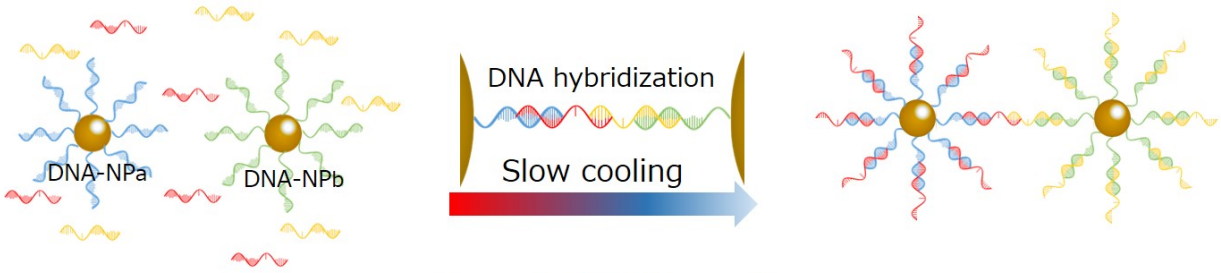


Figure 1. DNA-NP assembly

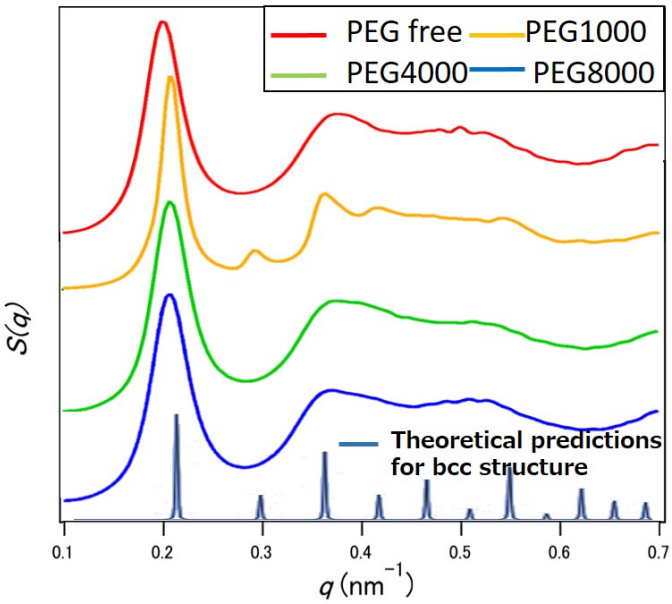


Figure 2. SAXS analysis of DNA-NP aggregates with PEG of different weights as additives

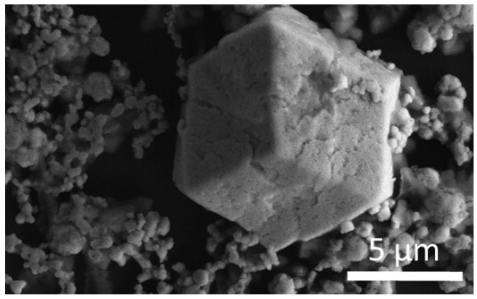


Figure 3. SEM image of DNA-NP superlattice

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Tue. May 28, 2019 10:45 AM - 12:15 PM JST | Tue. May 28, 2019 1:45 AM - 3:15 AM UTC | 303 3F

[M-IS10] Interface- and nano-phenomena on crystal growth and dissolution

convener:Yuki Kimura(Institute of Low Temperature Science, Hokkaido University), Hitoshi Miura(Graduate School of Natural Sciences, Department of Information and Basic Science, Nagoya City University), Hisao Satoh(Naka Energy Research Laboratory, Mitsubishi Materials Corporation), Katsuo Tsukamoto(Graduate School of Engineering, Osaka University), Chairperson:Hisao Satoh

Recent developments of observations in nano-scale opened a detail discussion concerning mechanisms of crystal growth and dissolution based on interface phenomena including dynamics. In this session, growth and dissolution mechanisms of crystals will be discussed focusing on interface phenomena of minerals in the fields of biological origin, global environment, planets and space in addition to general minerals.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MIS10-06] Growth mechanism of binary colloidal crystals

*Jun Nozawa[1], Suxia Guo[1], Hiromasa Niinomi[1], Junpei Okada[1], Satoshi Uda[1] (1.Tohoku University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MIS10-07] Solution-Mediated-Transformation Kinetics of Norsethite

*Harutoshi Asakawa[1], Hiroshi Uneda[1], Itaru Echigo[1], Ryuichi Komatsu[1] (1.Graduate School of Sciences and Technology for Innovation Yamaguchi University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MIS10-08] Formation of low-crystalline magnesium silicate in natural alkaline environment and flow-through experiments

*Yuto Nishiki[1], Misato Shimbashi[1], Tsutomu Sato[2], Tsubasa Otake[2] (1.Graduate School of Engineering, Hokkaido University, 2.Faculty of Engineering, Hokkaido University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MIS10-09] Homogeneous Nucleation from Vapor in Al-O Binary System

*Shinnosuke Ishizuka[1], Jun Kawano[2], Tomoya Yamazaki[3], Tetsuya Hama[3], Yuki Kimura[3] (1.National Institute for Environmental Studies, 2.Faculty of Science, Hokkaido University, 3.Institute of Low Temperature Science, Hokkaido University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MIS10-10] Crystal growth hysteresis in birth-and-spread mechanism

*Hitoshi Miura[1] (1.Graduate School of Natural Sciences, Department of Information and Basic Science, Nagoya City University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

Discussion

Growth mechanism of binary colloidal crystals

*Jun Nozawa[1], Suxia Guo[1], Hiromasa Niinomi[1], Junpei Okada[1], Satoshi Uda[1]

1. Tohoku University

Colloidal crystals have been attracted great attention from wide application fields owing to their unique optical properties. Now, varieties structures of the colloidal crystal, e.g. non-closed packed structure, are significantly demanded for diverse applications. For this ends, to grow binary colloidal crystal is promising method since it displays rich structural diversity. However, in contrast to single component system, growth mechanism of binary system of colloidal crystals is poorly understood. Also, to grow large size of binary colloidal crystals with high crystallinity is still difficult. In this study, in-situ observation is conducted to reveal detailed growth process of binary colloidal crystals. Then, growth mechanism is discussed.
Polystyrene particles are employed in the experiment. Green fluorescent particles with 500 nm and red with 700 nm are employed. Crystallization of colloidal crystals is induced by depletion attraction.
We have found several features on the growth of binary colloidal crystals. First, it grows on substrate. The AB_2 structure (A: 700 nm, B: 500 nm) is found to be grown by utilizing crystals composed only of 700 nm particles. The AB_2 crystals also grow on crystals of 500 nm. The specific crystallographic orientations between those crystals are recognized. Combination of orientations between AB_2 and substrate are classified into four types. Heteroepitaxial growth is found to occur for growth of AB2 structure. Second, growth rate of binary colloidal crystals is quite small compare to that of single component system under the same particle concentration. We think this is attributed to complex structure of the crystals, which requires each particle incorporating to their own site. This process is not required for crystals composed of single component. Third, cluster formation at the interface is recognized. The ordered structure composed only of 500 nm is formed at growing interface. Particles of 700 nm is incorporated into the ordered structure generates AB_2 structure.
These observations provide great hints to reveal overall growth mechanism of binary colloidal crystals, which will lead to establish sophisticated growth technique to grow large and high quality crystals.

Keywords: Colloidal crystal, Crystal growth

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Solution-Mediated-Transformation Kinetics of Norsethite

*Harutoshi Asakawa[1], Hiroshi Uneda[1], Itaru Echigo[1], Ryuichi Komatsu[1]

1. Graduate School of Sciences and Technology for Innovation Yamaguchi University

We investigated the induction periods of norsethie and withelite by polarized optical microscopy, X-ray diffraction measurements, pH measurements, inductively coupled plasma measurements and total organic carbon measurements. In this talk, we will show features of the solution-mediated-transformation kinetics of norsethite from the relation between nucleation rate and supersaturation.

Keywords: Norsethite, Solution-mediated transformation

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Formation of low-crystalline magnesium silicate in natural alkaline environment and flow-through experiments

*Yuto Nishiki[1], Misato Shimbashi[1], Tsutomu Sato[2], Tsubasa Otake[2]

1. Graduate School of Engineering, Hokkaido University, 2. Faculty of Engineering, Hokkaido University

INTRODUCTION

Magnesium silicate formation at low temperature (25-200℃) is receiving a lot of attention in various research fields. Sepiolite and serpentine, crystalline Mg-clay minerals, are known to be formed in MgO-SiO_2-H_2O systems at low temperature. However, some studies have been suggesting that low-crystalline magnesium silicate recently should be formed in this low-temperature condition. These kinds of low-crystalline silicates have actively been studied by many reaserchers and engineers. For instance, calsium and alminium silicates are known as C-S-H (calcium silicate hydrate) and allophane/imogolite, respectively. These are studied for both natural minerals and synthesized materials. On the other hand, studies of the low-crystalline magnesium silicate are still in their infancy and little is known. Therefore, the nature of the low-crystalline magnesium silicate has not been clear yet. Since the magnesium silicate can be utilized in various engineering fields (e.g., improved oil recovery, CO_2 geological storage, geothermal power generation, concrete degradation, mineral clogging in radioactive waste disposal, treatment of environmental pollutions, etc.), the current reserch gaps in the understanding of the low-crystallline magnesium silicate formation need to be addresed so as to contribute positively to the above engineering technologies. Moreover, this study can also be applied to the field of planetary science because low-crystalline magnesium silicate should be observed even on surface of Mars and in interstellar silicate dusts.

ANALYSES OF NATURAL PRODUCTS

Firstly, this study confirmed that low-crystalline magnesium silicate forms in nature. Samples of precipitates were collected from the surface where fluid flows out from serpentinite rocks around Kamuikotan metamorphic belts, Hokkaido, Japan. Although a clear XRD pattern from the bulk samples was not observed, electron microscopy (Field emission scanning electron microscope and Transmission electron microscope; TEM) clearly identified the phase. TEM-energy dispersive X-ray spectrometry indicated that the low-crystalline phase was composed of Mg, Si, and O. Moreover, electron diffraction with TEM showed diffuse halo rings from some particles in the samples, showing the formation of low-crystalline phase. Furthermore, the fluid samples participating in formation of the precipitates were collected and analyzed. From the results, the fluid samples were alkaline ($9.50 < pH < 10.67$) and saturated with low-crystalline magnesium silicate phase (magnesium silicate hydrate reported by Lothernbach et al., 2018).

FLOW-THROUGH EXPERIMENTS

Secondly, to demonstrate the above formation, flow-through experiments in open system were conducted. Alkaline solution with 1.5 mM of dissolved silica was flowed into MgO powder in the reaction cell. TEM observation revealed the low-crystalline magnesium silicate formation as well. Moreover,

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dissolution rate of Mg-bearing mineral and formation rate of magnesium silicate were obtained from dissolved silica and magnesium concentrations in the output solutions. These suggested that the magnesium silicate formation was extremely rapid under the oversaturated condition, and that the dissolution of Mg-bearing mineral is the rate-determining step during formation of the low-crystalline magnesium silicate. Although the flow-through experiments used only MgO as a Mg-bearing mineral, the above discussion can be applied to all of Mg-bearing minerals such as olivine and pyroxene because dissolution rate of MgO is greater than any other Mg-bearing minerals. Therefore, the flow-through experiments broaden the kinetical understanding of low-crystalline magnesium silicate formation not only at the Kamuikotan metamorphic belts, but also to other areas where the magnesium silicate is formed from the supply of Mg-bearing minerals in rocks/soil.

Keywords: Magnesium silicate, Transmission electron microscope, Kinetics, Kamuikotan metamorphic belts, Serpentine, Thermodynamic calculation

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Homogeneous Nucleation from Vapor in Al-O Binary System

*Shinnosuke Ishizuka[1], Jun Kawano[2], Tomoya Yamazaki[3], Tetsuya Hama[3], Yuki Kimura[3]

1. National Institute for Environmental Studies, 2. Faculty of Science, Hokkaido University, 3. Institute of Low Temperature Science, Hokkaido University

A gaseous molecule can have a chemical formula that is inconsistent with its ability to act as a building block for crystals; for example, hot AlO and AlO_2 vapors cannot solidify directly to crystals. The contributions of such gases to homogeneous nucleation processes are unknown. Using in situ IR spectroscopy on nucleating nanoparticles, we show that a liquid-like behavior of nucleating nanoparticles in the Al–O system induces immiscible phase segregation. In an oxygen-deficient atmosphere, aluminum oxide nanoparticles formed with a unique shape composed of an Al metal head and an anisotropic Al_2O_3 crystalline tail. The anisotropic nanoparticles are larger than Al_2O_3 nanoparticles formed in a sufficient oxygen condition. Fewer nuclei may be available in the supersaturated gas, indicating that homogeneous nucleation is initiated by oxygen-bearing species. The nuclei grow by incorporation of Al-bearing species, changing the composition of the particle as a whole toward an Al-rich material. In situ IR measurements revealed that the degree of anisotropy continues to increase, suggesting that oxygen-bearing species also formed by oxidation on the surface of the molten Al-rich head. The scenario is supported by quantum-chemical calculations indicating that oxygen-deficient $(AlO)_n$ clusters as few as 16 molecules induce aggregation of Al atoms. Because Al metal has a significantly lower melting temperature than Al_2O_3, the immiscibility of the nucleating nanoparticles leads to vapor–liquid–solid growth. Astronomical implication will be given in the presentation.

Keywords: Homogeneous Nucleation, Cosmic Dust

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Crystal growth hysteresis in birth-and-spread mechanism

*Hitoshi Miura[1]

1. Graduate School of Natural Sciences, Department of Information and Basic Science, Nagoya City University

Crystal growth hysteresis is a remarkable phenomenon induced by impurities: the crystal growth velocity when the driving force (supersaturation or supercooling) is increased is different from that when it is decreased. It has been considered that the growth hysteresis is caused by slow adsorption of impurities onto the crystal surface. On the surface, there are steps in atomic scale that advance independently due to continuous incorporations of growth units, therefore the surface is grown layer by layer (layer-by-layer growth mechanism). The step advancement is inhibited by impurities adsorbed on the surface. However, the amount of the adsorbed impurities is also affected by the step passages: frequent step passages reduce the amount of adsorbed impurities. The competition between two timescales —impurity adsorption timescale and time interval of surface-updating (terrace exposure time)— causes complex nonlinear phenomena such as crystal growth hysteresis.

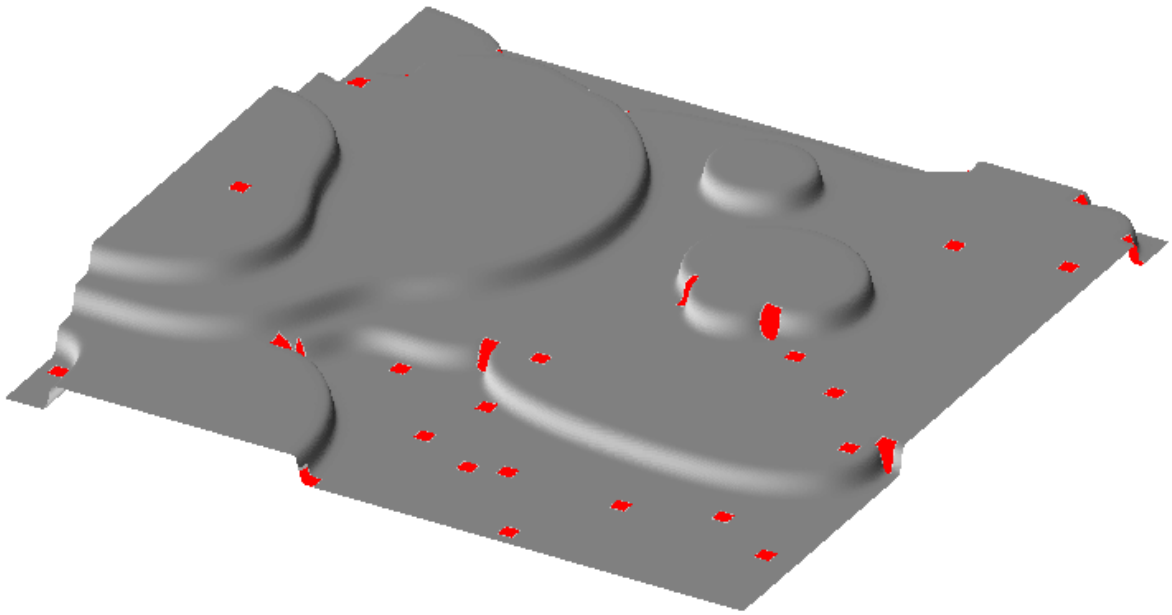
The mechanism of the crystal growth hysteresis was elucidated by a mean field theory. Punin & Artamonova [1] and Miura & Tsukamoto [2] formulated the following two effects —inhibition of step advancement by adsorbed impurities (pinning effect) and removal of adsorbed impurities by step passages (impurity sweeping)— to clarify the existence of multiple steady solutions that satisfies both of two formulas at a certain range of supersaturation. In the case of constant step interval, numerical simulations based on a phase-field method demonstrated that the growth hysteresis emerges as predicted by the mean field theory even when the physical quantities are fluctuated around these averages [3]. The phase-field simulations also confirmed the emergence of hysteresis in the case that the surface is grown by a screw dislocation [4]. However, the growth hysteresis has not been investigated in the case that the surface is grown by two-dimensional nucleation (birth-and-spread mechanism), which is another mechanism to generate new steps on the surface. The birth-and-spread growth dominates the spiral growth at high supersaturation, so it is important to elucidate the impurity-induced effect for that. In this study, we theoretically investigate the growth hysteresis in the birth-and-spread growth mechanism.

At first, we formulated the interdependence between the step velocity and the amount of adsorbed impurities based on the mean field theory, in the same way in the case of the spiral growth. As the result, we found that multiple steady solutions exist at a certain range of supersaturation. This suggests that the growth hysteresis can emerge even in the birth-and-spread growth in principle. At second, we carried out the phase-field calculation with the equivalent condition of the mean field theory. We confirmed the emergence of growth hysteresis in down-and-up cycles of supersaturation. In addition, we found that the range in supersaturation at which the growth hysteresis is observed depends on the rate of supersaturation variation: slow change in supersaturation makes the hysteresis behavior unclear.

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Keywords: Crystal growth, Step dynamics, Impurity effect, Phase-field method



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[J] Oral | M (Multidisciplinary and Interdisciplinary) : M-IS Intersection

Tue. May 28, 2019 9:00 AM - 10:30 AM JST | Tue. May 28, 2019 12:00 AM - 1:30 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[M-IS11] Aqua planetology

convener:Yasuhito Sekine(Earth-Life Science Insitute, Tokyo Institute of Technology), Tomohiro Usui(Earth-Life Science Institute, Tokyo Institute of Technology), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Takazo Shibuya(Japan Agency for Marine-Earth Science and Technology), Chairperson:Yasuhito Sekine(Dept. Earth & Planetary Sci., University of Tokyo), Takazo Shibuya(JAMSTEC), Tomohiro Usui

This proposed session covers a wide range of topics related to aqua planetology, including chemical reactions involving water on planetary bodies, water-rock reactions within planetesimals, distribution of water in the early Solar system and the origin of water on terrestrial planets, hydrological and biogeochemical processes on Earth, geochemical cycles and habitability on Mars and icy moons, exploration of water in the solar system, and theory to understand how to build a habitable aqua planet.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[MIS11-13] A forward modeling of infrared reflectance spectra of asteroids

*Hiroyuki Kurokawa[1], Takazo Shibuya[2], Yasuhito Sekine[1], Bethany L Ehlmann[3,4] (1.ELSI, Tokyo Tech, 2.JAMSTEC, 3.Caltech, 4.JPL)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[MIS11-14] Estimation of formation mechanism and morphological condition in calcite concretion

*Takayuki Ihara[1], Sin-iti Sirono[1] (1.Nagoya University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[MIS11-15] Reconstructing groundwater hydrology and water-rock reactions around Gale Crater on early Mars

*Natsumi Noda[1,2], Yasuhito Sekine[1], Shuya Tan[1,2], Takazo Shibuya[3], Hidenori Genda[1] (1.Earth-Life Science Institute, Tokyo Institute of Technology, 2.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 3.Department of Subsurface Geobiological Analysis and Research, Japan Agency for Marine-Earth Science and Technology)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[MIS11-16] Habitable zone for a land planet

*Takanori Kodama[1], Hidenori Genda[2], Ryouta O'ishi[3], Ayako Abe-Ouchi[3] (1.University of Bordeaux, 2.Earth-Life Science Institute, Tokyo Institute of Technology, 3.Atmosphere and Ocean Research Institute, University of Tokyo)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[MIS11-17] A study on the dependence of ocean planet climate on solar constant: influence of oceanic heat transport in the case of large absorption coefficients of gray atmosphere

*Yuta Kawai[1,2], Yoshiyuki O. Takahashi[1], Masaki Ishiwatari[5], Kensuke Nakajima[3], Shin-ichi Takehiro[4], Hiroki Kashimura[1,6], Seiya Nishizawa[2], Hirofumi Tomita[2], Yoshi-Yuki Hayashi[1,6] (1.Kobe University, 2.RIKEN Center for Computational Science, 3.Kyusyu University, 4.Kyoto University , 5.Hokkaido University, 6.Center for Planetary Science)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[MIS11-18] Water cycle and its evolution: High-speed H_2O transport to upper atmosphere on Mars

★Invited Papers

*Hiromu Nakagawa[1], Shohei Aoki[1], Nao Yoshida[1], Naoki Terada[1], Takeshi Imamura[2], Kazunori Ogohara[3], Toru Kouyama[4], Hiroki Ando[6], Katsuyuki Noguchi[5], Akiho Miyamoto[1], Kosuke Takami[1], Isao Murata[1], Yasumasa Kasaba[1], IUVS team MAVEN (1.Planetary Atmosphere Physics Laboratory, Department of Geophysics, Graduate School of Science, Tohoku University, 2.Graduate school of Frontier sciences, University of Tokyo, 3.University of Shiga prefecture, 4.The National Institute of Advanced Industrial Science and Technology, 5.Nara Women's university, 6.Kyoto Sangyo university)

A forward modeling of infrared reflectance spectra of asteroids

*Hiroyuki Kurokawa[1], Takazo Shibuya[2], Yasuhito Sekine[1], Bethany L Ehlmann[3,4]

1. ELSI, Tokyo Tech, 2. JAMSTEC, 3. Caltech, 4. JPL

The mineral assemblages on asteroids are useful to constrain the aqueous environments, the temperature (T), pressure (P), water to rock ratio (W/R), and bulk chemical composition, existed in them or in their parent bodies. Near- to mid-infrared (IR) reflectance spectroscopy of asteroids contains the information of the surficial minerals in their characteristic absorption features, spectral slopes, and overall brightness or darkness. Recent remote-sensing of asteroids by Hayabusa2, OSIRIS-Rex, and Dawn spacecrafts as well as telescopic observations by AKARI infrared space telescope provided detailed IR reflectance spectra of many types of asteroids. These observations would allow us to discuss the diversity of asteroids in their principle parameter space of paleo-aqueous environments: T, P, W/R, and the bulk chemical compositions. This study aims to connect the observed IR spectra of asteroids to the original bulk compositions and T-Pconditions of them or their parent bodies. We performed a series of chemical equilibrium calculations to obtain the mineral compositions. We computed the model IR reflectance spectra from the obtained mineral compositions. The chemical equilibrium calculations assumed the rocky bulk compositions of CV chondrites. We treated W/R as a parameter (0.2-10). We fixed the relative abundance of volatiles to water. The model IR reflectance spectra were calculated by adopting the radiative transfer theory for granular surfaces. The reflectance of a model mineral assemblage was computed from the weighted average of the single scattering albedos (SSAs) of endmembers. We found that the model reflectance spectra vary according to the equilibrium mineral compositions. Reducing W/R led to the darkening in overall reflectance as the dominant minerals change from bright carbonate to serpentine, gibbsite, and dark phases: pyrite, troilite, magnetite, and organics. The change in the dominant phase is visible in the characteristic absorption features: carbonate at 3.5 micro m and 4.0 micro m and serpentine at 2.7-2.8 micro m. We note that, though carbonate has a broad absorption from 2.7 to 3.2 micro m, the absorption feature of serpentine is sharp and distinguishable.Ammonia-bearing saponite more than a few wt.% shows its characteristic absorption feature at 3.1micro m in the reflectance of mixture. In this presentation, we discuss the implications for Haybusa2 and AKARI observation results.

Keywords: Asteroids, Near-infrared spectra

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Estimation of formation mechanism and morphological condition in calcite concretion

*Takayuki Ihara[1], Sin-iti Sirono[1]

1. Nagoya University

Iron oxide concretions were discovered on Meridiani plain by Mars explorer opportunity. The concretion found on Mars is called blueberry, it is spherical and the composition is mainly iron oxide. Concretions similar to them are found on the Navajo sandstone stratum in the United States of Utah , and is Gobi Desert, Mongolia. They are called Fe-oxide concretion. Both Fe-oxide concretion and blueberry have a spherical shell structure of iron oxide. [1] performed field work and analyzed element maps to investigate the mechanism of formation of Fe-oxide concretion of Utah and Gobi. As a result, [1] showed the formation mechanism of spherical Fe-oxide concretion as follows. In an eolian layer spherical calcite concretions were formed as a precursor. Second, acidic groundwater containing iron ions flows into it and reacts with $CaCO_3$ and iron precipitates in a spherical shell shape. Furthermore, [1] indicated that the iron contraction of Mars is a similar mechanism. However, the formation mechanism of spherical calcite concretion as a precursor is not known. If we can clarify the formation mechanism, we can restrict the ancient environment of Earth and Mars.

In this study, we focused on calcite concretion produced in an eolian layer. Calcite concretion of the eolian layer is produced in three forms, spherical, plate-like, fish egg (globular gathering state). It is aimed to clarify the forming mechanism and the forming conditions in indoor experiments. We will report the current experiment status. $CaCO_3$ is precipitated by evaporation in Utah's sand. In order to increase the solubility of the $CaCO_3$ aqueous solution, CO_2 is blown into the solvent. $Ca(HCO_3)_2$ is made in the solvent. By evaporating it $CaCO_3$ is precipitated in the layer of sand to generate a concretion. Then $Ca(HCO_3)_2$ is made in the solvent. It evaporates to precipitate $CaCO_3$ in the layer of sand.Utah's sand has an average particle diameter of 150 μm (Kawakami 2015). The minimum size of calcite concretion and Fe-oxide concretion discovered on Earth is several mm in diameter [2] and experiments are conducted with the aim of creating the size. $CaCO_3$ concentration and evaporation rate are changed as parameters. X-ray CT is used to analyze $CaCO_3$ in the experimental layer. In order to investigate whether $CaCO_3$ and sand can be distinguished from X-ray CT images, a experiment was conducted when $CaCO_3$ precipitated in the sand layer. The simulated sample was prepared by mixing sand from Navajo sandstone and a few mg of $CaCO_3$. As a result of the X-ray CT experiment, it was confirmed that a $CaCO_3$ having a size of 0.50 mm can be discriminated at a resolution of 0.019mm/pixel. It was also found that $CaCO_3$ and sand are close in density, so it can not be determined that $CaCO_3$ is not sufficiently larger than the average particle diameter of sand 150μm.

In the future, we will analyze the samples prepared in the experiment and try experiments under various conditions by adding experimental parameters as well as $CaCO_3$ concentration, evaporation rate and sand filling rate. Then we will clarify the formation mechanism and the morphological condition of calcite concretion in the eolian layer.

[1] Yoshida et al.(2018) Science Advances Vol.4, no.12;[2]Sally Latham Potter.2009 Chracteization of navajo sandstone hydrous ferric oxide concretions

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Keywords: Spherical calcite concretion

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Reconstructing groundwater hydrology and water-rock reactions around Gale Crater on early Mars

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NASA's Mars Science Laboratory Rover, Curiosity, has provided key information on geochemistry and mineralogy of the lacustrine sediments deposited within Gale Crater on early Mars(e.g. Grotzinger et al. 2015, Rampe et al. 2017). Gale's lacustrine mudstones of Murray Formation are characterized by authigenic depositions of high levels of silica (e.g., opal CT and amorphous silica) together with iron oxides (e.g., magnetite and hematite), suggesting inputs of dissolved SiO_2 and Fe^{2+} into the early Gale lake (Hurowitz et al. 2017). One possible source of dissolved SiO_2 and Fe^{2+} is upwelling groundwater. However, little is known about the conditions of both climate and water table capable of upwelling groundwater into Gale Crater. Additionally, the chemical compositions of groundwater on early Mars, particularly the determining factors of concentrations of dissolved SiO_2 and Fe^{2+}, have been poorly constrained.

Here, we perform both hydrological modeling and hydrothermal experiments to interpret the observations. Based on the simulation and experimental results, we discuss the climate, groundwater hydrology, and input fluxes of dissolved SiO_2 and Fe^{2+} of Gale lakes.

In the hydrological modeling, we perform three-dimensional hydrological simulations for the area surrounding Gale Crater using GETFLOWS, which deals with fully-coupled surface and subsurface flows based on the hydro-geophysical equations. We find two modes of the lake distribution and groundwater flow around Gale. One is the high-evaporation mode where multiple shallow lakes can appear at local topographic lows owing to vigorous upwelling of groundwater under (semi-)arid climate conditions. The other is the low-evaporation mode where lake(s) exists only at the lowest place(s) under relatively humid climate conditions. To explain both a closed-basin lake within Gale Crater and some lakes around Gale, the high-evaporation mode is most likely to have occurred on early Mars. Our results suggest (semi-)arid climate conditions around Gale with a shallow water table. Under the arid climate conditions, evaporation of lake water would have caused effective upwelling of groundwater. Given thermal gradient within the crust, such upwelled groundwater would have experienced hydrothermal reactions with the crustal rocks.

In the hydrothermal experiments, we simulate high-temperature water-rock reactions between groundwater and Martian crustal rocks. Hydrothermal reactions at 200ºC between a synthesized Martian rock analog and fluids are performed using a Dickson-type apparatus. Various secondary minerals, such as analcime, quartz, albite, Fe(Mg-)saponite, Fe(Mg-)serpentine, and trace carbonates are also formed via the hydrothermal reactions. We find that dissolved SiO_2 concentration (1–10 mM) is buffered by dissolution of quartz; whereas, that of Fe^{2+} (~10^{-3} mM) is likely controlled by dissolution of Fe-carbonate (siderite).

Combining these simulation and experimental results, we estimate the input fluxes of dissolved SiO_2 and Fe^{2+} contained in upwelled groundwater into Gale lakes. The flux of dissolved SiO_2 corresponds to ~0.02–0.2 mm/year of the deposition rate of silica, implying that the parallel laminae of the lacustrine

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mudstone(Grotzinger et al. 2015) may be varve. This further suggests ~10^5 years of warming periods to explain the thickness of Murray Formation. Upwelling groundwater might have also provided Fe^{2+} into the lake, leading to formations of Fe oxides and H_2. Our results suggest that low-latitude deep craters, including Gale, would have played key roles in upwelling deep groundwater at arid climates in the global hydrological cycles, providing reductants and greenhouse effect gas to the surface of early Mars.

Keywords: Mars, Hydrothermal experiment, hydrologic model

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Habitable zone for a land planet

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Most of the studies for habitable planets have focused on Earth-like planets with globally abundant water on the planetary surface. Liquid water vaporizes entirely when planets receive the insolation above a certain critical value, which is called runaway greenhouse threshold. On the other hand, the planetary climate state lapses into a snowball state when planets receive insolation below a certain value, which is called the complete freezing threshold. The habitable zone, in which planets can maintain liquid water on their surface for a long term, is determined by these thresholds.

Abe et al. (2011) focused on so-called land planets with a very small amount of water, and investigated these thresholds using a three-dimensional general circulation model. As results, they found that land planets have a wider habitable zone than Earth-like planets have. However, it is not enough to understand the relationship between the distribution of water and the climate because their range of the amount of water is extremely narrow, leading the almost same distribution of liquid water on the planetary surface.

We assumed various types of the surface water distribution, and investigated the effect of those on both the runaway greenhouse threshold and the complete freezing threshold for Earth-sized planets using a three-dimensional general circulation model. We consider the surface water distributions as longitudinally uniform water distribution and a 1-bar atmosphere whose composition is similar to the current Earth’s atmosphere. As results, both thresholds change gradually depending on the distribution of surface water. Additionally, they are dominated by the atmospheric circulation which determines the surface condition.

Keywords: Land planet, Habitable zone

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A study on the dependence of ocean planet climate on solar constant: influence of oceanic heat transport in the case of large absorption coefficients of gray atmosphere

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1. Introduction

In order to reveal the diversity of climate realized on planets with water and climate stability, our research group has been exploring climates on idealized planets. Ishiwatari et al. (2007) (INTH07) investigated solar constant dependence of climates on swamp ocean planet using a 3-dimensional atmospheric general circulation model, although oceanic heat transport is not considered. Since oceanic heat transport also affects planetary climates, for example, Rose (2015) (R15) explored climates on a planet globally covered with ocean (referred to as “ ocean planet”, here) with a coupled atmosphere-ocean-sea ice model, and showed the importance of oceanic heat transport for the climates. Recently, as an extension of INTH07, we also have investigated solar constant dependence of ocean planet climates with our coupled model. Representing ocean general circulation obviously changes atmospheric fields. However, the displacement of ice-line is small and there is no qualitative change of climate regime diagram which represents the relation between solar constant and ice-line latitude. We imagine the reason is that the variation of temperature with solar constant in partially ice-covered states obtained from gray radiation setting of INTH07 is quite smaller than that in R15. Therefore, we perform further experiments in the case of large absorb coefficients. In this presentation, the experimental results will be shown.

2. Model and Experimental setup

The model used here is our constructing coupled atmosphere-ocean-sea ice model. The atmosphere model is DCPAM, in which the 3-dimensional primitive equations are solved. Most of the atmospheric setting is same as that in INTH07, except absorb coefficients of water vapor and dry air in the gray radiation scheme are replaced with larger values, 1×10^{-1} and 1×10^{-5} [m^2/kg], respectively. The ocean and sea-ice model are zonally averaged 2-dimensional models. In the ocean model, the hydrostatic Boussinesq equations are solved, and mixing due to mesoscale eddies and convection is parameterized. The sea-ice model is a vertically 1-dimensional thermodynamics model, and the transport is represented by horizontal diffusion. The value of surface albedo is 0.5 if surface temperature is lower than 263 K, otherwise 0, but the value on grid-point is given considered the sub-grid distribution of surface temperature. In addition to experiments with the coupled model, in order to evaluate the effect of oceanic heat transport, we also perform experiments in which dynamic ocean is replaced with slab ocean. The number of atmosphere model grid is 64x32x16. The number of grid points on the ocean and sea ice models is 64x60 and 64, respectively. For most cases, the initial condition is a rest atmosphere and ocean with 280 K, but various solutions are also used. The temporal integration for slab ocean cases is basically performed over about 300 years, and, for dynamic ocean cases, over about 30,000 years with periodically synchronous coupling.

3. Results

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By specifying absorb coefficients larger than that in INTH07, features of climate regime diagram are significantly changed. In dynamic ocean experiments, partially ice-covered states are obtained over 1040 ≦ S ≦ 1055 W/m^2, where S is the solar constant. The solar constant at which partially ice-covered states are obtained becomes about 300 W/m^2 smaller and the range of solar constant becomes much narrower. We also confirm the appearance of runaway greenhouse state for S > 1070 W/m^2. The latitudinal extent where large ice-cap instability occurs is wider. Although it is not easy to obtain partially ice-covered state whose ice-line is lower than 40 degrees latitude, we can discover stable partially ice-covered state with about 30 degrees ice-line when initial state and variation of solar constant are carefully chosen. Because this behavior indicates two branches for the partially ice-covered state, similar to that in R15, and we will carefully investigate the existence of solutions with low ice-line latitude. In slab ocean experiments, there are no partially ice-covered states. Therefore, we consider partially ice-covered states in dynamic ocean experiments are maintained by oceanic heat transport. Note that the setting here produces the large variation of temperature with solar constant, as calculations in R15, and the parameter range over which partially ice-covered states are obtained is potentially very narrow. It is possible that the resolution and formulation of models strongly affect the results. To evaluate the probabilities, it is necessary to conduct further experiments using slightly different parameters.

Keywords: ocean planet, dependence of climates on solar constant, a coupled atmosphere-ocean-sea ice model

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Water cycle and its evolution: High-speed H_2O transport to upper atmosphere on Mars

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It is believed that Mars underwent drastic climate change, changing its environment from warm and wet to cold and dry. This gives rise to the idea that Mars may have hosted life in the past, and indeed, may do so even today. Atmospheric and water evolution is thus an important key to understanding the history of Martian habitability. Mars must somehow have lost most of its atmosphere and water. The evolution of the Mars environment is thought to have proceeded by some combination of atmospheric escape to space and surface-subsurface adsorption. Especially, a lack of global magnetic field on Mars must have a significant impact to the atmospheric escape. The upper atmosphere is the primary reservoir for atmospheric escape. Owing to the technical difficulties associated with observations, datasets of the upper atmosphere are limited. However, the last decade has seen a renewed interest in the upper atmosphere, thanks to the aggressive explorations by the Mars Reconnaissance Orbiter (MRO), Mars Express(MEX), and Mars Volatile Evolution (MAVEN) missions. Recent studies have highlighted various interesting facts related to the efficient of material/water transport from the lower to upper atmospheric reservoir which have an impact on the atmospheric escape or evolution.

High-altitude (above 60 km) H2O was first identified by SPICAM occultations [Maltagliati et al., 2011, 2013] in the southern summer, which happens to be a dusty season at a solar longitude of 240 degree or later. Chaffin et al. [2017] demonstrated that the high-altitude H2O can considerably increase H escape on the weekly timescale, which can potentially explain the observations. Purpose of this study is to clarify the mechanism for upward transport of H2O into the upper atmosphere and formation of the detached layer of H2O and aerosols, by using multi-spacecraft dataset in order to cover whole altitude range from lower to upper atmosphere.

Here we report the detection of an extensive layer of warm air at altitudes 70-100 km on the night side that we interpreted as the result of combinations of aerosol heating, thermal tides, and/or global circulation. Such a strong warm layer for which the current models have no explanation can maintain temperature to evaporate water ice adsorbed on the aerosols and can form the detached layer of water vapor. We also measured the mesospheric distribution sub-micron aerosols is abundant than our expectation at altitudes 70-100 km. Such a detached layer of aerosol can potentially explain the warm layer, and this implies the importance of aerosols for key processes in the Martian water cycle and climate as a whole. The remarkable heating at altitudes 70-80 km was also confirmed by our dedicated ground-based observations during global dust storm 2018. The new pathway of water loss proposed by this implies much higher loss to space, in addition to the diffuse-limited escape of H2.

Keywords: Mars, water, habitability, escape, upper atmosphere

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Tue. May 28, 2019 10:45 AM - 12:15 PM JST | Tue. May 28, 2019 1:45 AM - 3:15 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[M-IS21] Gas hydrate in environmental-resource sciences

convener:Hitoshi Tomaru(Department of Earth Sciences, Chiba University), Akihiro Hachikubo(Kitami Institute of Technology), Atsushi Tani(Graduate School of Human Development and Environment, Kobe University), Shusaku Goto(Institute for Geo-Resources and Environment National Institute of Advanced Industrial Science and Technology), Chairperson:Naoto Ishida, 戸丸 仁

An increasing number of researches focusing on natural gas hydrates has recently been conducted from the environmental, material, and resource scientific viewpoints. This session aims to share and discuss the latest research results associated with natural/experimental gas hydrates to understand and examine the nature and potential of gas hydrates in the past-present-future of the Earth and the development/application for our life. Because the researches on gas hydrates are interdisciplinary, broad topics from field and experimental researches, modeling, etc. will be presented in this session.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MIS21-01] Equilibrium pressure of clathrate hydrates encaged $^{13}CH_4$

*Yuki Kikuchi[1], Akihiro Hachikubo[1], Takahiro Ozeki[1], Satoshi Takeya[2] (1.Kitami Institute of Technology, 2.National Institute of Advanced Industrial Science and Technology (AIST))

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MIS21-02] Hydrogen isotopic fractionation of ethane encaged in different crystallographic structure

*Jumpei Matsuda[1], Akihiro Hachikubo[1], Satoshi Takeya[2] (1.Kitami Institute of Technology, 2.National Institute of Advanced Industrial Science and Technology (AIST))

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MIS21-03] Trend of effect of temperature on C–H symmetric stretching vibrational frequencies of hydrocarbon molecules in 12, 14 and 16-hedra cages of gas hydrates

*Go Fuseya[1], Satoshi Takeya[2], Akihiro Hachikubo[1] (1.Kitami Institute of Technology, 2.National Institute of Advanced Industrial Science and Technology (AIST))

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MIS21-04] The study on relations of the methane plume and atmospheric methane concentration

*Chiharu Aoyama[1] (1.Tokyo University of Marine Science and Technology)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MIS21-05] Sampling of Methane Bubble Plumes and Solid Gas Hydrate on the Cascadia Margin, Pacific Northwest

*John E Lupton[1], Tamara Baumberger[1], Robert W. Embley[1], Susan G. Merle[1], Camilla Wilkinson[1], Conrad Young[2] (1.NOAA Pacific Marine Environmental Laboratory, Newport, Oregon, USA, 2.Young Engineering, Ramona, CA. USA)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

Discussion

Equilibrium pressure of clathrate hydrates encaged $^{13}CH_4$

*Yuki Kikuchi[1], Akihiro Hachikubo[1], Takahiro Ozeki[1], Satoshi Takeya[2]

1. Kitami Institute of Technology, 2. National Institute of Advanced Industrial Science and Technology (AIST)

Methane molecule is composed of carbon and hydrogen, and three kinds of isotopologues, $^{12}CH_4$ (98.9%), $^{13}CH_4$ (1.1%), and CH_3D (0.013%) exist in nature. We often measure stable carbon isotope ($^{13}C/^{12}C$) of methane to understand its gas origin. Since their weight of isotopologues differ with each other, physicochemical properties of them are also different. Pure methane hydrate must be "mixed-gas hydrate" of their isotopologues. Ozeki *et al.* (2018) measured an equilibrium pressure of CH_3D hydrate, but that of $^{13}CH_4$ has not been studied yet. Fractionation of hydrogen isotope of methane during the formation of methane hydrate has been reported by Hachikubo *et al.* (2007) that δ D of hydrate-bound methane becomes several ‰smaller than that of residual methane. This result suggests that the equilibrium pressure of CH_3D hydrate is larger than that of CH_4 hydrate, and Ozeki *et al.* (2018) demonstrated the difference between these equilibrium pressures. Since Hachikubo *et al.* (2007) showed no isotopic fractionation in methane $\delta^{13}C$, the equilibrium pressures of $^{12}CH_4$ and $^{13}CH_4$ hydrates are thought to be almost the same. In this study, we measured the equilibrium pressures of $^{13}CH_4$ hydrate to check the difference from that of $^{12}CH_4$ hydrate.

Methane hydrate samples were synthesized in small pressure cells (volume: 5 mL). Fine ice powder (1g) was put in a pressure cell, and introduced $^{13}CH_4$ (purity: 99.5%, Taiyo-Nissan). Clathrate hydrate was formed by melting the ice powder at the temperature of 273.2K under high pressure of methane. We also prepared normal methane (purity: 99.99% for methane, but 98.9% for $^{12}CH_4$, Takachiho Chemical Industry Co. Ltd.) hydrate as a reference, using the same preparation method. These pressure cells were placed in a temperature-controlled liquid bath, and measured their equilibrium pressures from 269.5K to 277.9K.

The difference in equilibrium pressure between $^{13}CH_4$ and normal methane (mainly $^{12}CH_4$) hydrates was smaller than the measurement error. This results agree with the previous report by Hachikubo *et al.* (2007).

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Hachikubo A, Kosaka T, Kida M, Krylov A, Sakagami H, Minami H, Takahashi N, Shoji H (2007) Isotopic fractionation of methane and ethane hydrates between gas and hydrate phases. Geophys Res Lett 34: L21502. doi:10.1029/2007GL030557

Keywords: gas hydrate, methane hydrate, equilibrium pressure, stable isotope

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Hydrogen isotopic fractionation of ethane encaged in different crystallographic structure

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Methane and ethane mixed-gas hydrate forms the cubic structure II in appropriate gas composition. Hachikubo *et al.* (2009) measured isotopic compositions of Lake Baikal gas hydrates and showed that δD of hydrate-bound ethane in the structure II is smaller than that in the structure I. These results might be explained by the difference in hydrogen isotope fractionation between formation processes of the structure I and II. In the last JpGU meeting we reported that the isotopic difference between gas and hydrate phases increased to 9-12‰ in the case of the structure II, whereas the difference was 1-2‰ in the case of the structure I. However, the effect of methane on the isotopic fractionation of ethane is unknown. In this study, we choose argon instead of methane and synthesize argon and ethane mixed-gas hydrates to check the isotopic difference in ethane between gas and hydrate phases.

0.7 g of fine ice powder was introduced in a pressure cell (volume: 30 mL). Argon and ethane mixed-gas were introduced in the cell and gas hydrate sample formed at 274.2 K. Before the retrieval of gas hydrate sample, residual gas was sampled, and then gas hydrate was cooled at the temperature of liquid nitrogen and retrieved the hydrate-bound gas. We controlled the ethane composition of initial gas from 3% to 25%. We measured compositions of argon and ethane by a gas chromatograph, and hydrogen isotopic composition (δD) of ethane by a CF-IRMS. Crystallographic structure of gas hydrate was determined using a Raman spectrometer, because the Raman spectra (around 1000 cm^{-1}) of C-C stretching mode of ethane in hydrate phase provide information of the crystallographic structure.

Because ethane was concentrated into hydrate phase rather than argon, ethane compositions of hydrate-bound gas distributed from 30% to 71%. In the case of low concentration of ethane, crystallographic structure II forms due to the effect of argon (the structure II former). δD of hydrate-bound ethane was about 4-7‰ smaller than that of residual ethane in the case of structure II, where ethane composition was 30-36% in the hydrate phase. On the other hand, in the case of high concentration of ethane (around 70% in the hydrate phase) δD of hydrate-bound ethane was around 2‰ larger than that of residual ethane. In the transition zone between the structures I and II the isotopic difference between hydrate and residual gas phases seemed to be an intermediate value (1-4‰). From these results we can conclude that light ethane (C_2H_6) prefers to be encaged into the structure II clathrate hydrate, compared to heavy ethane (C_2H_5D).

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Keywords: gas hydrate, ethane, hydrogen isotope ratio

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Trend of effect of temperature on C–H symmetric stretching vibrational frequencies of hydrocarbon molecules in 12, 14 and 16-hedra cages of gas hydrates

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Clathrate hydrates are crystalline inclusion compounds that consist of guest molecules of suitable sizes and shapes trapped in well-defined cages formed by water molecules. Clathrate hydrates with natural gases as guest molecules are commonly known as gas hydrates. Gas hydrates with enclathrated hydrocarbon gases that exist in sea or lake bottom sediments and permafrost layers have attracted considerable interest as a potential source of unconventional natural gas.

There are three common crystallographic structures of hydrates, structure I (sI), structure II (sII), and structure H (sH). The unit cell of sI hydrates are composed of two pentagonal dodecahedral (5^{12}) and six tetrakaidecahedral ($5^{12}6^2$) water cages. The unit cell of sII hydrates are composed of sixteen 512 cages and eight hexakaidecahedral ($5^{12}6^4$) water cages. Small guest molecules such as methane (CH_4) or ethane (C_2H_6) form sI hydrates and larger molecules such as propane (C_3H_8) form sII hydrates.

In this study, we observed the variations of Raman shifts of C–H symmetric stretching vibrations of various hydrocarbons encaged in $5^{12,}$ $5^{12}6^2$ and $5^{12}6^4$ cages of sI and sII hydrates. By changing temperature, we investigated variations of Raman shifts of C–H symmetric stretching vibrations of guest hydrocarbons. It was revealed that the vibrations of guest hydrocarbons in smaller sI 51262 cages were greater than those in bigger sII 51264 cages. These results are inconsistent with our prediction in earlier study (Fuseya et al. 2018), that is, the volume of host water cages increases, and the variations of the Raman shifts of C–H symmetric stretching vibrations of guest hydrocarbon molecules in host water cages due to change temperature increase. Taking into account the facts obtained in this study and in our earlier study, we conclude that the temperature change of Raman shifts of C–H symmetric stretching vibrations is affected by geometric asymmetry of host water cages.

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Keywords: gas hydrate, Raman spectroscopy, powder X-ray diffraction, molecular vibrations

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The study on relations of the methane plume and atmospheric methane concentration

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PurposeWhen methane seeps out to the sea from the seabed, the following need to be observed and confirmed if the water concentration remains the same. High methane concentration in the atmosphere directly above the seeping point and separation of methane hydrate into gas and water. Then, by confirming the impact on the environment, we propose a survey method for environmental impact assessment of surface methane hydrate.**Method**The experimental site of this research was Umitaka Spur in offshore Niigata prefecture where a large amount of surface methane hydrate plumes is confirmed and investigated on the DAIIICHI KAIYOMARU(KAIYO Engineering). The experimental period was two days, August 6 and August 7.Atmospheric methane concentration was measured during this experiment using LI-7700 (LI-COR) which introduced Flux measurement to measure ppm of specific substances present in the atmosphere. Methane concentration was measured by LI-7700 which was attached to the upper bridge so it will not be affected by the exhaust of the ship. We measure the concentration of methane in the atmosphere from departure to arrival and graphed the data every hour.Using a quantitative echo sounder, we also explored if methane plumes exist underwater the atmospheric methane concentration becomes higher.**Summary** Methane concentration in the atmosphere of the sea, the area near directly above, in the sea area where the methane seeps from the seabed to the sea tends to rise. **Proposal for environmental impact assessment** When extracting surface methane hydrate and at experimental stages at sea, it is effective to monitor methane concentration on the sea, not in the seawater to detect sudden seepage of methane into seawater as soon as possible. Even if methane hydrate leaks into the sea, there is no change in sodium concentration, so we do not have be concerned about the influence on the environment.

Keywords: methaneplume, methane concentration in atmosphere, Japan sea

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Sampling of Methane Bubble Plumes and Solid Gas Hydrate on the Cascadia Margin, Pacific Northwest

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The Cascadia Margin along California, Oregon, and Washington is host to hundreds of offshore methane seeps that produce bubble streams that ascend through the water column. In addition to the bubble streams, seismic reflection studies have detected the presence of extensive methane hydrate deposits beneath the seafloor. There are also a few sites along the Cascadia Margin where hydrate deposits are exposed and visible on the seafloor. During an expedition in 2016, our group used an ROV to collect uncontaminated samples of the bubble stream gas at several Cascadia Margin sites using special gas-tight bottles. Although we have successfully obtained samples of the bubble streams, the question remains as to whether the bubble streams are produced by the dissociation of hydrate, or instead represent free gas ascending through the sediment. We have developed a new sampler in which small samples of hydrate can be hermetically sealed into a small gas-tight volume in-situ while incorporating only a small amount of ambient seawater. The hydrate is then allowed to dissociate in the sample volume without exposure to air or other contaminates. During a return expedition to the Cascadia margin in June 2018 we successfully sampled solid methane hydrate at two sites using this new sampler and also collected additional samples of the free gas bubble streams. The paper will compare the results from these hydrate collections with the composition of the free gas.

Keywords: methane, hydrate, Cascadia Margin

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Tue. May 28, 2019 1:45 PM - 3:15 PM JST | Tue. May 28, 2019 4:45 AM - 6:15 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[M-IS21] Gas hydrate in environmental-resource sciences

convener:Hitoshi Tomaru(Department of Earth Sciences, Chiba University), Akihiro Hachikubo(Kitami Institute of Technology), Atsushi Tani(Graduate School of Human Development and Environment, Kobe University), Shusaku Goto(Institute for Geo-Resources and Environment National Institute of Advanced Industrial Science and Technology), Chairperson:八久保 晶弘(北見工業大学), 戸丸 仁

An increasing number of researches focusing on natural gas hydrates has recently been conducted from the environmental, material, and resource scientific viewpoints. This session aims to share and discuss the latest research results associated with natural/experimental gas hydrates to understand and examine the nature and potential of gas hydrates in the past-present-future of the Earth and the development/application for our life. Because the researches on gas hydrates are interdisciplinary, broad topics from field and experimental researches, modeling, etc. will be presented in this session.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MIS21-06] The distribution of atmospheric CH_4 concentration and gas plume location in the sea around Japanese islands.

*Shinsuke Aoki[1], Shujiro Komiya[2], Kosuke Noborio[3], Ryo Matsumoto[4] (1.Graduate School of Agriculture, Meiji Universiy, 2.Max Planck Institute, 3.School of Agriculture, Meiji Universiy, 4.Gas Hydrate Laboratory - Meiji University Organization for the Strategic Coordination of Research and Intellectual Property)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MIS21-07] Reaction/fixation/migration of methane within the gas chimney on the Umitaka Spur, eastern margin of the Japan Sea

*Hitoshi Tomaru[1], Ryo Matsumoto[2] (1.Department of Earth Sciences, Chiba University, 2.Gas Hydrate Research Laboratory, Meiji University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MIS21-08] Slope failures induced by methane hydrate dissociation: a case of submarine slide in the southwestern Oki Trough, Japan Sea

*Naoto Ishida[1], Shota Morihita[2], Takao Ebinuma[1], Hitoshi Tomaru[3], Ryo Matsumoto[4] (1.Social Systems and Civil Engineering, Graduate School of Engineering, Tottori University, 2.Department of Social Systems and Civil Engineering, Faculty of Engineering, Tottori University, 3.Department of Earth Sciences, Faculty of Science, Chiba University, 4.Gas Hydrate Research Laboratory, Organization for the Strategic Coordination of Research and Intellectual Properties, Meiji University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MIS21-09] Origin and evolution of H_2S-bearing methane hydrate in the Sea of Japan

*Ryo Matsumoto[1], Tomoko Fukazawa[2], Akihiro Hiruta[1], Glen Snyder[1] (1.Organization for the Strategic Laboratory of Research and Intellectual Properties, Meiji University, 2.Department of Applied Chemistry, School of Science and Technoloty, Meiji University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MIS21-10] Discovery of gas hydrate at the new point off Abashiri, the Sea of Okhotsk

*Akihiro Hachikubo[1], Jumpei Matsuda[1], Satoshi Yamashita[1], Hirotoshi Sakagami[1], Masaaki Konishi[1], Hirotsugu Minami[1], Kenji Nishina[2], Kenji Sakaguchi[3] (1.Kitami Institute of Technology, 2.Geological Survey of Hokkaido, Hokkaido Research Organization, 3.Kushiro Fisheries Research Institute, Hokkaido Research Organization)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MIS21-11] All about gas hydrates and heat flow offshore Chile

*LUCIA ALEJANDRA VILLAR MUNOZ[1], IVAN VARGAS-CORDERO[2], JOAQUIM P. BENTO[3], JAN BEHRMANN[1], UMBERTA TINIVELLA[4], MICHELA GIUSTINIANI[4] (1.Helmholtz Centre for Ocean Research, 2.Universidad Andres Bello , 3.Pontificia Universidad Catolica de Valparaiso, 4.Istituto Nazionale di Oceanografia e di Geofisica Sperimentale)

The distribution of atmospheric CH_4 concentration and gas plume location in the sea around Japanese islands.

*Shinsuke Aoki[1], Shujiro Komiya[2], Kosuke Noborio[3], Ryo Matsumoto[4]

1. Graduate School of Agriculture, Meiji Universiy, 2. Max Planck Institute, 3. School of Agriculture, Meiji Universiy, 4. Gas Hydrate Laboratory - Meiji University Organization for the Strategic Coordination of Research and Intellectual Property

In previous studies, methane emissions from the seabed have been reported worldwide. The reports that methane reached the atmosphere are limited to some sea areas with shallow water depths in the Arctic Ocean. Most of the researches reported that methane does not reach the atmosphere in many other sea areas and is decomposed in the water column. However, a methane hydrate shell is formed on the surface of methane bubbles released from the seabed in the gas hydrate stability zone. The methane hydrate shell delays the dissolution of methane in the water column. Therefore, a system efficiently transports methane to a shallow location in the ocean. It is difficult to clarify the amount of methane carried by this transport system and it is pointed out that some methane may release into the atmosphere. As methane is one of the greenhouse gases like carbon dioxide, release to the atmosphere leads to an increase in atmospheric concentrations and can be a cause of climate change. On the other hand, if an increase in atmospheric concentration occurs, there is a possibility that it can help in searching the methane hydrate-bearing area from the observation with the artificial satellite. Our objectives were to investigate the influence of gas seep from the sea floor on atmospheric methane concentration. In this study, we performed continuous measurement of atmospheric methane concentration, observed gas plume and measured water temperature profile by CTD. The survey area is the Japan Sea (7 K 14 and 7 K 15 cruises) where the gas plumes were reported and the Pacific Ocean (MR 15 - 3, KH 16 - 3, KH 17 - 3 cruise) as the control area. The upper limit of the stable region of methane hydrate was estimated from the water temperature profile by CTD and the phase equilibrium curve of methane hydrate in seawater for each sea area. Atmospheric methane concentration observed in the Pacific Ocean at 1.9 ppm slightly higher than the average concentration of the whole earth. Atmospheric methane concentration observed around the Japanese islands was also the mode of 1.9 ppm, which was the highest in methane concentration (> 2.1 ppm) compared with other sea areas only in the Mogami trough and off Abashiri. As gas plume was observed in these two regions, it seems that capture the influence of the gas plume on the atmosphere. However, since the methane concentration observed in other gas plume sites (off Tokachi and off Hidaka) was almost unchanged from those in which no gas plume was observed, all gas plumes did not always influence atmospheric concentrations. A high methane concentration was observed only the surrounding of the gas plume at Mogami trough and off Abashiri. However, high concentrations are not always observed when passing through the same gas plume point, but different concentrations are observed depending on time. This is considered to be caused by the methane discharged from the sea floor is flowed by ocean currents and offshore winds, and the amount of methane discharged has changed. The upper limit of the gas hydrate stability estimated from the water temperature profile was slightly shallow in off Abashiri and Mogami trough. Heeschen et al. (2003) reported that the height of the gas plume coincided with the water depth at the upper limit of the gas hydrate stability, but the gas plume observed shallower than a depth of the upper limit off Abashiri. This results suggested that methane emitted from the seafloor reaches the atmosphere at not only the gas plume with shallow water depth but the gas plume with a shallow upper limit of the gas hydrate stability. This study was conducted under the commission from AIST as a part of the methane hydrate research project funded by METI (the Ministry of Economy, Trade, and Industry, Japan). We appreciate the support of the crew during 7K14, 7K15,

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MR15-3, KH16-3, and KH17-3 cruise.

Keywords: gas hydrate, gas plume, methane (CH4)

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Reaction/fixation/migration of methane within the gas chimney on the Umitaka Spur, eastern margin of the Japan Sea

*Hitoshi Tomaru[1], Ryo Matsumoto[2]

1. Department of Earth Sciences, Chiba University, 2. Gas Hydrate Research Laboratory, Meiji University

Pore water geochemistry has reported that methane is oxidized anaerobically by sulfate (anaerobic oxidation of methane: AOM) at the sulfate-methane interface (SMI), and the methane flux has been estimated using the sulfate gradient or SMI depth. The methane flux is therefore an essential factor for assessing the near-seafloor environment of high methane potential area. Gas chimney, characterized by active methane migration, often associates with methane hydrate accumulation just below the seafloor and methane plume in the overlying water column on the Umitaka Spur, eastern margin of the Japan Sea. However, the behavior of these methane cannot be examined by the change of sulfate concentration, direct measurements of the amount of methane in hydrate phase and methane seepage are required. In this research, we estimated the amount of methane that is 1) oxidized at SMI via AOM, 2) fixed in gas hydrate deposit, and 3) released into water column, using independent data sets recently obtained on the Umitaka Spur, respectively, in order to understand more practically the behavior of methane within the gas chimney.
The methane flux oxidized at the SMI was calculated to be >600 mmol/m^2/yr using the SMI depth of <1 mbsf within the gas chimney. Assuming that the methane flux has been constant and all the methane has formed hydrates of 6×10^8 m^3 within 200×250 m gas chimney in <363 ka (data from METI coring), the methane flux directly associated with hydrate was estimated to be >1500 mmol/m^2/yr. The methane flux released into the water column was calculated to be <5 mmol/m^2/yr using the methane concentration in bottom water of <1500 nM and bottom water current of <10 cm/s. These numbers are still tentative because sedimentation rate within gas chimney is rather variable among sites, gaseous methane in sediment must be accounted, a part of methane hydrate has dissolved during massive accumulation of hydrate body, etc. However, recent intensive researches on the shallow gas hydrate system have provided the better understanding of total methane behavior within the gas chimney.
This study was conducted partially under the commission from AIST as a part of the methane hydrate research project funded by METI (the Ministry of Economy, Trade and Industry, Japan).

Keywords: gas hydrate, methane flux, Japan Sea

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Slope failures induced by methane hydrate dissociation: a case of submarine slide in the southwestern Oki Trough, Japan Sea

*Naoto Ishida[1], Shota Morihita[2], Takao Ebinuma[1], Hitoshi Tomaru[3], Ryo Matsumoto[4]

1. Social Systems and Civil Engineering, Graduate School of Engineering, Tottori University, 2. Department of Social Systems and Civil Engineering, Faculty of Engineering, Tottori University, 3. Department of Earth Sciences, Faculty of Science, Chiba University, 4. Gas Hydrate Research Laboratory, Organization for the Strategic Coordination of Research and Intellectual Properties, Meiji University

A huge submarine slide in the Oki Trough, Japan Sea, was examined from the viewpoint of methane hydrate dissociation due to BGHS (Base of Gas Hydrate Stability) fluctuation. The submarine slide, which occurred 34 ka, is located in the southwestern slope of the Oki Trough having a 1.6 degrees slant. Geothermal gradients were measured at the 700 m and 1000 m water depths by the side of the slide as 83.13 mK/m and 99.42 mK/m, respectively. Based on our simulation, the BGHS was situated just below the landslide masses at the time of the slope failure. The response of BGHS to the external factors, e.g. sea-level change, sedimentation, etc., is prominently involved in methane hydrate disassociation, which makes the submarine ground unstable. Relation between the slope failure and the methane hydrate disassociation is strongly suggested in the study case.

Unpublished data by surveys conducted under the commission from AIST as a part of the methane hydrate research project funded by the Ministry of Economy, Trade and Industry, Japan was used in this study.

Keywords: base of gas hydrate stability, submarine slide, shallow-type methane hydrate, Oki Trough, Japan Sea

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Origin and evolution of H_2S-bearing methane hydrate in the Sea of Japan

*Ryo Matsumoto[1], Tomoko Fukazawa[2], Akihiro Hiruta[1], Glen Snyder[1]

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Thick massive deposits of hydrates of the Sea of Japan have accumulate in gas chimneys in two steps. The first step is related to a 25 million years' rifting of the Sea of Japan, characterized by a high heat flows, high TOC sediments and a tectonic inversion at a few million years ago. Tectonic inversion has developed deep reverse faults and tight folds with open fracture systems, which facilitated the development of gas chimney structures. Second one is a glacial-interglacial cycles for a few 100 ka. Eustatic sea level fall resulted in a shoal up the base of gas hydrate stability (BGGS), dissociation of deep-seated hydrates, and enhanced methane-flux and massive accumulation of hydrates. Shallow hydrates are characterized by high H2S contents up to a few %v/v, reflecting AOM in shallow subsurface. Shallow H2S-bearing hydrates have repeatedly and intermittently accumulated on the top of gas chimneys at glacial period, while the H2S contents rapidly decreased with depth due to recrystallization perhaps through molecular diffusion during burial diagenesis. Key conditions to develop massive deposits of shallow hydrates are strong flux of mixed-microbial and thermogenic gases and a recycling of deep-seated hydrates during the glacial-interglacial.

Keywords: shallow gas hydrates, H2S, eustatic sea level change

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Discovery of gas hydrate at the new point off Abashiri, the Sea of Okhotsk

*Akihiro Hachikubo[1], Jumpei Matsuda[1], Satoshi Yamashita[1], Hirotoshi Sakagami[1], Masaaki Konishi[1], Hirotsugu Minami[1], Kenji Nishina[2], Kenji Sakaguchi[3]

1. Kitami Institute of Technology, 2. Geological Survey of Hokkaido, Hokkaido Research Organization, 3. Kushiro Fisheries Research Institute, Hokkaido Research Organization

To understand environment of near-surface gas hydrates at the sea floor, HKS16, HKS17, and HKS18 cruses were conducted using RV Hokushin-Maru (255t) of the Kushiro Fisheries Research Institute off Abashiri, the Sea of Okhotsk, in a framework of joint research between Kitami Institute of Technology and Hokkaido Research Organization. We report success in retrieval of hydrate-bound sediment cores using a research vessel belonging to Hokkaido Prefecture. In this area, natural gas hydrates have been recovered in the NT13-20 and C020 cruises using RV Natsushima and TS Oshoro-maru, respectively. We also observed gas hydrate crystals with many crabs at the seepage sites using a remotely operated vehicle (ROV, KAIYO3000) in the 1KY17 cruise. In the cruise of HKS18, we got gas hydrate samples from a gas seepage site, located 2 km south from the 1KY17 site.

In the HKS18 cruise, we used a hydrostatic corer optimally tuned for a small vessel and a transponder to know exact position of the corer. We obtained nine sediment cores, including two hydrate-bound cores. Gas hydrate crystals were preserved in liquid nitrogen, and sediment gases were obtained by a headspace gas method. Raman spectroscopic analysis was conducted to know crystallographic structure, hydration number and cage occupancies. Molecular and isotopic compositions of gas samples were measured using a gas chromatograph and an isotope ratio mass spectrometer, respectively.

Crystallographic structure of gas hydrate samples belonged to the structure I, and hydration number was estimated as 6.00±0.02. Hydrate-bound H_2S molecules were also detected in the Raman spectra. Hydrate-bound gas was mainly methane, and C_1 / (C_2 + C_3) distributed between 30,000 and 60,000. C_1 $\delta^{13}C$ and δD were -66‰ and -197‰. These molecular and isotopic compositions of hydrate-bound hydrocarbons suggested microbial origin. The depths of sulfate-methane interface (SMI) in HC1807, HC1808, and HC1810 cores were less than 30 cm, indicating high gas flux. Concentrations of H_2S in the headspace gas samples were in the same order (around 1 mM), therefore process of anaerobic oxidation of methane was active. C_1 / (C_2 + C_3) of headspace gases in the hydrate-bound cores (HC1807 and HC1808) distributed between 4,000 and 9,000, and those of other sediment cores were relatively small, indicating that they are in the oxidation layer above the SMI depth. Headspace gas in the HC1808 core contained a lot of isobutane. It is possible that thermogenic gas supplied from deeper sediment layer partly mixes with microbial gas.

Keywords: gas hydrate, Sea of Okhotsk, gas origin

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All about gas hydrates and heat flow offshore Chile

*LUCIA ALEJANDRA VILLAR MUNOZ[1], IVAN VARGAS-CORDERO[2], JOAQUIM P. BENTO[3], JAN BEHRMANN[1], UMBERTA TINIVELLA[4], MICHELA GIUSTINIANI[4]

1. Helmholtz Centre for Ocean Research, 2. Universidad Andres Bello , 3. Pontificia Universidad Catolica de Valparaiso, 4. Istituto Nazionale di Oceanografia e di Geofisica Sperimentale

From a geological point of view, Chile lies in an incomparable area of the globe, which include four tectonic plates moving against (Nazca, Antarctic, South American and Scotia plates), two triple junctions (Chile and Fuegian triple junctions), numerous mega-earthquakes and tsunami-related, more than 500 active volcanoes, the Andes, and several mineral resources. One of the last natural resources where the Chilean government and institutions have focused on is in gas hydrate, which is a solid ice-like form of water that contains gas molecules highly-concentrated in methane. Since Chile import most of its gas budget, hence the discovery of this new resource open a new window for the national economy, but also for geosciences, due to methane that escapes from sediments and enter to the ocean or even reach the atmosphere could pose a great environmental threat. To identify the presence of hydrates, in this thesis it was used the bottom-simulating reflector BSR, which has the half amplitude and opposite polarity relative to the seafloor.

Moreover, fluids play a key role in the nucleation and rupture propagation of earthquakes in convergent margins, since are a major agent of advective heat transfer from depth to the Earth’ s surface. If provide enough information for the regional heat flow we will improve our knowledge of these violent shakes of plate motion. For this purpose, it is crucial to know the BSR-depth, which serves to calculate the steady-state heat flow q (mW m^{-2}), and therefore, the heat flow can be envisaged in a regional overview.

This work aims to investigate the tectonic processes of the Chilean forearc through the calculation of the regional BSR-derived heat flow, identification of fluid escape sites, description of the distribution of gas hydrates and estimation of the gas hydrate and free gas reservoirs .

One of the major results is the regional overview of the thermal regime and BSR-based gas hydrate distribution along the Chilean forearc. Here, the BSR was identified into the marine sediments mainly along the accretionary prism between 33˚-57˚S, around 2000 m water depth, and between 90-600 m below seafloor. The heat flow estimated through the forearc on the upper and middle continental slope, from Valparaiso to Chiloe (33˚-43˚S), shows common values of heat flow for the continental basement and overlying slope sediments. However, on the lower slope of the actively deforming accretionary wedge, some places show unexpected values, which indicates that advecting pore fluids from deeper may transport a considerable part of the heat there.

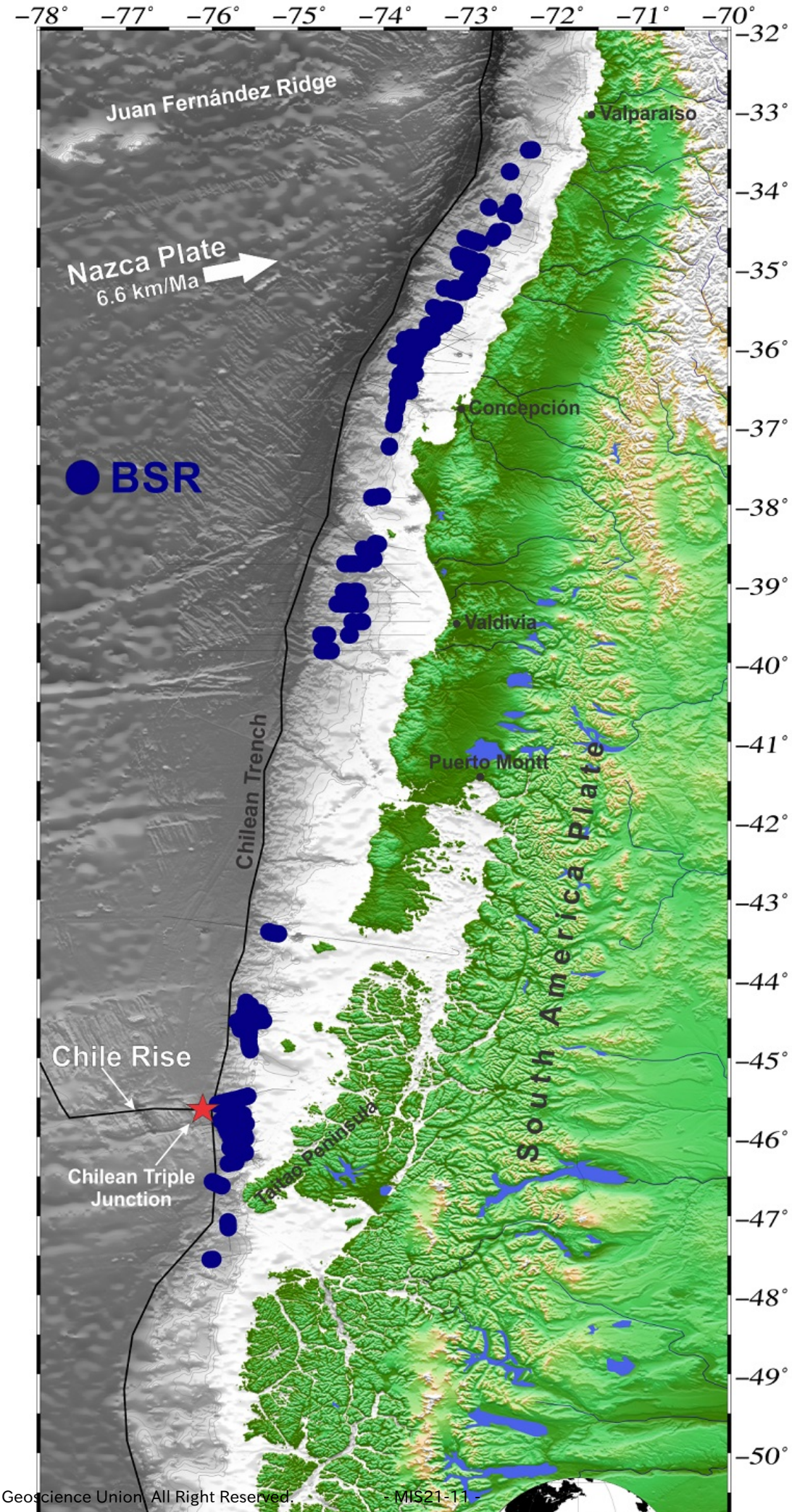
Southern, a second approach was made over a large area of extremely anomalous heat flow that is associated with a major tectonic feature: the Chile Triple Junction. In this unusual place, the Nazca, Antarctic and South American plate converge in a common point; while an active spreading centre (the Chile Rise) is subducting beneath the continental plate. Here, gas hydrates are located in very shallow sediments and the extreme values of heat flow estimated (<280 mW m^{-2}) indicate that the overriding South American Plate is effectively heated by subjacent zero-age oceanic plate material. In order to improve the understanding of the geological risk, in case the methane is released to the ocean/atmosphere system, it was estimated the concentration of gas hydrate in this particular region.

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Finally, in the southernmost tip of the continent (offshore Patagonia), the heat flow estimated once again shows a range of values typical for subduction zones of oceanic crust older than 10 Ma. Here, a high concentration of methane hydrate is present beneath the active margin. The average thickness of the gas hydrate layer modelled is almost 300 m and the volume of methane estimated is more than $3x10^{13}$ m^3 at standard pressure-temperature conditions, concluding that the active forearc of the Chilean Patagonia is an important reservoir of methane hydrates.

Keywords: gas hydrates, heat flow, BSR, active margin, Chile, fluids flow

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Tue. May 28, 2019 9:00 AM - 10:30 AM JST | Tue. May 28, 2019 12:00 AM - 1:30 AM UTC | 202 2F

[M-IS27] Atmospheric electricity: Applications toward natural disaster mitigation

convener:Yasuhide Hobara(Graduate School of Information and Engineering Department of Communication Engineering and Informatics, The University of Electro-Communications), Masashi Kamogawa(Department of Physics, Tokyo Gakugei University), Chairperson:Takeshi Morimoto

In recent years, various types of natural disasters caused by climate change, earthquake, etc. occur frequently in the world. In 2018 heavy precipitation in various regions of Japan and the earthquakes in Hokkaido and Indonesiaproduced/greater human and economic/damage.

In 2019JpGU Atmospheric Electricity (AE) session, invited experts are going to introduce their scientific challenges in order to monitor, predict and mitigate natural disasters by using knowledge of the atmospheric electricity. For example, monitoring and prediction of extreme weather by the latest weather radar system and lightning observations, electromagnetic phenomena prior to earthquakes, etc. will be included. We certainly welcome contributed papers regarding all topics on atmospheric electricityincluding global circuit, ion and fair weather electricity, thunderstorm electrification, lightning physics, lightning and meteorology, electrical effects of thunderstorms on the middle and upper atmosphere such as transient luminous events and high energy phenomena, lightning protection, terrestrial electromagnetic environment and so on.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[MIS27-01] Advantage and Disadvantage of the Phased Array Weather Radar

*Tomoo Ushio[1], Tomoaki Mega[1], Hiroshi Kikuchi[2], Eiichi Yoshikawa[3] (1.Tokyo Metropolitan University, 2.University of Electro-Communications, 3.JAXA)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[MIS27-02] Initial Observations with X-band Dual Polarimetric Phased Array Weather Radar in Tokyo

*Hiroshi Kikuchi[1], Taku Suezawa[2], Yasuhide Hobara[1], Tomoo Ushio[2] (1.The University of Electro-Communications, 2.Tokyo Metropolitan University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[MIS27-03] Three-dimensional total lightning characteristics of convective cells observed by the Tokyo LMA in the summer season in Tokyo Metropolitan area

*Namiko Sakurai[1], Paul R. Krehbiel[2], William Rison[2], Ronald J. Thomas[2], Daniel Rodeheffer[2], Shingo Shimizu[1], Koyuru Iwanami[1], Takeshi Maesaka[1], Kaori Kieda[1], Yasushi Uji[1] (1.National Research Institute For Earth Science and Disaster Resilience, 2.New Mexico Tech.)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[MIS27-04] Estimating rainfall in heavy rain events using lightning data in Japan

*Ogawa Tetsuya[1], Yasuhide Hobara[1], Hiroyuki IWASAKI[2], Stan Heckman[3], Michael Stock[3] (1.University of Electro-Communications, 2.Gunma University, 3.EarthNetworks)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[MIS27-05] The Effect of Lightning Phenomena on Lightning Protection for Objects on the Ground

★Invited Papers

*Yokoyama Shigeru[1] (1.Shizuoka University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[MIS27-06] Lightning charge moment changes deduced from highly sensitive ELF magnetic field observations in Southeast Asia

*Yasuhide Hobara[1], Amir Izzani Mohamed[2], Chandima Gomes[3], Wan Ismail Bin Ibrahim[2], Zulkurnain Abdul-Malek[4], Syahrun Nizam[5], Michael Stock[6], Kazuo Shiokawa[7], Hiroshi Kikuchi[1], Takuo T. Tsuda[1]
(1.Graduate School of Information and Engineering Department of Communication Engineering and Informatics, The University of Electro-Communications, 2.University of Malaysia Pahang Pekan, Malaysia, 3.University of the Witwatersrand Johannesburg, South Africa, 4.Universiti Teknologi Malaysia Johor Bahru, Malaysia, 5.University Malaysia Perlis Perlis, Malaysia, 6.EarthNetworks, Inc. Germantown, USA, 7.Nagoya University, Nagoya, Japan)

Advantage and Disadvantage of the Phased Array Weather Radar

*Tomoo Ushio[1], Tomoaki Mega[1], Hiroshi Kikuchi[2], Eiichi Yoshikawa[3]

1. Tokyo Metropolitan University, 2. University of Electro-Communications, 3. JAXA

Recent progress of information and communication technologies has been enabling us to realize a rapid scanning radar system. In 2012, Toshiba Corporation and Osaka University succeeded in developing a new type of Phased Array Radar (PAR) system (Yoshikawa et al. 2013, Ushio et al. 2015, Mizutani et al. 2018) under a grant of National Institute of Communication and Information Technology (NICT), and installed in Suita Campus, Osaka University. This PAR system can scan the whole sky within 30 seconds up to 60 km in radius over 100 elevation angles with digital beam forming technique, and the initial observation results demonstrate the unique capability of the new PAR system. However, the observation is sometimes seriously contaminated by strong ground clutter through relatively high sidelobes at transmitting stage. In this study, a new clutter mitigation algorithm from adaptive beam forming technique on Minimum Mean Square Error (MMSE) formulation was investigated, and succeeded in suppressing not only the ground clutter but also ghost echo from strong precipitation echo nearby more than 20dB. And also the adaptive algorithm was applied to supress the range sidelobe and showed the sidelobe level of -60dB. In this presentation, the advantages and disadvantages of the PAR will be discussed based on the observation results.

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Initial Observations with X-band Dual Polarimetric Phased Array Weather Radar in Tokyo

*Hiroshi Kikuchi[1], Taku Suezawa[2], Yasuhide Hobara[1], Tomoo Ushio[2]

1. The University of Electro-Communications, 2. Tokyo Metropolitan University

The weather radars using parabolic dish antenna generally require 5-10 minutes to mechanically rotate and to tilt upwards as they sample the atmosphere at several different elevation angles. The number of the observable elevation angles is about ten or so. The single polarization phased array weather radar (SP-PAWR), which has been developed in 2012, was designed to conduct precipitation measurement of a radar reflectivity factor, in less than 10 or 30 seconds in a range of 20 or 60 km in real-time, respectively. As a next radar development project, a dual polarimetric phased array weather radar (Multi-parameter phased array radar; MP-PAWR) is being developed. It can provide multi-parameter measurements that reveal detailed microphysics of storms in addition to accurate precipitation estimation, and can improve weather forecasts.
The first made MP-PAWR, which simultaneously transmits pulses of horizontal and vertical polarized radiation, has been developed and installed in December 2017, at Saitama University, Japan. The center of frequency is 9.4GHz (X-band). The MP-PAWR has a scanning scheme similar to the SP-PAWR, which uses the mechanical and electronic scanning in azimuth and elevation angles, respectively. The MP-PAWR provides the polarimetric precipitation measurements in three-dimensional volume scanning in less than 30 or 60 seconds in a range of 60 or 80 km in real-time, respectively.
In this presentation, we will show the initial observation results. To confirm reliability of the measurements and to evaluate the accuracy of the measurements by the MP-PAWR, the initial observation results of the MP-PAWR are compared with an optical disdrometer data.

Keywords: Precipitation Observation, Phased array radar

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Three-dimensional total lightning characteristics of convective cells observed by the Tokyo LMA in the summer season in Tokyo Metropolitan area

*Namiko Sakurai[1], Paul R. Krehbiel[2], William Rison[2], Ronald J. Thomas[2], Daniel Rodeheffer[2], Shingo Shimizu[1], Koyuru Iwanami[1], Takeshi Maesaka[1], Kaori Kieda[1], Yasushi Uji[1]

1. National Research Institute For Earth Science and Disaster Resilience, 2. New Mexico Tech.

The National research Institute for Earth science and Disaster resilience, Japan (NIED) has observed three-dimensional total lightning with Lightning Mapping Array in Tokyo metropolitan area (Tokyo LMA) since 2017. In this study, we report various total lightning characteristics of convective cells observed by the Tokyo LMA in the summer season. Three convective cells developed at around 14:00 JST on 30 August 2017 in Tokyo. They were located at a short distance each other, and they merged into a multi-cell thunderstorm after a while. The total lightning characteristics of the three convective cells before they merged into the multi-cell thunderstorm are as follows: in one convective cell which was located in the middle of the cells, IC lightning flashes preceded the first CG lightning for about 20 minutes. On the other hand, a CG lightning flash firstly occurred in another convective cell. In the other convective cell, IC lightning flashes predominated. These three cells and the multi-cell thunderstorm had normal tripole structures. In addition, several bolt-from-the-blue were observed in these three cells.

Keywords: lightning

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Estimating rainfall in heavy rain events using lightning data in Japan

*Ogawa Tetsuya[1], Yasuhide Hobara[1], Hiroyuki IWASAKI[2], Stan Heckman[3], Michael Stock[3]

1. University of Electro-Communications, 2. Gunma University, 3. EarthNetworks

In this study, we examined the relationship between total lightning (TL) and heavy rainfall in high spatio-time resolution by using 37 severe thunderstorms in Japan. TL is continuously monitored by the Japanese Total Lightning Network (JTLN) deployed by UEC and operated jointly by UEC and EarthNetworks, whilst high spatio-temporal precipitation data is obtained by eXtended Rader Information Network (XRAIN) operated by Ministry of Land, Infrastructure, Transport and Tourism in Japan. As a result, positive linear relation with rather high cross correlation (r2 ~ 0.54 between TL and Precipitation Volume (PV) [m3] has been obtained. The cross correlation between TL and PV is much higher than that for cloud-to-ground lightning (CG) and PV. Although the slope of linear relation (TL vs. PV) varies depending on heavy rain events, TL can be promising tool to estimate severe rainfall.

Keywords: lightning, Total lightning, severe weather

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The Effect of Lightning Phenomena on Lightning Protection for Objects on the Ground

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1. Shizuoka University

When lightning strikes the transmission line or the distribution line, high voltage is generated between the wire and the earth, discharge occurs in the insulator, and power failure occurs. A high voltage is generated when the peak value of the lightning current is large. Also, as the wave front length of the current is shorter, a higher voltage is generated. On the other hand, the lightning rod fails to catch the lightning discharge and destroys the roof and wall of the building even with the low peak value of the lightning current. Furthermore, damage caused by lightning arrester burnout is not much affected by the length of wave front length, and it is greatly influenced by the duration (charge amount) of the lightning current. Table 1 shows the relationship between the types of lightning damage and lightning parameters. Since lightning properties related to lightning damage of ground structures depend upon the object, it is important to fully understand the lightning phenomena to take countermeasures against lightning damages. Moreover, it is also necessary to clarify the seasonal and local characteristics of lightning from the viewpoint of risk management because there are lightning with significantly different properties from ordinary summer lightning such as the Japanese winter lightning. In this paper I will explain the lightning properties necessary for countermeasures against lightning damage and consider the issues of lightning observations in the future.

Keywords: Lightning, Lightning Protection, Power Grid, Wind Power

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表１雷被害と関係する雷のパラメータ

	電流波高値	雷撃距離	波頭峻度（波頭長の逆数）	波尾長（電流継続時間）		対策法	備考
絶縁破壊(碍子など回復可能なもの)	◎		○			架空地線、避雷器、SPD	統流の影響
絶縁破壊(半導体など)	◎					SPD,光ファイバ	
通過電荷量によるエネルギー被害(避雷器焼損、架空地線素線切れ)				○		避雷器（SPD）の容量増加	
オーミックロス（エネルギー）によるエネルギー被害（風車塔体内焼損など）	○			○		引下げ導体と受雷部などの接続部強固化	
送電線架空地線遮蔽失敗		○				架空地線の２条化	
建築物損壊（コンクリート、レンガ等）		○				避雷針（受雷部）の強化	
建築物損壊、着火（藁葺き屋根、桧皮葺き屋根）		○		◎		避雷針（受雷部）の強化	消火体制
ノイズ（EMC 的影響）	○		○			離隔距離の確保、信号線の電磁シールド	雷電流の通過による回路の誤動作など

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Lightning charge moment changes deduced from highly sensitive ELF magnetic field observations in Southeast Asia

*Yasuhide Hobara[1], Amir Izzani Mohamed[2], Chandima Gomes[3], Wan Ismail Bin Ibrahim[2], Zulkurnain Abdul-Malek[4], Syahrun Nizam[5], Michael Stock[6], Kazuo Shiokawa[7], Hiroshi Kikuchi[1], Takuo T. Tsuda[1]

1. Graduate School of Information and Engineering Department of Communication Engineering and Informatics, The University of Electro-Communications, 2. University of Malaysia Pahang Pekan, Malaysia, 3. University of the Witwatersrand Johannesburg, South Africa, 4. Universiti Teknologi Malaysia Johor Bahru, Malaysia, 5. University Malaysia Perlis Perlis, Malaysia, 6. EarthNetworks, Inc. Germantown, USA, 7. Nagoya University, Nagoya, Japan

In 2018 we established the new permanent observation site in Pahang, Malaysia and started continuous recording of horizontal magnetic waveforms in the Extremely Low Frequency (ELF) band by using high sensitivity search coils. We carried out test measurements at four different locations in Malay peninsula and found out that Pahang is the most electromagnetically quiet place for measurement. Initial results indicate a very good performance registering clear waveforms from lightning discharges. We successfully estimated individual lightning charge moment changes (CMCs) with a small lower bound (~few Ckm) with a lightning location data from total lightning network indicative of deducing spatial and temporal dependence of lightning with CMC over Southeast Asia region.

Keywords: Lightning, ELF (Extremely Low Frequency), Charge Moment Changes

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Tue. May 28, 2019 10:45 AM - 12:15 PM JST | Tue. May 28, 2019 1:45 AM - 3:15 AM UTC | 202 2F

[M-IS27] Atmospheric electricity: Applications toward natural disaster mitigation

convener:Yasuhide Hobara(Graduate School of Information and Engineering Department of Communication Engineering and Informatics, The University of Electro-Communications), Masashi Kamogawa(Department of Physics, Tokyo Gakugei University), Chairperson:Yasuhide Hobara

In recent years, various types of natural disasters caused by climate change, earthquake, etc. occur frequently in the world. In 2018 heavy precipitation in various regions of Japan and the earthquakes in Hokkaido and Indonesiaproduced/greater human and economic/damage.
In 2019JpGU Atmospheric Electricity (AE) session, invited experts are going to introduce their scientific challenges in order to monitor, predict and mitigate natural disasters by using knowledge of the atmospheric electricity. For example, monitoring and prediction of extreme weather by the latest weather radar system and lightning observations, electromagnetic phenomena prior to earthquakes, etc. will be included. We certainly welcome contributed papers regarding all topics on atmospheric electricityincluding global circuit, ion and fair weather electricity, thunderstorm electrification, lightning physics, lightning and meteorology, electrical effects of thunderstorms on the middle and upper atmosphere such as transient luminous events and high energy phenomena, lightning protection, terrestrial electromagnetic environment and so on.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MIS27-07] Earthquake precursory electromagnetic phenoma : Summary and prospective

★Invited Papers

*Masashi Hayakawa[1] (1.Hayakawa Institute of Seismo Electromagnetics.Co. LTD. University of Electro-Communications venture company)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MIS27-08] Detection of lower ionospheric anomaly preceding earthquake using nonlinear autoregressive neural network

*Kakeru Matsuki[1], Hayato Iibuchi[1], Hendy Santosa[3], Yasuhide Hobara[1], Michael A Balikhin[2] (1.The University of Electro-Communications , 2.University of Sheffield, 3.University of Bengkulu)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MIS27-09] Analysis of multipoint measurements of plasma turbulence

*Michael A Balikhin[1], Simon N Walker[1] (1.University of Sheffield)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MIS27-10] Progress of Observation Project for High-energy Phenomena in Winter Thunderstorms

*Yuuki Wada[1,2], Teruaki Enoto[3], Takahiro Matsumoto[1], Kazuhiro Nakazawa[4], Yoshihiro Furuta[5], Takayuki Yuasa, Harufumi Tsuchiya[5], Daisuke Yonetoku[6], Tatsuya Sawano[6], Kazuo Makishima[1,2], Masashi Kamogawa[7], Yoshitaka Nakamura[8], Takeshi Morimoto[9], Mitsuteru Sato[10], Hideo Sakai[11], Hidehito Nanto[12], Tomoo Ushio[13] (1.The University of Tokyo, 2.RIKEN, 3.Kyoto University, 4.Nagoya University, 5.Japan Atomic Energy Agency, 6.Kanazawa University, 7.Tokyo Gakugei University, 8.Kobe City College of Technology, 9.Kindai University, 10.Hokkaido University, 11.University of Toyama, 12.Kanazawa Institute of Technology, 13.Tokyo Metropolitan University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MIS27-11] Electromagnetic and stroke current observations on rocket-triggered lightning

*Takeshi Morimoto[1], Shinya Kurokawa[1], Yoshitaka Nakamura[2], Kazuo Yamamoto[3] (1.Kindai University, 2.Kobe City College of Technology, 3.Chubu University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

Discussion

Earthquake precursory electromagnetic phenoma : Summary and prospective

*Masashi Hayakawa[1]

1. Hayakawa Institute of Seismo Electromagnetics.Co. LTD. University of Electro-Communications venture company

This paper describes the overview of electromagnetic phenomena mainly prior to an earthquake (EQ)(so-colled Seismo Electromagnetics). Initially this paper will report on the history of seismo-electromagnetics, findings for the 1995 Kobe EQ and the 2011 Tohoku EQ, recent statistical results, latest achievement (lithosphere-atomosphere-ionosphere coupling), prospective, etc.

Keywords: Seismo-Electromagnetics

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Detection of lower ionospheric anomaly preceding earthquake using nonlinear autoregressive neural network

*Kakeru Matsuki[1], Hayato Iibuchi[1], Hendy Santosa[3], Yasuhide Hobara[1], Michael A Balikhin[2]

1. The University of Electro-Communications , 2. University of Sheffield, 3. University of Bengkulu

It is possible to monitor the state of the lower ionosphere by observing the VLF (Very Low Frequency) transmitter radio waves with a frequency band of 10 to 50 kHz propagating between the Earth and the ionosphere. In recent years, NARX - NN (Nonlinear Auto Regressive with eXogenous Input - Neural Network) has been applied as a highly accurate modeling and prediction method of temporal variation of VLF band transmitter radio wave amplitude. As a result, we obtain the extremely high prediction accuracy of cross correlation coefficient 0.9 or more between predicted and observed amplitude. Meanwhile, anomalies in the VLF band transmitter radio wave amplitude have been reported indicating the disturbance of the lower ionosphere at night from a week to few days before large earthquakes. Since the accuracy of anomaly detection is not high yet, this study aims to improve the detection accuracy of the lower ionospheric disturbance by analyzing the nighttime amplitude of the VLF band transmission wave using NARX - NN. By specifying the external factors that affect the lower ionospheric disturbance preceding the earthquakes and statistically investigating the difference between observed and predicted values of the VLF amplitude, we contribute to understand occurrence mechaism of lower seismo ionospheric anomalies.

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Analysis of multipoint measurements of plasma turbulence

*Michael A Balikhin[1], Simon N Walker[1]

1. University of Sheffield

The presentation is devoted to the review of advanced methods for the analysis of multipoint measurements of plasma turbulence. Both time and frequency domain methods are reviewed. Using examples of in situ spacecraft observations of plasma turbulence it is shown how the system science based approaches can be used to identify linear and nonlinear dynamical processes within the turbulence.

Keywords: Turbulence, Dynamical processes

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Progress of Observation Project for High-energy Phenomena in Winter Thunderstorms

*Yuuki Wada[1,2], Teruaki Enoto[3], Takahiro Matsumoto[1], Kazuhiro Nakazawa[4], Yoshihiro Furuta[5], Takayuki Yuasa, Harufumi Tsuchiya[5], Daisuke Yonetoku[6], Tatsuya Sawano[6], Kazuo Makishima[1,2], Masashi Kamogawa[7], Yoshitaka Nakamura[8], Takeshi Morimoto[9], Mitsuteru Sato[10], Hideo Sakai[11], Hidehito Nanto[12], Tomoo Ushio[13]

1. The University of Tokyo, 2. RIKEN, 3. Kyoto University, 4. Nagoya University, 5. Japan Atomic Energy Agency, 6. Kanazawa University, 7. Tokyo Gakugei University, 8. Kobe City College of Technology, 9. Kindai University, 10. Hokkaido University, 11. University of Toyama, 12. Kanazawa Institute of Technology, 13. Tokyo Metropolitan University

In strong electric fields of thunderclouds and lightning, electrons are accelerated to relativistic energy, and emit bremsstrahlung gamma rays which are observed by space bourne, airbourne, and on-ground experiments. To reveal the mechanism and condition where the electron acceleration takes place, we have been performing the Gamma-Ray Observation of Winter Thunderclouds (GROWTH) experiments in coastal areas of Japan Sea since 2007. In 2015, we started multi-point observation campaigns with portable radiation detectors in Ishikawa and Niigata Prefectures. So far, we have revealed characteristics of long-lasting gamma-ray bursts from thunderclouds (long bursts: Tsuchiya et al. 2007), and photonuclear reacitons in the atmosphere triggered by terrestrial gamma-ray flashes coincident with lightning discharges (short bursts: Enoto et al. 2017). We are expanding the number of detectors to observe more events of such long and short bursts with multiple detectors. in the 2018-2019 winter season, we operated more than 20 radiation detectors. We are also promoting joint-observation campaigns with low-frequency radio and atmospheric electric-field measurements (Wada et al. 2018). We succeeded in the first simultaneous detection of long and short burst events in Kanazawa. Because the short-burst-triggering LF pulse took place within 1 km from the position where the long burst ceased, it is suggested that the strong electric field responsible for the long burst assisted the short burst. We will report the progress of the GROWTH project and this simultaneous detection event.

Keywords: lightning, gamma ray, radiation

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Electromagnetic and stroke current observations on rocket-triggered lightning

*Takeshi Morimoto[1], Shinya Kurokawa[1], Yoshitaka Nakamura[2], Kazuo Yamamoto[3]

1. Kindai University, 2. Kobe City College of Technology, 3. Chubu University

Rocket-triggered lightning is the most effective technique for artificial triggering lightning. It involves launching a small rocket trailing a thin grounded wire toward an overhead charged cloud. This technique is incredibly favorable for various lightning observations for example earth currents, leader developments, related electromagnetic and high-energy radiations etc. because a lightning strike is induced at the desired location. In Japan, a number of rocket-triggered lightning experiments were succeeded in winter thunderstorm seasons.

During the winter of 2017-18, the authors conducted a rocket-triggered lightning experiment in Noto Peninsula, facing to the Sea of Japan in Ishikawa Prefecture. A conductive wire was connected to the rocket and launched at faster than 100 m/s. A rope was also connected to prevent the rocket from rising above an altitude of 200 m. The rod-type ground electrode with a diameter of 1 cm was buried at a depth of 1 m.

We were successful in triggering lightning stroke at 1352:28h December 29, 2017. The two types of Rogowski coils to measure lightning current, hi-speed video cameras, RF antennas in VHF and LF bands were equipped around the striking point. The corona current and e-field were measured at about the distance of 50 m from the point. The measured lightning current was reached to -12 kA and continued for 290 ms. The recorded images with high time resolutions against recoded RF radiations and the current will be demonstrated in this talk.

Keywords: Rocket-triggered lightning, Winter thunderstorm, Lightning current, EM observations



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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Tue. May 28, 2019 3:30 PM - 5:00 PM JST | Tue. May 28, 2019 6:30 AM - 8:00 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[M-GI34] Marine Manganese Minerals

convener:Akira Usui(Marine Core Research Center, Kochi University), Yoshio Takahashi(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Katsuhiko Suzuki(Research and Development Center for Submarine Resources, Japan Agency for Marine-Earth Science and Technology), Takashi Ito(Faculty of Education, Ibaraki University), Chairperson:takashi ito(Ibaraki Univ.), Yoshio Takahashi(東京大学), Katsuhiko Suzuki(JAMSTEC)

Marine manganese deposits include nodules and crusts of massive iron-manganese oxide aggregates associated with useful metals. The deposits are known as potential resources of cobalt, copper, nickel, rare earth elements, platinum, and tellurium. However, the controlling parameters on the regional and temporal variations in chemical and mineralogical composition have not been clarified yet. In this session, various factors in the growth of manganese oxides, enrichment and circulation of metals, paleoenvironment, and formation age of manganese deposits will be discussed from viewpoints of geology, mineralogy, paleocean sciences, geochemistry, microbiology, and sea floor engineering.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MGI34-01] Challenges in microstratigraphy on the hydrogenetic ferromanganese crusts: Depositional processes and environments recorded as secular variations in microstructure, chemical and mineralogical compositions.

*Akira Usui[1], Anna Nagaoka[2], Go-Ichiro Uramoto[1], Masafumi MURAYAMA[3] (1.Marine Core Research Center, Kochi University, 2.Graduate School of Science, Kochi University, 3.Fac. Agriculture and Marine Sciences, Kochi University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MGI34-02] Abundant ferromanganese microparticles in oxic pelagic sediments

*Go-Ichiro Uramoto[1,2], Yuki Morono[2], Naotaka Tomioka[2], Shigeyuki Wakaki[2], Ryoichi Nakada[2], Rota Wagai[3], Kentaro Uesugi[4], Akihisa Takeuchi[4], Masato Hoshino[4], Yoshio Suzuki[4,5], Satoshi Mitsunobu[6], Fumito Shiraishi[7], Hiroki Suga[5], Yasuo Takeichi[8], Yoshio Takahashi[5], Fumio Inagaki[2] (1.Kochi University, 2.Japan Agency for Marine-Earth Science and Technology, 3.National Agriculture and Food Research Organization, 4.Japan Synchrotron Radiation Research Institute, 5.University of Tokyo, 6.Ehime University, 7.Hiroshima University, 8.High Energy Accelerator Research Organization)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MGI34-03] Fractionation of Zirconium-Hafnium in ferromanganese crusts

*Aya Sakaguchi[1], Junpei Inagaki[1], Minami Inoue[2], Akira Usui[3], Hiromitsu Haba[4], Masashi Kaneko[5], Shinya Yamasaki[1], Keisuke Sueki[1], Yoshio Takahashi[6] (1.Faculty of Pure and Applied Science, 2.Graduate School of Science, Hiroshima University, 3.Center for Advanced Marine Core Research , Kochi University, 4.Nishina Center, Riken, 5.Nuclear Science and Engineering Center, Japan Atomic Energy Agency, 6.Graduate School of Science, The University of Tokyo)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MGI34-04] Isotope fractionation of Mo-like elements during adsorption to ferromanganese oxides

*Masato Tanaka[1], Yoshio Takahashi[1] (1.Graduate School of Science, The University of Tokyo)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MGI34-05] **Distinct distribution trends of arsenate and molybdate in marine ferromanganese nodules**

*Shitong Yang[1], Soichiro Uesugi[1], Haibo Qin[1], Akira Usui[2], Yoshio Takahashi[1] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2.Geology Department, Kochi University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MGI34-06] Mineralogical and geochemical characteristics of ferromanganese nodules in the Minamitorishima EEZ

*Kentaro Nakamura[1], Koichi Horinouchi[1], Ryo Shimomura[1], Shiki Machida[2], Kazutaka Yasukawa[1,2], Koichiro Fujinaga[1,2], Yasuhiro Kato[1,2] (1.Department of Systems Innovation, School of Engineering, University of Tokyo, 2.ORCeNG, Chiba Institute of Technology)

Challenges in microstratigraphy on the hydrogenetic ferromanganese crusts: Depositional processes and environments recorded as secular variations in microstructure, chemical and mineralogical compositions.

*Akira Usui[1], Anna Nagaoka[2], Go-Ichiro Uramoto[1], Masafumi MURAYAMA[3]

1. Marine Core Research Center, Kochi University, 2. Graduate School of Science, Kochi University, 3. Fac. Agriculture and Marine Sciences, Kochi University

We attempted to apply the method of Shima-Shima-gaku (lamina stratigraphy named by prof. S. Kawakami) on the secular variations in growth structure, chemical and mineralogical properties between the growth columns of the hydrogenetic ferromanganese deposit. The critera for describing each bands or zones based on the macroscopic (=physical) properties are not always consistant with chronological correlations or may not match with mineral/chemical composition. Our microscopic characterization using optical microscope, XRF mapping, XRD, acid-leach, micro-focus X-ray CT proved a possibility of separating local and regional sources of each mineral particle or element which is closely associated the environments of eposition.

Keywords: marine manganese deposit, manganese crust, microstratigraphy, Shima-Shima-gaku

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Abundant ferromanganese microparticles in oxic pelagic sediments

*Go-Ichiro Uramoto[1,2], Yuki Morono[2], Naotaka Tomioka[2], Shigeyuki Wakaki[2], Ryoichi Nakada[2], Rota Wagai[3], Kentaro Uesugi[4], Akihisa Takeuchi[4], Masato Hoshino[4], Yoshio Suzuki[4,5], Satoshi Mitsunobu[6], Fumito Shiraishi[7], Hiroki Suga[5], Yasuo Takeichi[8], Yoshio Takahashi[5], Fumio Inagaki[2]

1. Kochi University, 2. Japan Agency for Marine-Earth Science and Technology, 3. National Agriculture and Food Research Organization, 4. Japan Synchrotron Radiation Research Institute, 5. University of Tokyo, 6. Ehime University, 7. Hiroshima University, 8. High Energy Accelerator Research Organization

Manganese is the third most abundant metallic element, after iron and titanium, in the Earth’ s crust, and ferromanganese minerals are sensitive to changes in redox condition. Assessing the formation and preservation of ferromanganese minerals is important for understanding the global marine cycles of manganese and numerous associated trace elements. The most extensive manganese mineral deposits occur on abyssal plains, including those below open-ocean gyres. However, the extent of ferromanganese minerals buried in subseafloor sediments remains unclear. During the Integrated Ocean Drilling Program (IODP) Expedition 329, we drilled the entire sedimentary sequence at 6 sites in the ultra-oligotrophic region of the South Pacific Gyre (SPG), where dissolved O_2 and aerobic microbial communities are present from the seafloor to the sediment-basement interface [1]. By using high-resolution imaging techniques, we found abundant (10^8-10^9 particles cm^{-3}) micrometer-scale ferromanganese mineral particles (Mn-microparticles) in the oxic pelagic clays of the South Pacific Gyre [2]. Furthermore, we established microparticle separation technique by the combined use of density concentration and flowcytometer/particles sorting techniques. Major and trace element compositional analyses revealed that iron and manganese were the major components of Mn-microparticles, while they also contained rare-earth elements. From the number of Mn-microparticles per unit volume of sediment and the global distribution of oxic pelagic clays, we estimated the number of Mn-microparticles to be 1.5-8.8 $\times 10^{28}$ particles, which accounted for 1.28-7.62 Tt of manganese. This estimate is at least 2 orders of magnitude larger than the manganese budget for manganese nodules and manganese crusts on the seafloor. Along with the examination of manganese input, formation, and preservation, this study provides new insights into the global budget of metallic elements in the abundant Mn-microparticles present in deep subseafloor environments.

[1] D’ Hondt, S., Inagaki, F., Zarikian, C. A., Abrams, L. J., Dubois, N., Engelhardt, T., Evans, H., Ferdelman, T., Gribsholt, B., Harris, R. N., Hoppie, B. W., Hyun, J.-H., Kallmeyer, J., Kim. J., Lynch, J. E., McKinley, C. C., Mitsunobu, S., Morono, Y., Murray, R. W., Pockalny, R., Sauvage, J., Shimono, T., Shiraishi, F., Smith, D. C., Smith-Duque, C., Spivack, A. J., Steinsbu, B. O., Suzuki, Y., Szpak, M., Toffin, L., Uramoto, G., Yamaguchi, T. Y., Zhang, G., Zhang, X.-H., and Ziebis, W. Presence of oxygen and aerobic communities from seafloor to basement in deep-sea sediment. *Nature Geosciences,* 8(4), 299-304, 2015.
[2] Uramoto, G.-I., Morono, Y., Tomioka, N., Wakaki, S., Wagai, R., Uesugi, K., Takeuchi, A., Hoshino, M., Suzuki, Y., Shiraishi, F., Mitsunobu, S., Suga, H., Nakada, R., Takeichi, Y., Takahashi, Y., and Inagaki, F., Significant contribution of subseafloor microparticles to the global manganese budget. *Nature Communications*. **10**, 400, https://doi.org/10.1038/s41467-019-08347-2, 2019

Keywords: Mn-microparticle, oxic pelagic clay, IODP Exp. 329

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Fractionation of Zirconium-Hafnium in ferromanganese crusts

*Aya Sakaguchi[1], Junpei Inagaki[1], Minami Inoue[2], Akira Usui[3], Hiromitsu Haba[4], Masashi Kaneko[5], Shinya Yamasaki[1], Keisuke Sueki[1], Yoshio Takahashi[6]

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Ferromanganese crusts (FMCs) are abyssal benthic chemical sediments that consist mainly of Fe and Mn oxide and hydroxide minerals, enriched with trace and precious metals. Due to their similar physicochemical properties, the elements zirconium (Zr) and hafnium (Hf), which are concentrated in FMCs, have a theoretically uniform ratio (Zr/Hf), which ratio is found in numerous systems. However, recent advances in analytical techniques have allowed observation of significant differences in the fractionation of these elements between seawater (Zr/Hf~45-350; Firdaus et al. 2011) and FMCs (Zr/Hf~57-88; Schmidt et al., 2014). In this study, we conducted adsorption experiments and XAFS analyses to clarify the concentrations and fractionation mechanisms of Zr-Hf in FMCs using synthesized minerals (Ferrihydrite and δ-MnO_2), radio-Zr and Hf tracers, and natural samples.

Six FMCs were collected from the Takuyo-Daigo and Ryusei seamounts, at water depths of from 950 m to 3000 m, using a ROV equipped with a live video camera and manipulators. The near surface layers (less than 1 mm) of all the FMCs were analyzed with XAFS and ICP-MS for Zr, Hf and other elements, and with XRD for mineral composition. Radiotracers were produced using the RIKEN AVF cyclotron for adsorption and co-precipitation experiments. Appropriate amounts of these tracers were added to 0.7 M NaCl solutions containing desferrioxamine B (DFOB) to obtain some Zr and Hf concentrations of solutions. The speciations of these elements in said solutions were confirmed by ESI-TOF-MS. Synthesized Ferrihydrite or δ-MnO_2 was added to the solutions and stirred for three hours at a pH of 8. In addition, Ferrihydrite or δ-MnO_2 was synthesized in said solutions. The activities of radio tracers in the filtered solutions were measured using a Ge detector. The adsorption/co-precipitation amounts to the solid phase were calculated using the differences in the radioactivity of the solution before and after filtration.

The major mineral composition of Fe and Mn in the FMCs did not vary significantly with the water depth of these seamounts. The concentrations of Zr and Hf increased with depth, and their ratios were totally fractionated from those of the seawater (Firdaus et al., 2011). Hf was more enriched in all FMCs than was Zr. The observed Zr chemical states in the FMCs were mainly coprecipitation with Ferrihydrite and coprecipitation with d-MnO2. In our adsorption experiments, the largest adsorption rate was observed in Hf to δ-MnO_2, followed in order by Zr to δ-MnO_2, Hf to Ferrihydrite and Zr to Ferrihydrite. The partition coefficients (K_D values) were calculated using the concentration ranges of Zr and Hf in seawater, where it was clear that Hf adsorbed more on both. Even though complexation rates estimated by RI-TLC were considered, there was no change in the adsorption behaviors in these experiments. For these samples, we found that the bond lengths between Zr-O and Hf-O in the first shells were shortened when they were incorporated into the oxides, with Hf-O becoming more shortened compared to Zr-O. The DFT calculations showed that Zr and Hf adsorbs on Fe and Mn oxides as bidentate-mono nuclear and bidentate-binuclear structures. The calculation results for the binding energies and bond orders of Zr and Hf to minerals gave a reasonable explanation of the fractionation mechanism for Zr-Hf pairs in FMCs.

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Keywords: Ferromanganese crusts, Zirconium, Hafnium

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Isotope fractionation of Mo-like elements during adsorption to ferromanganese oxides

*Masato Tanaka[1], Yoshio Takahashi[1]

1. Graduate School of Science, The University of Tokyo

A large mass-dependent isotope fractionation between seawater and ferromanganese oxides was observed, where lighter isotopes of Mo were preferentially incorporated into ferromanganese oxides. The large isotopic fractionation of molybdenum (Mo) is most likely caused by geometrical change from tetrahedral (Td) to distorted octahedral (Oh) during adsorption on manganese oxides based on X-ray absorption fine structure (XAFS) spectroscopy. The coordination number relates to its ionic radius. Thus, the elements which have similar ionic radius to Mo are expected to show the similar phenomena to Mo, i.e. the large isotope fractionation. Germanium (Ge) and Vanadium (V) can be candidate of such elements because they have similar ionic radius to Mo (Ge(IV): r= 0.53 Å, V(V): r=0.54 Å, and Mo(VI): r=0.59 Åfor 6-hold coordination). In this study, we examine the adsorption structure of Ge and V on Fe-/Mn-(oxyhydr)oxides by XAFS spectroscopy. Furthermore, the isotope fractionation during adsorption on the minerals is estimated by quantum chemical calculations.

XAFS analysis indicated that the adsorbed species of Ge on Fe- and Mn-(oxyhydr)oxides have Td geometry. On the other hand, the adsorbed structure of V on ferrihydrite is Td whereas that on δ-MnO_2 is distorted Oh. This trend of V in adsorbed species is similar to that of Mo. The geometries of hydrated species of Ge and V are Td. Thus, it is expected that a large V isotope fractionation occur during adsorption on Mn oxide, but a small fractionation in the case of Ge. In fact, a large isotope fractionation for V and a small isotope fractionation for Ge were estimated by quantum chemical calculations. This finding indicates that the requirement to show a Mo like large isotope fractionation during adsorption is not only an appropriate ionic radius. Recently, we found that two elemental properties of Mo(VI), namely d^0 electronic configuration and appropriate ionic radius, lead to the large isotope fractionation. In fact, V(V) possesses d^0 electronic configuration, but Ge(IV) does not. Tungsten (W)(VI) also satisfies the two properties and shows a large isotope fractionation during adsorption on Fe-/Mn-(oxyhydr)oxides. Thus, the elements which have the two elemental properties (Mo-like elements) can exhibit a Mo like large isotope fractionation during ferromanganese oxides.

Keywords: molybdenum, ferromanganese oxide, isotope fractionation, quantum chemical calculation, vanadium, germanium

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Distinct distribution trends of arsenate and molybdate in marine ferromanganese nodules

*Shitong Yang[1], Soichiro Uesugi[1], Haibo Qin[1], Akira Usui[2], Yoshio Takahashi[1]

1. Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2. Geology Department, Kochi University

Marine ferromanganese nodules or crusts with the hydrogenetic (HG), diagenetic (DG) and hydrothermal (HT) origins, are important sedimentary substrates for various elements such as lead (Pb), zinc (Zn), cobalt (Co), cerium (Ce), molybdenum (Mo), tungsten (W), arsenic (As), antimony (Sb), tellurium (Te), and etc. However, the distribution behaviors and host phases of tetrahedral arsenate (AsO_4^{3-}) and molybdate (MoO_4^{2-}) oxyanions in the ferromanganese oxides are far from understood. Herein, we combine sequential extraction approach and spectroscopic analyses to explore the mineralogical components of HG ferromanganese nodules collected from the Pacific Ocean and the speciation of arsenate and molybdate therein.

X-ray diffraction (XRD), X-ray absorption near-edge structure (XANES) and extended X-ray absorption fine structure (EXAFS) spectroscopy analyses indicate that the predominant manganese and iron phases were vernadite (δ-MnO_2) and ferrihydrite, respectively. According to the sequential extraction examination, both As and Mo are associated with the iron (oxyhydr)oxide phases. As K-edge EXAFS analyses indicate the immobilization of arsenate by ferrihydrite via forming inner-sphere complexes in double corner-shared form. This result is consistent with the sequential extraction data. However, Mo L_3-edge XANES analyses suggest the adsorption of molybdate on vernadite surfaces via the edge-shared complexation, being contrary to the conclusion derived from the sequential extraction results. This inconsistency reveals the unreliability of sequential extraction approach to verify the host phase of trace elements in complicated natural samples due to the potential occurrence of re-adsorption risk.

According to the spectroscopic analyses, chemical binding (ΔG_{chem}) rather than the previously proposed coulombic interaction (ΔG_{coul}) is the predominant driving force for the retention of arsenate and molybdate by HG ferromanganese nodules. The disparate distribution trends of arsenate and molybdate are attributed to their different intrinsic properties (e.g., averaged dissociation constants of conjugate acids) and the diverse properties (e.g., surface site densify, adsorption equilibrium constant and crystalline structure) of ferrihydrite and vernadite. These research findings will help assess the geochemical behaviors and environmental fate of trace elements in marine environment.

Keywords: Marine ferromanganese nodules, Arsenate , Molybdate, Host phases, Geochemical behaviors

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Mineralogical and geochemical characteristics of ferromanganese nodules in the Minamitorishima EEZ

*Kentaro Nakamura[1], Koichi Horinouchi[1], Ryo Shimomura[1], Shiki Machida[2], Kazutaka Yasukawa[1,2], Koichiro Fujinaga[1,2], Yasuhiro Kato[1,2]

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Ferromanganese nodules are spherical material mainly composed of manganese, iron, and other transition metal (oxyhydro)oxides, which are widely distributed on the deep seafloor around the world [1]. It has been widely accepted that ferromanganese nodules can be classified into three types: hydrogenetic, diagenetic and hydrothermal types [1]. Among them, hydrogenetic nodules are composed of Fe–Mn (oxyhydr)oxides that precipitated from seawater and thus, this type of nodules can be expected to provide proxy paleoceanographic records [2, 3, 4, 5].
In this study, we investigated mineralogy and geochemistry of ferromanganese nodules sampled from the Minamitorishima EEZ for the purpose of elucidating formation environment of the nodules. Both the ferromanganese mineral phase and bulk chemical compositions clearly show that these nodules are hydrogenetic in origin. Based on X-ray CT and micro X-ray mapping analyses, oxide layer of the nodules can be subdivided into five layers [6. 7]. Although ferromanganese mineral is common to all the oxide layers, we found that Mn/Fe and Ni content systematically changed from inner layer to outer layer. The result implies that bottom water of the Minamitorishima EEZ has gradually been oxygenated toward the present.

Keywords: ferromanganese nodules, ferromanganese mineral, bulk chemical compositions, formation environment, Minamitorishima EEZ

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Tue. May 28, 2019 1:45 PM - 3:15 PM JST | Tue. May 28, 2019 4:45 AM - 6:15 AM UTC | 301B 3F

[M-GI35] Development of computational sciences on planetary formation, evolution and surface environment

convener:Yoshi-Yuki Hayashi(Department of Planetology/CPS, Graduate School of Science, Kobe University), Masaki Ogawa(Division of General Systems Studies, Graduate School of Arts and Sciences, University of Tokyo), Shigeru Ida(Earth-Life Science Institute, Tokyo Institute of Technology), Kanya Kusano(Institute for Space-Earth Environmental Research, Nagoya University), Chairperson:Hiroki Kashimura

Computer simulations have been recognized as one of the fundamental tools in understanding planetary formation, evolution and diversity of surface environment. However, is may be notified that the continuous development of computational abilities in recent years does not seem to be well utilized in improving numerical simulations in those fields; computational efficiency has been improved by 6 orders of magnitude compared from the early 90's, many of our simulations do not seem to catch up qualitatively and quantitatively such improvement. We propose here in this session to ask those who are interested in computational sciences of various fields not only of planetary formation and evolution but also of earth and planetary sciences in general to join. The aim is to discuss various scientific and technical aspects of our numerical simulations to improve our skills to fully utilize those development of computational resources that is realized or will be realized in near future as "K" to "post-K".

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MGI35-01] Simulation Studies of Solar Activities as a Cause of Solar-Terrestrial Environment Variation

*Kanya Kusano[1], Hideyuki Hotta[2] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Faculty of Science and Engineering, Chiba University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MGI35-02] Development of a global non-hydrostatic Martian atmospheric model and its high-resolution simulation

*Hiroki Kashimura[1], Hisashi Yashiro[2], Seiya Nishizawa[2], Hirofumi Tomita[2], Kensuke Nakajima[3], Masaki Ishiwatari[4], Yoshiyuki O. Takahashi[1], Yoshi-Yuki Hayashi[1] (1.Kobe University/Center for Planetary Science, 2.RIKEN Center for Computational Science, 3.Kyushu University, 4.Hokkaido University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MGI35-03] Numerical simulations on the collision, adhesion, and growth of dust particles in turbulent gas in a protoplanetary disk

*Takashi Ishihara[1], Kohei Hamabata[2], Yoshiki Sakurai[2], Masayuki Umemura[3] (1.Graduate School of Environmental and Life Science, Okayama University, 2.Graduate School of Engineering, Nagoya University, 3.Center for Computational Sciences, University of Tsukuba)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MGI35-04] Development of N-body Simulation Code for Planetary System Formation With Particle-Particle Particle-Tree Scheme

*Yota Ishigaki[1,4], Junko Kominami[2], Junichiro Makino[3], Masaki Fujimoto[4] (1.University of Tokyo, 2.Tokyo Institute of Technology, 3.RIKEN AICS, 4.Institite of Space and Astronautical Science, Japan Aerospace Exploration Agency)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MGI35-05] Current status of post-K Exploratory Challenge, computational planetary science

*Junichiro Makino[1,2] (1.Kobe Univ, 2. RIKEN R-CCS)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC
Discussion

Simulation Studies of Solar Activities as a Cause of Solar-Terrestrial Environment Variation

*Kanya Kusano[1], Hideyuki Hotta[2]

1. Institute for Space-Earth Environmental Research, Nagoya University, 2. Faculty of Science and Engineering, Chiba University

Solar activity is the main driver of disturbance of solar-terrestrial environment, and an extreme space weather disaster caused by a giant solar eruption is a potential risk to modern society. The prediction is just a way to mitigate the space weather disaster. In this study, in order to improve our understanding and predictability of the solar-terrestrial environmental variation, we are developing the various types of simulations of solar activities. In this paper, we will report the recent progress of the following two topics. The first topic is for the comprehensive simulation of the whole solar convection zone. Since comprehensive calculation covering whole convection zone has not been carried out ever due to significant temporal and spatial differences between deep and surface layers, our understanding for connection between the solar surface and the deep solar interior has been limited. Here we succeed in carrying out such a calculation for the first time. The results show that the surface region has an unexpectedly small effect on the deep convection zone. The second topic is for the physics-based prediction of imminent giant solar flares. The results indicate that the non-linear force-free modeling based on the vector magnetic field data can be a powerful tool to predict when, where and how large giant solar flares will occur.

Keywords: solar convection zone, solar flares, space weather

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Development of a global non-hydrostatic Martian atmospheric model and its high-resolution simulation

*Hiroki Kashimura[1], Hisashi Yashiro[2], Seiya Nishizawa[2], Hirofumi Tomita[2], Kensuke Nakajima[3], Masaki Ishiwatari[4], Yoshiyuki O. Takahashi[1], Yoshi-Yuki Hayashi[1]

1. Kobe University/Center for Planetary Science, 2. RIKEN Center for Computational Science, 3. Kyushu University, 4. Hokkaido University

Scales of atmospheric motions in Earth range from a few meter scale to the planetary scale, and multi-scale phenomena interact with each other. This is a reason for promoting an atmospheric simulation with higher resolution. The situation must be the same in other planets such as Mars. In the Martian atmosphere, dust storms in various scales—from dust devils of tens to hundreds of meter scales, to local dust storm of several tens of kilometer scale, and to global dust storm—have been observed. However, interactions between these scales are unknown. In addition, since Mars has a thin atmosphere and no ocean, the temperature difference between day and night is large and vertical convection should play an essential role in the Martian meteorology, but it is also unknown. To investigate these mysteries, global atmospheric simulations with horizontal resolution as high as few kilometers are required. Additionally, in order to explicitly simulate vertical convection, it is necessary to solve the governing equations without assuming the hydrostatic balance.

We are developing a non-hydrostatic global Martian atmospheric model (Martian SCALE-GM) which is suitable for large-scale parallel computation, targeting to perform high-resolution simulations described above on the post-K computer. SCALE-GM (http://scale.aics.riken.jp/) is being developed by using the dynamical core of NICAM (Tomita and Satoh, 2005; Satoh et al., 2008; Satoh et al., 2014), a non-hydrostatic model using a finite volume method in the icosahedral grid systems (Tomita et al., 2001, 2002), that has been used for simulations of Earth atmosphere and climate, and by aiming at sharing of physical process modules with the regional model (SCALE-RM) and application to other planetary atmospheres. We are developing Martian SCALE-GM by incorporating constants and physical process modules of the Martian atmosphere. The Martian physical modules are taken from DCPAM (https://www.gfd-dennou.org/library/dcpam/), an existing pan-planetary atmospheric general circulation model (GCM). DCPAM is a traditional, hydrostatic GCM using a spectral method for horizontal discretization.

In this study, we ported a Martian atmospheric radiation model (Forget et al., 1999) and a soil model from DCPAM to SCALE-GM and performed a test of temperature evolution in a vertical 1D-atmosphere and soil. The atmosphere model has 100 layers (Δz = 1 km), and distribution of dust is fixed with 0.2 optical depth. The soil model has 18 layers. Soil's heat capacity and thermal conductivity are set to 9.7×10^5 [J K^{-1} kg^{-1}] and 0.076 [W m^{-1} K^{-1}], respectively. Surface albedo is fixed at 0.2. For the calculation of surface fluxes and vertical diffusion, BH91B95 (Beljaars & Holstang, 1991; Beljaars, 1995) and MY2.5 (Mellor & Yamada, 1982) are used, respectively. The initial condition is the 200 K constant temperature atmosphere and soil. We have confirmed that both models (SCALE-GM and DCPAM) show almost the same temperature evolution.

Next, we performed 3D calculations under a Mars-like condition in 7 different horizontal resolutions and checked the dependence of the numerical solutions on the horizontal resolution. Horizontal grid intervals are $240\times(1/2)^n$ [km] (n = 0, 1, 2, 3, 4, 5, 6); i.e., 3.75 km at minimum. The horizontal diffusion

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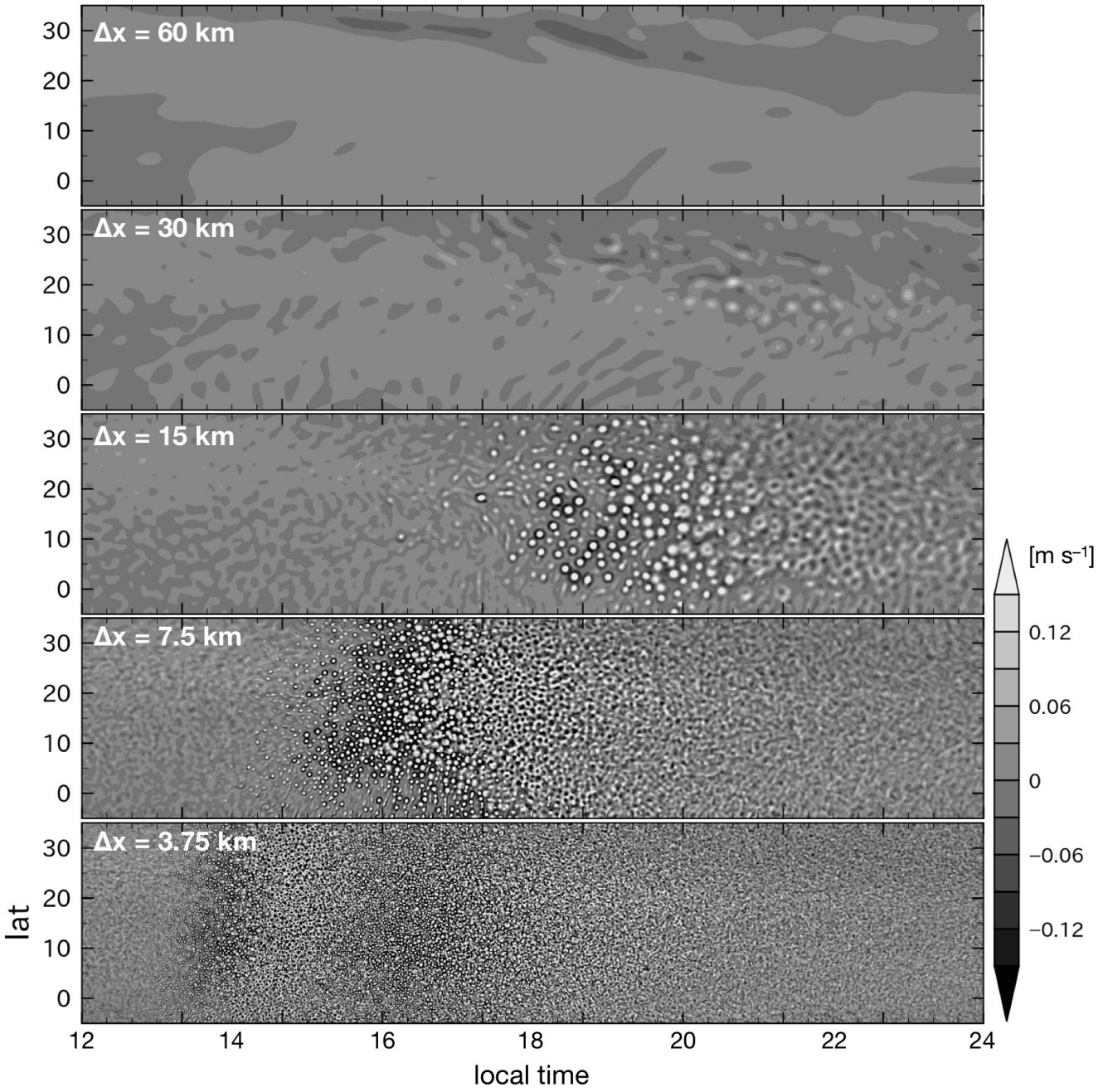
representing turbulent mixing in sub-grid scales is given in the 3rd order Laplacian with the relaxation time for the shortest scale given by $100\times(1/2)^n$ [s]. The atmosphere is divided into 36 layers, which are concentrated near the surface. To avoid wave reflections at the model top, a sponge layer represented by 1st order Laplacian is set above 40 km altitude; the relaxation time for the shortest scale is given by $3600\times(1/4)^n$ [s] except for the case of $\Delta x = 3.75$ km, in which 3 s is used. The 4th order Runge-Kutta method is used for time-integration with a time step of $360\times(1/2)^n$ [s]. The surface albedo is set to 0.5. Neither topography nor condensation processes are included.

Numerical solutions showed that vertical convections due to diurnal solar heating did not appear clearly in the cases with Δx larger than 15 km, whereas they appeared in higher resolution cases. Furthermore, it was confirmed that the horizontal scale and occurrence local-time of the vertical convection are highly dependent on the horizontal resolution at least in this range.

(Figure: Horizontal resolution dependence of vertical wind. Snapshots at 2 km altitude after 30 days from the spring equinox of the Northern hemisphere.)

Keywords: Mars, atmosphere, global, non-hydrostatic, high-resolution simulation, model development

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Numerical simulations on the collision, adhesion, and growth of dust particles in turbulent gas in a protoplanetary disk

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1. Graduate School of Environmental and Life Science, Okayama University, 2. Graduate School of Engineering, Nagoya University, 3. Center for Computational Sciences, University of Tsukuba

In a protoplanetary disk, dust grains, which are icy or rocky microscopic particles, are present at about one percent of gas mass. The dust grains collide and adhere with each other to grow in size repeatedly in turbulent gas of a protoplanetary disk. Planetesimals are widely believed to form as a consequence of this hierarchical coagulation from submicron-size dust particles to kilometer-size bodies in a protoplanetary disk. However, it has been argued that there are several physical barriers such as bouncing and radial drift barriers in the planetesimal formation process, and these remain unresolved, especially for silicate dust. In recent years, as a possible solution to these problems, the effect of turbulent clustering of dust grains has been attracting attentions.

In previous studies, it was pointed out that the clustering of particles by turbulence promotes adhesion growth (Pan et al, ApJ2011), and the statistics such as the collision velocity of dust particles in turbulent flow were investigated by a direct numerical simulation (DNS) of turbulence, solving the Navier–Stokes equations (Pan and Padoan, ApJ 2015). Recently, a series of large-scale DNSs of turbulence was conducted to study the velocity distribution of colliding particles in the turbulent flow and the dependence on flow nonlinearity (Reynolds number) (Ishihara et al, ApJ2018). However, numerical simulations on the coagulation process of dust particles were not performed. Therefore, whether dust grains grow hierarchically has not been clarified.

In this study, we developed a parallel code (using MPI and OpenMP) to simulate the collisional adhesion process of dust particles, in which the critical collision velocity (Wada et al, A & A, 2013) is taken into account, and investigated the adhesion processes of 512^3 dust particles using a large-scale DNS of turbulence.
As a result, we have found the following by the analyses of the obtained data:
(1) Dust particles collides with each other within the critical collision velocity preferentially at positions with smaller enstrophy (intensity of vorticity), while dust particles collide with the critical or higher collision velocity at positions with larger enstrophy.
(2) Even if the average collision speed exceeds the critical collision velocity, the collisions within the critical collision velocity can occur repeatedly, and thus rapidly growing dust grains do exist.
(3) The sticking probability of dust particles directly obtained by our simulations is larger than that estimated by the previous DNS data analysis (Ishihara et al ApJ 2018).
(4) The Reynolds number dependence of the dust motion for grains with long stopping time (the response time to flow change) is very weak. Hence, even in protoplanetary disk turbulence with much larger Reynolds number, the same growth process as in this study is expected.

The reasons and implication of the above results will be discussed by conducting the additional data analysis.

Keywords: Protoplanetary disk, Planetesimal formation, Numerical simulations on the collision, adhesion, and growth of dust particles

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Development of N-body Simulation Code for Planetary System Formation With Particle-Particle Particle-Tree Scheme

*Yota Ishigaki[1,4], Junko Kominami[2], Junichiro Makino[3], Masaki Fujimoto[4]

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In general, the planetary system is thought to be formed from protoplanetary disks surrounding the central star. In particular, it is accepted that terrestrial planets and the cores of gas giant planets are formed by accretion of km size objects (planetesimals) in the protoplanetary disk. The accretion process of the planets has been mainly discussed using the gravitational multi-body simulations (N-body simulations) of planetesimal systems. Various unresolved problems have been pointed out in the conventional standard planetary system formation theory.In recent years, new planetary system formation models have been proposed to solve these problems.However, there is no model with no problem even in these new models. Since N-body simulations with sufficient number of particles has not been performed, the generalized planetary system formation theory has not been constructed yet.

We have developed a new N-body simulation code with particle-particle particle-tree (P^3T) scheme for planetary system formation, GPLUM. The code GPLUM uses a fourth-order Hermite scheme to calculate gravitational interactions between particles within a cut-off radius and a Barnes-Hut tree scheme for gravitational interactions from particles beyond. The conventional simulation codes with P^3T scheme has the bottleneck that the calculation speed decreases when the mass ratio among the particles becomes large. We have solved it by implementing an algorithm which determines the cut-off radius based on mass and orbital semi-major axis of particles individually for each particle. The performance of GPLUM is significantly improved for the simulations of particle systems with mass distribution.

By improving the performance of the N-body simulation code, we made it possible to carry out numerous global simulation with various parameters. GPLUM allows us to perform N-body simulations with ~10^6-10^7 particles. By using GPLUM, we will perform N-body simulations with wide range and high resolution and investigate various parameters by perform parameter studies with N-body simulations.

Keywords: N-body simulation, planetary system formation

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Current status of post-K Exploratory Challenge, computational planetary science

*Junichiro Makino[1,2]

1. Kobe Univ, 2. RIKEN R-CCS

In FY 2016, as one of research project for post-K supercomputer, "Exploratory Challenge 3 Elucidation of the Birth of Exoplanets and the Environmental Variations of Planets in the Solar System" has been started. This FY is the last year for the two-year production phase, even though the post-K computer will not be ready until FY 2021. In this talk, I'll overview this project (we call this project computational planetary science project for short).

The development of post-K supercomputer was started in 2014, and its planed completion year is around 2021, with up to 100 times faster speed on real applications compared to K computer. As one of four "Exploratory Challenges", computational planetary science has been selected, and it is assigned to Kobe University, with other eight research institutes.

The computational planetary science project consists of four sub topics: planetary formation, dynamics and evolution of planets, solar activities and environmental change, and the origin of life. In this talk, I'll overview these topics, computational challenges, and products so far and future prospects.

Keywords: High Performance Computing, Computational Science

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[J] Oral | U (Union)：Union

Wed. May 29, 2019 1:45 PM - 3:15 PM JST | Wed. May 29, 2019 4:45 AM - 6:15 AM UTC | 103 1F

[U-04] Capture the fast process in Earth and planetary science

convener:Takashi Yoshino(Institute for Planetary Materials, Okayama University), Yoshinori Tange(Japan Synchrotron Radiation Research Institute), Chairperson:Takashi Yoshino(Okayama University), Yoshio Kono(愛媛大学地球深部ダイナミクスセンター), Yoshinori Tange

Phenomena such as destruction, eruption and collision are catastrophic phenomena, which is different from geological phenomena like mantle convection. However, global phenomena such as meteorite collisions characterised by extinction of dinosaurs were caused not only by long-term fluctuations but also by such a dramatic high-speed phenomenon. It is also important to understand the high-speed dynamics in order to consider evolution of the Earth and disaster prevention. Now it has become possible to capture fast phenomena from femtosecond to several minutes scale under the extreme condition with progress of synchrotron radiation technology. The purpose of this session is that comprehensively understand high-speed dynamics from many methods such as material science / observation / numerical model.

1:45 PM - 1:48 PM JST | 4:45 AM - 4:48 AM UTC

Introduction

1:48 PM - 2:00 PM JST | 4:48 AM - 5:00 AM UTC

[U04-01] Toward organization of a new field on fast process in Earth and planetary science

★Invited Papers

*Takashi Yoshino[1] (1.Institute for Planetary Materials, Okayama University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[U04-02] Fractal particle size distribution of pulverized fault rocks and dynamic fragmentation of rocks

★Invited Papers

*Jun Muto[1], Osamu Nishikawa[2], Hiroyuki Nagahama[1] (1.Department of Earth Sciences, Tohoku University, 2.Graduate School of Engineering and Resource Sciences, Akita University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[U04-03] Universal aspects of acceleration process toward unstable fast rupture

★Invited Papers

*Takahiro Hatano[1] (1.Earthquake Research Institute, University of Tokyo)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[U04-04] Semi-brittle flow in dunite and harzburgite at upper mantle pressures

★Invited Papers

*Tomohiro Ohuchi[1], Xinglin Lei[2], Yuji Higo[3], Yoshinori Tange[3] (1.Geodynamics Research Center, Ehime University, 2.National Institute of Advanced Industrial Science and Technology, 3.Japan Synchrotron Radiation Research Institute)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[U04-05] A mechanism of magma fracturing revealed by in-situ X-ray imaging and diffraction

★Invited Papers

*Satoshi Okumura[1], Kentaro Uesugi[2], Tatsuya Sakamaki[1], Akio Goto[3] (1.Division of Earth and Planetary Materials Science, Department of Earth Science, Graduate School of Science, Tohoku University, 2.SPring-8/JASRI, 3.Center for Northeast Asian Studies, Tohoku University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[U04-06] Estimation of physical parameters of volcanic eruptions based on analysis of eruptive products –Toward understanding of eruption dynamics–

★Invited Papers

*Fukashi Maeno[1] (1.Earthquake Research Institute, University of Tokyo)

Toward organization of a new field on fast process in Earth and planetary science

*Takashi Yoshino[1]

1. Institute for Planetary Materials, Okayama University

In the evolution of the Earth and the planet, it is necessary to consider that the event occurred on a short scale, which is different from the evolution on the geological time scale, gives a global impact on the evolution of the planetary scale and its surface environment.In order to understand such events, it is indispensable to understand high-speed processes such as destructive processes as typified by seismic activity, eruption processes in volcanic activities, and huge meteorite collision processes. Since these phenomena are events that can occur anytime even now, it is also an important research topic in terms of disaster prevention. In this presentation, we propose to combine the research on the elementary processes of these phenomena and the research on the influence of these phenomena from various types of research fields, and aim to construct an interdisciplinary research organization.
In recent years, with the progress of measurement experiment technology in large synchrotron radiation facility and X-ray free electron laser facility, It has been possible to detect the short time scale catastrophic phenomenon occurring in extreme environments in a wide range time interval extending from several minutes (> 10^2 s) to femtosecond (10^{-15} s). Studies combining synchrotron radiation with high pressure experiments is shifting from the observation of static processes to monitoring of dynamic processes such as deformation, attenuation, and destruction. It is becoming possible to capture phenomena on the millisecond scale.Situations are being developed that can detect the high-speed process. In studies using X-ray free electron laser, a situation where the collision process can be tracked in detail at 100 picosecond scale has been realized during impact compression experiment using high intensity laser. Furthermore, in the field of computer science using supercomputers, the progress of high-speed process reproduction experiments has been remarkable, and it is time to be able to oversee seamless research on capturing high-speed processes from atomic scale to huge meteorite collision.Research on high-speed processes has been studied independently in each event, but there are many aspects that common phenomena in the method of grasping the high-speed process and its elementary process are common. This session was planned with the goal of forming a research network that can efficiently operate "knowledge" by incorporating numerous methods such as material science, geophysical observation and numerical model. By establishing and utilizing this network, it is expected that we will comprehensively understand the high speed dynamics in Earth and planetary science, and at the same time obtain new knowledge about the impact on the global scale and cause a new paradigm shift.

Keywords: high speed process, failure, collision, eruption

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Fractal particle size distribution of pulverized fault rocks and dynamic fragmentation of rocks

*Jun Muto[1], Osamu Nishikawa[2], Hiroyuki Nagahama[1]

1. Department of Earth Sciences, Tohoku University, 2. Graduate School of Engineering and Resource Sciences, Akita University

Earthquake is a catastrophic phenomenon caused by the rapid slip on fault. Development of high-speed rotary shear apparatus enables us to conduct friction experiments of various rocks at seismic slip rates to investigate dynamic fault behaviors [1]. The nominal strain rate at the seismic slip reaches 100 /s under the slip rate of 1 m/s occurring across the 1 cm width of the slip zone. On the other hand, the field observations along large-scale strike-slip faults reported the peculiar fault rocks with in-situ shattered microstructures [2]. The rocks are called pulverized fault rocks and characterized by a lack of shear deformation and intense fragmentation. These intensive damage zones have been suggested to form dynamically during earthquake rupture propagation. Theoretical calculation of the rupture propagation predicts much higher strain-rate deformation exceeding 10000 /s near the rupture tip [3]. However, because such high strain rate can be achieved only along the very close to the tip, several models have also been proposed to explain the wide distribution (~ 100 m from the fault core) of the pulverized rocks along the fault [2,4,5]. From the microstructural analysis of pulverized rocks, we reported the measurements of size distributions of fractured particles [6]. Fragments in those rocks in both fault zones show a fractal size (power-law) distribution down to the micron scale. Fractal dimensions of fragments, dependent on mineral types, reaches 2.92 near the fault cores. The value exceeds a theoretical upper fractal limit of confined comminution (~2.58 [7]) and experimentally created gouges by high-speed friction experiment (~2.6 [8]). Fractal dimensions close to 3.0 have been reported in high-speed impact loading experiments. The observed fractal properties imply that pulverization is likely to have occurred by a dynamic stress pulse with instantaneous volumetric expansion, possibly during seismic rupture propagation similar to impact loading. The obtained results from fractal properties of the pulverized rocks are consistent with laboratory experiments for dynamic fragmentation of rocks using Split-Hopkinson Pressure Bar (SHPB or Kolsky Bar) apparatus [5, 9]. SHPB is a loading apparatus that transmits planar elastic compressive waves into a sample under strain rates of 10 ~ 1000/s. Using the apparatus, Doan and Gary [5] clearly showed that the high strain rate exceeds 150 /s is required to cause pulverization of granite. Moreover, from the analysis of grain size distribution of fragments created by SHPB experiments of fine-grained novaculite, Barber and Griffith [9] showed that energy dissipation by fragmentation is not trivial than previously considered (10 % to as much as 40 %). According to dynamic fragmentation model by Hild [10], strength of rocks in multiple fragmentation regime dramatically increases with strain rate. This implies that the significant strain-rate hardening accompanying pulverization may be the responsible for the significant energy sink of the earthquake [9]. In the presentation, we review the dynamic fragmentation phenomena based on field evidence, theoretical models and laboratory experiments using SHPB apparatus to shed light on the dynamic fault behavior.

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A. (2017) Phil. Trans. R. Soc. A, 375, 20160002. [10] Hild, F. et al. (2003) Rev. Franco. Gen. Civ., 7, 973-1003.

Keywords: Pulverized rocks, Dynamic fragmentation, Split-Hopkinson Pressure Bar Apparatus, Fractal, Earthquake rupture propagation

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Universal aspects of acceleration process toward unstable fast rupture

*Takahiro Hatano[1]

1. Earthquake Research Institute, University of Tokyo

In this talk, we will elaborate the acceleration process of unstable slip on a model of earthquake fault. based on an empirical friction law that has been verified in the lab scale, it is shown that slip velocity increases in a power law manner resembling the inverse Omori law. This acceleration process has been known empirically, and is derivable theoretically for a class of simple systems. We will show that this power-law acceleration is realized in a wider class of systems including non-planer faults and random brittle media. Analysis on a mean-field model indicates saddle node bifurcation is responsible for the power law behavior.

Keywords: earthquake, slip nucleation, precursory phenomena

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Semi-brittle flow in dunite and harzburgite at upper mantle pressures

*Tomohiro Ohuchi[1], Xinglin Lei[2], Yuji Higo[3], Yoshinori Tange[3]

1. Geodynamics Research Center, Ehime University, 2. National Institute of Advanced Industrial Science and Technology, 3. Japan Synchrotron Radiation Research Institute

The mechanism of intraslab earthquakes (> 40 km depth) is fundamentally different from those of shallower ones. This is because the frictional strength is much higher and fracture process associates ductile flow (i.e., semi-brittle flow) at deeper parts. The location of the double seismic zone in the subducting Pacific slab corresponds to the main dehydration field in the pressure-temperature diagram of the hydrous peridotite (Omori et al., 2002). The cause of intraslab seismicity at intermediate depths has been attributed to breakdown of hydrous minerals such as serpentinite (e.g., Ferrand et al., 2017) and lawsonite (Okazaki et al., 2016) because it causes unstable fault slip or shear localization. However, the role of aqueous fluid in fracturing at high pressures is still unclear.

To evaluate the effect of water on semi-brittle behavior of dunite and harzburgite, we conducted in-situ uniaxial deformation experiments on as-is/water-saturated dunite and harzburgite at pressures 1-3 GPa and temperatures 670-1250 K with a constant displacement rate using a deformation-DIA apparatus. Pressure, stress, and strain were measured in situ by using x-ray diffraction patterns and radiographs. Radiographs were taken at each several minutes in most of deformation experiments, though radiographs were continuously taken (each 5 seconds) during a deformation run (at 2 GPa and 860 K). Acoustic emissions (AEs) were also recorded continuously on six sensors, and three-dimensional AE source location were determined.

Formation of throughgoing faults was observed in water-saturated dunite and harzburgite at 860 K and lower temperatures. Fault slip rate is between 3E-5 and 4E-4 s^{-1} which are comparable to the background strain rate just before a faulting (1E-5 and 3E-4 s^{-1}), showing that shear localization is ineffective under water-saturated conditions. Addition of the aqueous fluid resulted in the reduction in the number of AE events in the faulted sample (i.e., aseismic faulting). A high time-resolution strain monitoring revealed that fault slip rate fluctuate within several ten seconds (i.e., stick-slip phenomena). Because the high time-resolution strain monitoring is a preliminary experiment, the relationship between stick-slip phenomena and aqueous fluid is unclear. We will investigate that point in near future.

Keywords: water, semi-brittle flow, faulting

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A mechanism of magma fracturing revealed by in-situ X-ray imaging and diffraction

*Satoshi Okumura[1], Kentaro Uesugi[2], Tatsuya Sakamaki[1], Akio Goto[3]

1. Division of Earth and Planetary Materials Science, Department of Earth Science, Graduate School of Science, Tohoku University, 2. SPring-8/JASRI, 3. Center for Northeast Asian Studies, Tohoku University

Explosive volcanism is one of the most spectacular phenomena on Earth. Explosive volcanism is characterized by the vigorous release of magma fragments and volcanic gases to the surface. In such cases, the magma is the continuum in the crust but becomes fragmented during its ascent. In particular, brittle fragmentation of silicic (relatively SiO2-rich) magma results in explosive eruptions. Therefore, the cause of brittle fragmentation of magma determines whether the eruption will be explosive or effusive.

The viscoelasticity of magma and the relaxation timescale of its structure are currently thought to control fragmentation (Dingwell, 1996 Science). Under rapid deformation rates, magma exhibits elastic behaviour, while viscous magma behaviour is dominant when the deformation rate is slow. Fiber elongation experiments for magmas clearly demonstrate the transition from viscous elongation to brittle fracturing with increased elongation rates. This transition is empirically formulated and can be applied to the modelling of volcanic eruptions (Gonnermann and Manga, 2003 Nature). In contrast, the atomic- to nano-scale structure of melt across this transition is poorly understood. For example, magma exhibits shear thinning (viscosity decreases as shear rate increases) behaviour when the shear rate is close to the conditions at which magma fracturing occurs. No explanation for the relationship between shear thinning and brittle fracturing has yet been proposed. Understanding the atomic- to nano-scale structures across viscous to brittle transition will provide important information for clarifying the mechanism of magma fragmentation. We have investigated magma fracturing by using in-situ X-ray imaging and diffraction techniques. Some preliminary results of our work will be introduced in this presentation.

Keywords: Volcanic eruption, Magma, Fracturing, X-ray imaging, X-ray diffraction

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Estimation of physical parameters of volcanic eruptions based on analysis of eruptive products –Toward understanding of eruption dynamics–

*Fukashi Maeno[1]

1. Earthquake Research Institute, University of Tokyo

'Volume' and 'mass discharge rate' of volcanic eruptions are fundamental parameters in understanding the spatiotemporal scale of magma accumulation and migration in the shallow crust and the type and nature of the surface phenomena accompanying the eruption. 'Volume' of one volcanic eruption is the most fundamental physical parameter for determining the scale of the eruption. Its mid- to long-term transition is related to the accumulation process of magma and the frequency of the eruption, as well as the entire volcanic activity. On the other hand, 'discharge rate' of magma is closely related to magma ascending process, and it is a parameter that controls diversity and transition of eruption styles, eruption intensity, and plume height, etc. The elucidation of 'volume' and 'discharge rate' of magma (physical parameter of eruption) is a key in understanding various volcanic phenomena occurring in the crust and the earth surface as the magma rises. The improvement of the estimation accuracy is indispensable to promote the understanding of the causes of diversity of volcanic activities and eruption phenomena, and the magma reservoir-conduit system. Also the magma discharge rate, which is one of the factors that dominates the diversity of the eruption, greatly influences the characteristics of the eruptive products caused by magma ascent and decompression such as the microstructure and texture, and the chemical composition heterogeneity. The elucidation of the relationship between such physical parameters of eruption and the characteristics of the products may enhance the understanding of volcanic eruptions. On the other hand, in recent eruptions, by comparing ejecta/deposit data with various remote observation data from the ground and satellites, it is possible to grasp the process from magma extrusion to deposition at high resolution. The knowledge obtained therefrom is expected to be an important constraint in the reconstruction of past volcanic events. Estimation of the eruption physical parameters is important not only for understanding the dynamics of volcanic eruption but also for predicting volcanic disasters and future eruptions. In this presentation, we will introduce the estimation of physical parameters of eruption in recent volcanic eruptions and the past gigantic caldera-forming eruptions and also describe the issues.

Keywords: volcanic eruption, eruptive volume, discharge rate, physical parameter

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[J] Oral | U (Union)：Union

Wed. May 29, 2019 3:30 PM - 5:00 PM JST | Wed. May 29, 2019 6:30 AM - 8:00 AM UTC | 103 1F

[U-04] Capture the fast process in Earth and planetary science

convener:Takashi Yoshino(Institute for Planetary Materials, Okayama University), Yoshinori Tange(Japan Synchrotron Radiation Research Institute), Chairperson:Takashi Yoshino(Okayama University), Yoshio Kono(愛媛大学地球深部ダイナミクスセンター), Yoshinori Tange

Phenomena such as destruction, eruption and collision are catastrophic phenomena, which is different from geological phenomena like mantle convection. However, global phenomena such as meteorite collisions characterised by extinction of dinosaurs were caused not only by long-term fluctuations but also by such a dramatic high-speed phenomenon. It is also important to understand the high-speed dynamics in order to consider evolution of the Earth and disaster prevention. Now it has become possible to capture fast phenomena from femtosecond to several minutes scale under the extreme condition with progress of synchrotron radiation technology. The purpose of this session is that comprehensively understand high-speed dynamics from many methods such as material science / observation / numerical model.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[U04-07] Chemical reaction processes bridge between asteroid Ryugu and early evolution of Earth

★Invited Papers

*Seiji Sugita[1,3], Hideharu Kuwahara[2], Kosuke Kurosawa[3] (1.Department of Earth and Planetary Science, Graduate School of Science Sciece, The University of Tokyo, 2.Ehime University, 3.Chiba Institute of Technology)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[U04-08] Time-resolved synchrotron X-ray observations of mineral transformations under static pressures: applications to non-equilibrium behaviors in shocked meteorites

★Invited Papers

*Tomoaki Kubo[1], Masaaki Miyahara[2] (1.Kyushu University, 2.Hiroshima University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[U04-09] Ultrafast pump-probe experiemnts for planetary materials using high-power lasers and XFEL

★Invited Papers

*Norimasa Ozaki[1] (1.Osaka University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[U04-10] Tracking dynamical phenomena with X-ray free-electron lasers

★Invited Papers

*Tetsuo Katayama[1] (1.Japan Synchrotron Radiation Research Institute)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[U04-11] High speed measurement with synchrotron radiation X-ray.

★Invited Papers

*Kentaro Uesugi[1] (1.Japan Synchrotron Radiation Research Institute)

4:45 PM - 4:58 PM JST | 7:45 AM - 7:58 AM UTC

[U04-12] Recent advances in high-pressure synchrotron X-ray experiments on magmas under pressure at the beamline 16-BM-B in Advanced Photon Source

★Invited Papers

*Yoshio Kono[1] (1.Geodynamics Research Center, Ehime University)

4:58 PM - 5:00 PM JST | 7:58 AM - 8:00 AM UTC

Discussion

Chemical reaction processes bridge between asteroid Ryugu and early evolution of Earth

*Seiji Sugita[1,3], Hideharu Kuwahara[2], Kosuke Kurosawa[3]

1. Department of Earth and Planetary Science, Graduate School of Science Sciece, The University of Tokyo, 2. Ehime University, 3. Chiba Institute of Technology

JAXA's Hayabusa2 has arrived at asteroid Ryugu and is uncovering many new aspects of the primitive asteroid, such as extremly low albedo (4.5+/- 0.1%), flat spectra (Cb type), young resurfacing age (<10^6 yr for the top 1 m layer), high boulder number dentity (x2 of Itokawa) and low abundance of hydrated minerals. These pieces of information is very importance for understanding the early evolution of inner solar system and Earth's surface environment. In particular, what happens upon hypervelocity impacts of such bodies is important for understading the atmospheric chemistry of early Earth. In this study, we review atmospheric entry processes, high-temperature chemistry processes, and discuss the implications of recent results on asteroid missions, such as Hayabusa2 and OSIRIS-REx, for Earth's early evolution.

Keywords: Asteroid missions, Hypervelocity impacts, Impact vapor clouds, Atmospheric entry physics

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Time-resolved synchrotron X-ray observations of mineral transformations under static pressures: applications to non-equilibrium behaviors in shocked meteorites

*Tomoaki Kubo[1], Masaaki Miyahara[2]

1. Kyushu University, 2. Hiroshima University

High-pressure transformations occur on timescales of ~0.01 to a few seconds in shocked meteorites. Reactions in such short timescales often remain incomplete and/or metastable state, which is usually problematic for the interpretation, but can be good information for shock durations if the kinetics is experimentally known. Here we present some experimental results on curious kinetic behaviors in seifertite and lingunite, those presences in shocked meteorites have been difficult to explain based on phase equilibrium. A conventional method combining multi-anvil high-pressure apparatus with synchrotron white X-ray was routinely used to observe non-equilibrium behaviors and their kinetics in minerals at pressures up to ~30 GPa by collecting time-resolved X-ray diffraction data every 10 sec with energy dispersive method. By using this system, we found that seifertite and lingunite are metastably formed at high pressures from silica and plagioclase, respectively. The problematic presence of these phases in shocked meteorites can be reasonably explained as metastable phases. Extrapolations of kinetic data obtained to shorter timescales at higher temperatures of shock events uniquely constrain the critical shock durations and the size of the impactor. Similar strategy has also been applied to the back-transformation recorded in shocked meteorites. Time-resolved X-ray observations have revealed that some high-pressure phases such as bridgmanite and lingunite do not directly transform to their low-pressure phases, but through the amorphous state. This may explain the presence of amorphous phases with enstatite and plagioclase compositions in shocked meteorites. Our studies demonstrate that the conventional 10-second time-resolved synchrotron X-ray observations under static pressures capture the critical processes of solid-state reactions during shock events. On the other hand, crystallization of high-pressure phases from shock-induced melt is another important process to be solved. Improvement of the system with better time resolution and grain observations by 2D detector are required to detect the rapid melt crystallization processes.

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Ultrafast pump-probe experiemnts for planetary materials using high-power lasers and XFEL

*Norimasa Ozaki[1]

1. Osaka University

Materials at high pressures and temperatures are of great current interest for warm dense matter (WDM) physics, planetary sciences, and inertial fusion energy research. At the high-energy density (HED) conditions, the micro-structures of material significantly influence the behavior and properties. Ultra-short X-ray pulse, *i.e.*, X-ray free electron laser (XFEL), is a unique and powerful tool to directly observe a structure and to reveal the time scale of the structural change under the dynamic high pressures. Here we present recent experimental results on shock-compressed planetary materials using high-power laser and XFEL.

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Tracking dynamical phenomena with X-ray free-electron lasers

*Tetsuo Katayama[1]

1. Japan Synchrotron Radiation Research Institute

X-ray free-electron lasers (XFELs) provide brilliant X-ray pulses with femtosecond duration and are utilized to track dynamics, which is difficult to capture using synchrotron radiation. In the femtosecond time domain, one can achieve "molecular movie"[1-3] with an atomic spatio-temporal resolution by combining XFEL and synchronized optical laser pulses. On the other hand, in the nanosecond time domain, XFELs are utilized to observe irreversible dynamic processes[4,5] with the single-shot measurement scheme that can not be performed with synchrotron radiation.
In this presentation, I will talk XFEL properties and research examples at SACLA to discuss the XFEL potentials in Earth and planetary science.

1. T. Katayama *et al.*, submitted.
2. K. H. Kim *et al.*, *Nature* **518**, 385-389 (2015).
3. T. Katayama *et al.*, *Struct. Dyn.* **3**, 034301 (2016).
4. K. H. Kim *et al.*, *Science* **358**, 1589-1593 (2017).
5. E. Nango *et al.*, *Science* **354**, 1552-1557 (2016).

Keywords: X-ray free-electron laser, dynamics

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High speed measurement with synchrotron radiation X-ray.

*Kentaro Uesugi[1]

1. Japan Synchrotron Radiation Research Institute

X-ray is suitable for a probe for investigation of materials inside because of its deep penetration depth. For examples, X-ray transmission images show the internal structure of materials, the X-ray energy spectrums show the chemical characteristics and mineral phase of the materials can be obtained from X-ray diffraction.

Synchrotron radiation X-ray has continuum spectrum and is highly collimated basically. Therefore, the X-ray condition such as energy, beam size and intensity could be tuned for the purpose of the measurement and materials. A lot of insertion devices such as in-vacuum type undulator have been installed in a storage ring of third-generation synchrotron radiation facility to obtain ultra-high flux density (photons / sec / mm^2) or brilliance (photons / sec / mm^2 / $(mrad)^2$ / 0.1%b.w.) X-ray at the sample. The highest brilliance of X-ray is about 10^9 time higher than the laboratory-based X-ray source. The high brilliant X-ray enable us to do ultra-high speed, spatial resolution and energy resolution measurement comparing to laboratory-based system.
At the SPring-8 the following experiments could be possible, X-ray imaging with more than 1kHz frame rate (liquid flow), X-ray diffraction with several kHz (insect flapping) and dispersive XAFS with 100Hz. These are essential technique for capturing various non-equilibrium or dynamic phenomena. At the conference, some examples of high speed measurement will be shown.

Keywords: Synchrotron radiation X-ray, High speed measurement, X-ray imaging

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Recent advances in high-pressure synchrotron X-ray experiments on magmas under pressure at the beamline 16-BM-B in Advanced Photon Source

*Yoshio Kono[1]

1. Geodynamics Research Center, Ehime University

High-pressure synchrotron X-ray experiments using large volume press is one of the most useful tools to investigate structure and properties of Earth’ s materials under high pressure and high temperature conditions. However, in contrast to extensive studies on high-pressure mineralogy and mineral physics, experimental investigation of structure and properties of magmas under pressure has been limited, due to experimental difficulties. In the past decade, new developments in high-pressure experiments, particularly combined with synchrotron X-ray techniques, have advanced the study of magmas under pressure. The new experiments have revealed significant changes to the structure and physical properties of magmas under pressure. In this talk, I will introduce recent advances in high-pressure synchrotron X-ray experiments for studying magmas at high pressures, developed at the beamline 16-BM-B, HPCAT in Advanced Photon Source, USA.

Keywords: High pressure, Magma, Synchrotron X-ray

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[J] Oral | U (Union)：Union

Wed. May 29, 2019 10:45 AM - 12:15 PM JST | Wed. May 29, 2019 1:45 AM - 3:15 AM UTC | Convention Hall A 2F

[U-07] How JpGU will manage environment and disaster from the impacts of unforeseen geo-hazards

convener:Koji Okumura(Graduate School of Letters, Hiroshima University), Jun Matsumoto(Deaprtment of Geography, Tokyo Metropolitan University), Daisaku Kawabata(Institute of Geology and Geoinformation, Geological Survey of Japan, AIST), Masaki Matsushima(Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology), Chairperson:Daisaku Kawabata, Koji Okumura(Hiroshima University)

Japan Geoscience Union has established the Environment and Disaster Coping Committee in 2008 to cope with various environmental and natural hazard issues. Those issues are among the most urgent and important geoscientific issues for the society. The enormous extent and severity of the disasters caused by the 2011 Tohoku earthquake and tsunamis urged collaboration of many scientific associations to know the effects of the extreme natural hazards. A number of severe meteorological, volcanic, and earthquake hazards demanded interdisciplinary collaboration to respond to the emergencies. The occurrence and consequence of severe disasters were clearly controlled by the combined effect of environments and hazards. In this session, we share our activities related with recent unforseen disasters, and discuss how Japan Geoscience Union sets up the framework to enhance the real cooperation among scientific associations to prepare the impacts of unexpected hazards.

10:45 AM - 10:55 AM JST | 1:45 AM - 1:55 AM UTC

[U07-01] Seismotectonic environments and landscape as keys to mitigate the impacts from unexpected hazards

*Koji Okumura[1] (1.Graduate School of Letters, Hiroshima University)

10:55 AM - 11:10 AM JST | 1:55 AM - 2:10 AM UTC

[U07-02] Activities related with the eruption at Kusatsu-Shiranesan (Motoshiranesan) volcano on 23 Jan,2018 - Focusing on JMA's activities -

*Junichi Miyamura[1] (1.Japan Meteorological Agency)

11:10 AM - 11:25 AM JST | 2:10 AM - 2:25 AM UTC

[U07-03] Correspondences to society events at emergency disaster – In case of the Annual Meeting of the Geological Society of Japan -

*Matsuda Hiroki[1,2] (1.Kumamoto University, 2.the Geological Society of Japan)

11:25 AM - 11:40 AM JST | 2:25 AM - 2:40 AM UTC

[U07-04] Aftershock and microtremor array observation around the source area of the 2018 Hokkaido Eastern Iburi earthquake

*Masayuki Yoshimi[1], Kahori Iiyama[2], Hitoshi Morikawa[2], Hiroyuki Goto[3] (1.Geological Survey of Japan, AIST, 2.Tokyo Institute of Technology, 3.DPRI, Kyoto Univ.)

11:40 AM - 11:55 AM JST | 2:40 AM - 2:55 AM UTC

[U07-05] Effect of non-linear site response on earthquake hazard map

*Takao Kagawa[1] (1.Tottori University Graduate School of Engineering)

11:55 AM - 12:10 PM JST | 2:55 AM - 3:10 AM UTC

[U07-06] Evolution of catastrofic landslides due to rapid valley incision and filling since Last Glacial Age in central Nepal Himalayas

★Invited Papers

*Hiroshi YAGI[1] (1.Faculty of Art, Science and Education, Yamagata University)

12:10 PM - 12:15 PM JST | 3:10 AM - 3:15 AM UTC
Discussion

Seismotectonic environments and landscape as keys to mitigate the impacts from unexpected hazards

*Koji Okumura[1]

1. Graduate School of Letters, Hiroshima University

Even if we know little about the hazards that may occur at certain location, the geologic envieonments and landscape may tell us the risks. They are seismotectonic enveironments and landscapes. Since people contact with geologic and geomorphic environments and landscapes very often, they will be useful keys to understand the risks from natural hazards in that location. The environments and landscapes of the 2018 June 16 Osaka-hokub earthquakes and 2018 September 6 Hokkaido Iburi Tobu earthquakes will be discussed.

Keywords: seismotectonics, geology, geomorphology

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Activities related with the eruption at Kusatsu-Shiranesan (Motoshiranesan) volcano on 23 Jan,2018 - Focusing on JMA’s activities -

*Junichi Miyamura[1]

1. Japan Meteorological Agency

Japan is one of the world's leading volcanic country with 111 active volcanoes, and so many volcanic disasters have been repeated. But after the early 20th century, no large eruptions occurred and volcanic activity in Japan has been quiet.
On the other hand, the eruption at Ontakesan volcano on 2014 sacrificed many mountaineers who were near the crater and caused the greatest volcanic disaster after the war. One of the features of eruptive disasters is that even a small eruption could lead to a great disaster if encountered near the crater. In the latest case, the eruption at Kusatsu-Shiranesan volcano on January 23, 2018 suddenly occurred at Motoshiranesan where there was no record of historical eruption and caused human damage at the ski resort near the eruption point.
The Volcanological Society of Japan was established as the world's first academic conference on volcanoes in 1932 and re-established as a specified nonprofit corporation in 2002 for the purpose of advance and disseminate volcanology and related science. The institution to which the member belongs is not only universities and research institutes, but also local municipalities, disaster prevention organizations, high schools and geological consultants. Recently, in order to lead to the reduction of volcanic disaster by volcanology research, we also focus on public awareness raising, such as opening lectures and symposiums targeting the general public.
In this presentation, we will introduce the activities related with the 2018 Motoshiranesan eruption by each institution, mainly on the correspondence of Japan Meteorological Agency.

Keywords: The Volcanological Society of Japan, The 2018 Motoshiranesan Eruption, Japan Meteorological Agency, Support for Activities of Volcanic Disaster Mitigation

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Correspondences to society events at emergency disaster –In case of the Annual Meeting of the Geological Society of Japan -

*Matsuda Hiroki[1,2]

1. Kumamoto University, 2. the Geological Society of Japan

We, the Geological Society of Japan, had the misfortune to be hit by emergency disasters during the Annual Meeting last two years. Consequently, we had no choice but to cancel a part of the Meeting. In this presentation, the circumstances and our treatments in those emergencies will be introduced.

Keywords: correspondence at emergency disaster, typhoon, earthquake, the Geological Society of Japan

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Aftershock and microtremor array observation around the source area of the 2018 Hokkaido Eastern Iburi earthquake

*Masayuki Yoshimi[1], Kahori Iiyama[2], Hitoshi Morikawa[2], Hiroyuki Goto[3]

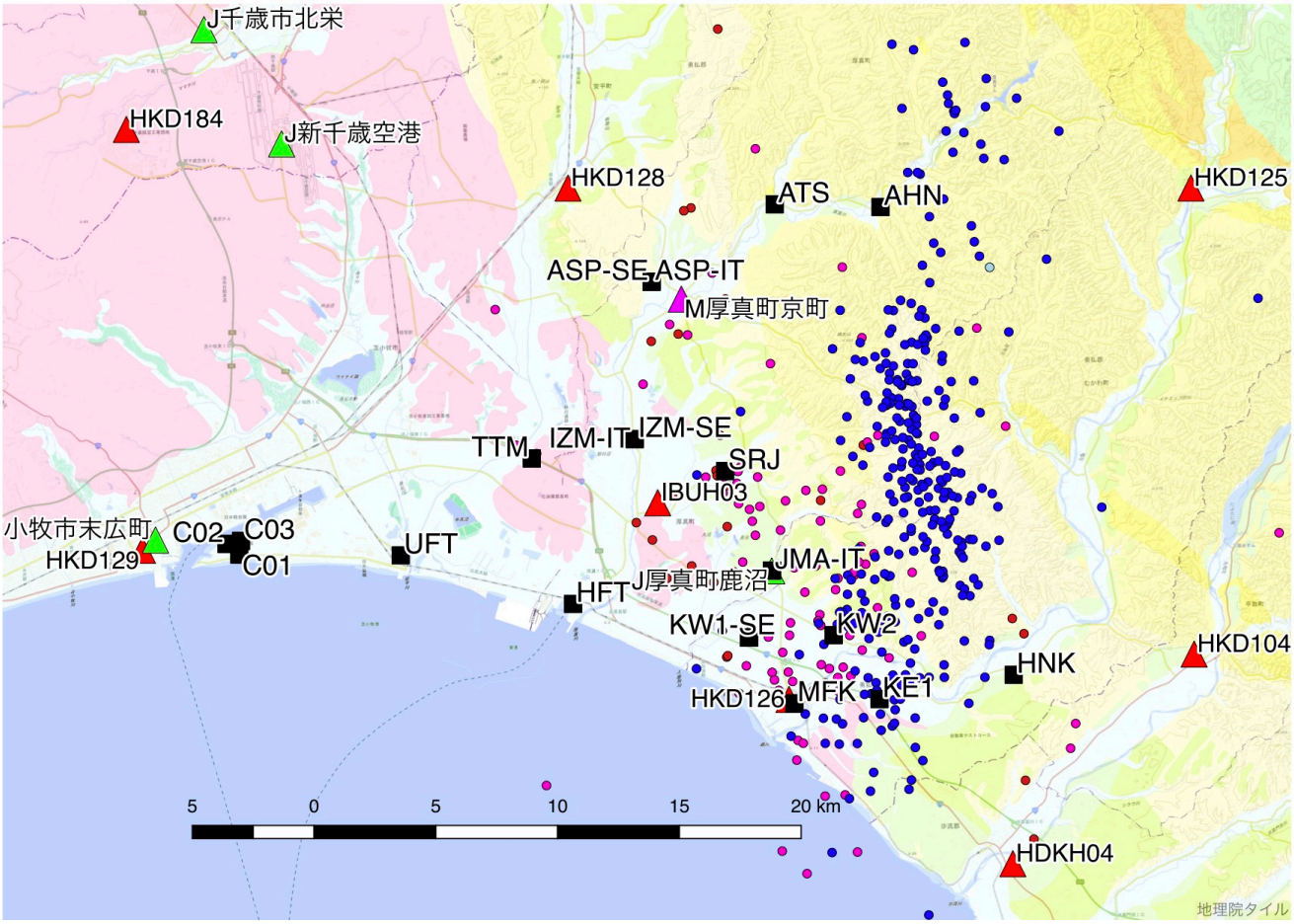
1. Geological Survey of Japan, AIST, 2. Tokyo Institute of Technology, 3. DPRI, Kyoto Univ.

The 2018 Hokkaido Eastern Iburi earthquake (Mw 6.6, depth=37 km) is a shallow to moderate depth earthquake. Strong ground motions were widely observed around the source area and in the Ishikari-Yufutsu sedimentary basin, culminated with the maximum seismic intensity VII of the JMA scale at JMA Atsuma seismic station. Waveforms with clear velocity pulse, having 1 to 3 dominant period, were observed along the west of the source area: K-NET Mukawa (HKD126), JMA Atsuma, KiK-net Atsuma (IBUH03), and Atsuma city hall. Velocity response spectra of these pulse waveforms are comparable to that of the Takatori station record, located close to the heavy damage area, during the 1995 Kobe earthquake. Therefore, we need to resolve the reason why such strong ground motions were developed during the 2018 earthquake although the magnitude was moderate (Mw 6.6) and focal depth was not shallow.

Four seismic station, where the strong pulse waveform was observed, are commonly located along the basin edge of the Yufutsu sedimentary basin. The subsurface velocity structure around the source area is considered to responsible for producing the ground motions. Thus, we conducted temporal observation of aftershocks and microtremor array measurements around the source area to investigate spatial variation of the site amplification and subsurface velocity structure. We deployed 14 temporal seismic station during 16th-21st Sep., 2018 to record around 20 aftershocks with magnitude larger than M2. We also conducted microtremor array survey at 13 locations with array aperture of several to 30 meters. Site amplification and subsurface velocity structures will be shown.

Keywords: The 2018 Hokkaido Eastern Iburi earthquake, strong ground motion, aftershock observation, microtremor array survey, subsurface velocity structure, site amplification

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Effect of non-linear site response on earthquake hazard map

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1. Tottori University Graduate School of Engineering

Various earthquake hazard maps are published by country and municipalities in Japan. It is better to consider non-linear site response for the hazard maps, however, simple frequency independent amplification of ground motion is frequently adopted. The site responses are generally evaluated from the data of microtremor or stationary earthquake observations; i.e. weak motion, therefore rigidity reduction and damping increase under strong ground motion are not considered in the responses. It is suspected that prolonged predominant period by non-linear site response and synchronized prolongation of residential natural period cause heavy building damages by the 2016 Kumamoto earthquake. It is also suspected that non-linear site response was one of triggers of slope failures and fill ground disaster through the 2018 Hokkaido eastern Iburi earthquake. The non-linear site response is an important issue to consider earthquake disaster by strong ground motion and also ground disaster.

Seismological community has noticed the effect from 1990s, however, evaluation methodology; i.e. program SHAKE, has been proposed in 1970s in engineering community. Latest methodologies have been introduced for modeling subsurface structures in seismological community such as microtremor survey, seismic interferometry, diffuse wave field theory and so on. Joint study across research fields beyond earth and planetary science is required for providing further realistic earthquake hazard map.

Keywords: Non-linear site response, Earthquake hazard map, Joint study across research fields

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Evolution of catastrofic landslides due to rapid valley incision and filling since Last Glacial Age in central Nepal Himalayas

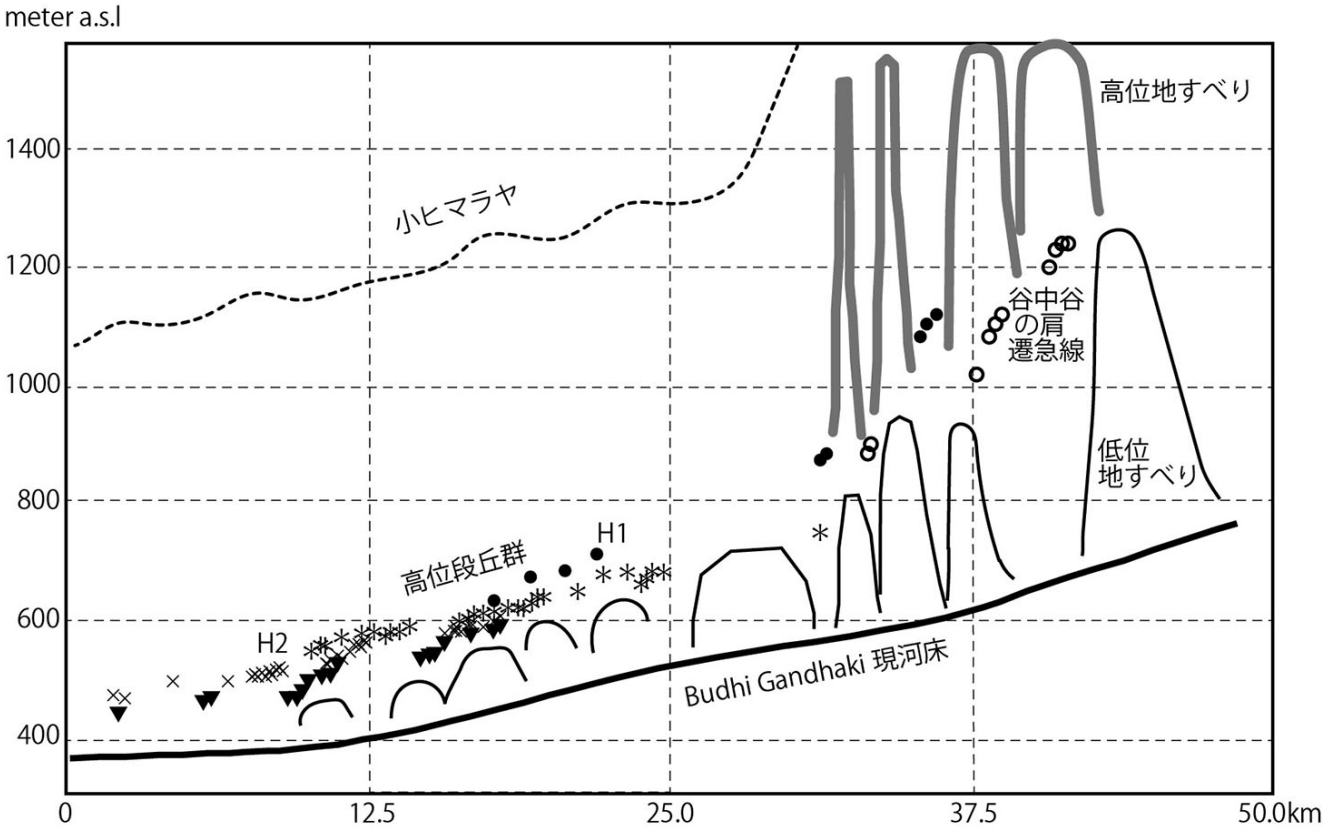
*Hiroshi YAGI[1]

1. Faculty of Art, Science and Education, Yamagata University

There remain higher landslides located on the upper slope of inner gorge, that was formed due to sever valley incision before 20k in the Last Glacial Age.

Sever valley incision caused destabilization of valley slope and the consequent valley filling stabilized the valley slope again. Present landslides are caused by re-incision of the filling of the Last Glacial Age.

Keywords: Nepal Lessor Himalaya, rapid valley incision & valley filling, destabilization of valley slope, inner gorge, last glacial age



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[J] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Wed. May 29, 2019 9:00 AM - 10:30 AM JST | Wed. May 29, 2019 12:00 AM - 1:30 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[P-EM16] Physics and Chemistry in the Atmosphere and Ionosphere

convener:Yuichi Otsuka(Institute for Space-Earth Environmental Research, Nagoya University), Takuya Tsugawa(National Institute of Information and Communications Technology), Seiji Kawamura(National Institute of Information and Communications Technology), Chairperson:Mitsumu Ejiri(国立極地研究所), Yuichi Otsuka

This session covers a broad scope of studies of physics and chemistry in the atmosphere and the ionosphere. Coupling processes between plasma and neutral species, and upward and downward coupling among lower/upper atmosphere, and ionosphere/mesosphere/thermosphere including magnetosphere are discussed. We solicit papers based on experiments with ground-based and/or space-borne instruments, theoretical studies, numerical simulations, and development of new observation techniques.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[PEM16-01] The model study of ionospheric variations during the solar eclipse event by assimulating the GNSS TEC observations

*Chia-Hung Chen[1], Charles Lin[1], Tomoko Matsuo[2] (1.Department of Earth Sciences, National Cheng Kung University, 2.Department of Aerospace Engineering Sciences, University of Colorado at Boulder, CO)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[PEM16-02] Characteristics of mesoscale thermospheric-ionospheric dynamics associated with heating in the auroral region

*Tomokazu Oigawa[1], Hiroyuki Shinagawa[2], Satoshi Taguchi[1] (1.Department of Geophysics, Graduate School of Science, Kyoto University, 2.National Institute of Information and Communications Technology)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[PEM16-03] Spatial distribution of the polar thermospheric wind acceleration and importance of the 2D measurement

*Shin-ichiro Oyama[1,2,3], Anita Aikio[2], Mark G Conde[4], Heikki Vanhamaki[2], Ilkka Virtanen[2], Thomas Ulich[5], Urban Brandstrom[6], Pekka Verronen[7], Monika Andersson[7], Niilo Kalakoski[7], Lassi Roininen[8], Sari Lasanen[8], Abiyot Workayehu[2], Kazuo Shiokawa[1], Heqiucen XU[1], Mamoru Ishii[9], Masafumi Hirahara[1], Takeshi Sakanoi[10], Masato Kagitani[10], Juha Sorri[5], Tomi Teppo[5], Yoshimasa Tanaka[3], Christopher Fallen[4], Brenton J Watkins[4], Mikko Orispaa[5], Yasunobu Ogawa[3], Lei Cai[11], Esa Turunen[5], Kirsti Kauristie[7], Takuo T. Tsuda[12], Junichi Kurihara[13] (1.Institute for Space-Earth Environmental Research, Nagoya University, Japan, 2.University of Oulu, Finland, 3.National Institute of Polar Research, Japan, 4.Geophysical Institute, University of Alaska Fairbanks, US, 5.Sodankyla Geophysical Observatory, University of Oulu, Finland, 6.The Swedish Institute of Space Physics (IRF), Sweden, 7.Finnish Meteorological Institute, Finland, 8.Lappeenranta-Lahti University of Technology, Finland, 9.National Institute of Information and Communications Technology, Japan, 10.Tohoku University, Japan, 11.KTH Royal Institute of Technology, Sweden, 12.The University of Electro-Communications, 13.Hokkaido University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[PEM16-04] Analysis of the thermospheric neutral wind vector using observed images of *Trimethylaluminium* (*C6H18Al2*) released from sounding rocket in the upper atmosphere

*Yuki Otsuka[1], Masa-yuki Yamamoto[1], Hiroaki Saito[1] (1.Kochi University of Technology)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[PEM16-05] Establishment of real-time analysis method in a new HRO interferometer system and operation test of comprehensive meteor observation

*Takumi Sato[1], Seiya Takeda[2], Masa-yuki Yamamoto[1] (1.KOCHI UNIVERSITY OF TECHNOLOGY, 2.Inc.Bascule)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[PEM16-06] Solar flare effects of the D-region ionosphere using daytime tweek atmospherics

*Kodai Yamanobe[1], Hiroyo Ohya[2], Hiroyuki Nakata[2], Toshiaki Takano[2], Kazuo Shiokawa[3] (1.Graduate School of Science and Engineering, Chiba University , 2.Graduate School of Science and Engineering, Chiba University, 3.Institute for Space-Earth Environmental Research, Nagoya University)

The model study of ionospheric variations during the solar eclipse event by assimulating the GNSS TEC observations

*Chia-Hung Chen[1], Charles Lin[1], Tomoko Matsuo[2]

1. Department of Earth Sciences, National Cheng Kung University, 2. Department of Aerospace Engineering Sciences, University of Colorado at Boulder, CO

Using the physics-based thermosphere-ionosphere model (NCAR-TIEGCM) with an ensemble Kalman filter, this study reports the first data assimilative analysis of the ionosphere responses to the solar eclipse on 21 August 2017. The system, using a 2-minute assimilation cycle of data from ground-based GNSS observations, show dynamic variations of the equatorial ionization anomaly (EIA) due to the electrodynamic effects of the solar eclipse. Two major ionospheric responses are captured: (1) an early appearance of EIA at the westward boundary of moon shadow and (2) an enhanced EIA at lower latitudes and suppressed EIA at the higher latitudes. These eclipse-induced conjugate EIA variations are produced by an eastward electric field perturbation around magnetic equator and a westward electric field perturbation at the higher latitudes.

Keywords: Ionospheric data assimilation, solar eclipse, electric field perturbation

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Characteristics of mesoscale thermospheric-ionospheric dynamics associated with heating in the auroral region

*Tomokazu Oigawa[1], Hiroyuki Shinagawa[2], Satoshi Taguchi[1]

1. Department of Geophysics, Graduate School of Science, Kyoto University, 2. National Institute of Information and Communications Technology

The thermosphere and ionosphere in the polar region have been studied for a long time. Recent results of the ground and satellite measurements have suggested that polar thermospheric and ionospheric dynamics are extremely complicated. In particular, in the auroral region, various processes, such as ion-neutral drag, Joule heating, heating and ionization by particle precipitation, chemical processes, diffusion, and atmospheric gravity waves, are strongly coupled. Previous observations have shown some characteristic mesoscale phenomena such as large vertical winds and significant increasing of mass density in the auroral region. It is considered that local heating plays an important role in such phenomena. However, we still have not quantitatively understood how such large vertical winds and significant increasing of mass density occur. In order to study the mesoscale thermospheric and ionospheric dynamics in the auroral region, a high-resolution numerical model including various physical and chemical processes is required. We will report on how the thermospheric and ionospheric dynamics change depending on the magnitude of the heating and the spatial structure of the heating region using a two-dimensional numerical model. In addition, interaction between the thermosphere and the ionosphere will be discussed.

Keywords: vertical neutral wind, neutral mass density, heating, auroral region, mesoscale, numerical simulation

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Spatial distribution of the polar thermospheric wind acceleration and importance of the 2D measurement

*Shin-ichiro Oyama[1,2,3], Anita Aikio[2], Mark G Conde[4], Heikki Vanhamaki[2], Ilkka Virtanen[2], Thomas Ulich[5], Urban Brandstrom[6], Pekka Verronen[7], Monika Andersson[7], Niilo Kalakoski[7], Lassi Roininen[8], Sari Lasanen[8], Abiyot Workayehu[2], Kazuo Shiokawa[1], Heqiucen XU[1], Mamoru Ishii[9], Masafumi Hirahara[1], Takeshi Sakanoi[10], Masato Kagitani[10], Juha Sorri[5], Tomi Teppo[5], Yoshimasa Tanaka[3], Christopher Fallen[4], Brenton J Watkins[4], Mikko Orispaa[5], Yasunobu Ogawa[3], Lei Cai[11], Esa Turunen[5], Kirsti Kauristie[7], Takuo T. Tsuda[12], Junichi Kurihara[13]

1. Institute for Space-Earth Environmental Research, Nagoya University, Japan, 2. University of Oulu, Finland, 3. National Institute of Polar Research, Japan, 4. Geophysical Institute, University of Alaska Fairbanks, US, 5. Sodankyla Geophysical Observatory, University of Oulu, Finland, 6. The Swedish Institute of Space Physics (IRF), Sweden, 7. Finnish Meteorological Institute, Finland, 8. Lappeenranta-Lahti University of Technology, Finland, 9. National Institute of Information and Communications Technology, Japan, 10. Tohoku University, Japan, 11. KTH Royal Institute of Technology, Sweden, 12. The University of Electro-Communications, 13. Hokkaido University

Understanding the flow of energy and mass throughout the magnetosphere-ionosphere-thermosphere coupled system is a fundamental goal of solar-terrestrial physics. Since substantial energy accumulated in the substorm growth phase in the magnetospheric tail flows into the polar ionosphere immediately after the substorm onset, investigating the energy dissipation process at high latitudes around the time of substorm onset can contribute significantly to achieving that objective. The energy dissipation generates acceleration and heating of the ionosphere and thermosphere, but this might occur not only near aurora but also far from it by hundreds kilometers equatorward. We analyzed ionospheric and thermospheric measurements in the northern Scandinavian area (65-80 N) during periods of considerably low geomagnetic activity but with some aurorae above Svalbard (75-80 N). Thermospheric winds measured with a Fabry-Perot interferometer (FPI; 630.0 nm) at Tromsø, Norway (69.6 N) showed westward accelerations coinciding with auroral brightening at the Svalbard area at the dusk sector though the relative distance from Tromsø to the aurora was 200-500 km in some cases. Moving into the dawn sector with the earth’ s rotation, the acceleration direction turned to southeastward through stagnation area or period seen at magnetic local midnight. The acceleration pattern well represents thermospheric responses to the ionospheric convection, but of particular interest is its location, in which the thermospheric wind have been obtained at the sub-auroral region far from the main auroral oval. In this analysis, we cannot infer to horizontal patterns of the wind acceleration because we have only a point measurement from the Tromsø FPI. While this result suggests the importance of two-dimensional measurements of ionosphere and the thermosphere, we need a new configuration of the observation network to infer horizontal winds and accelerations. In this presentation, we will introduce “SDI-3D” project, which aims at developing 3 Scanning Doppler Imagers (SDIs) and deploying them at the same area as for the EISCAT_3D, which may start in operation in 2022.

Keywords: aurora, substorm, Thermosphere, Ionosphere

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Analysis of the thermospheric neutral wind vector using observed images of *Trimethylaluminium* (*C6H18Al2*) released from sounding rocket in the upper atmosphere

*Yuki Otsuka[1], Masa-yuki Yamamoto[1], Hiroaki Saito[1]

1. Kochi University of Technology

Altitude profiles such as neutral atmospheric density and ionized atmospheric density in the thermosphere/ionosphere fluctuate by solar activity, season, day and night changes. These fluctuations with affecting on ground, communication with artificial satellites, and make affecting there orbits, but the detailed mechanism of occurrence has not been well understood. We have been conducting collaborative experiments with JAXA, NASA, etc. on inverstigating neutral atmospheric wind in the thermosphere/ionosphere, which is thought to play an important role in this mechanism.
In this research, the main objective is to calculate the neutral wind velocity in the thermosphere from the images of TMA observed in rocket experiment by JAXA conducted in July 2013.
JAXA conducted a rocket experiment in July 2013 to clarify the full picture of electromagnetic interaction and ionized/neutral atmosphere interaction acting on mid-latitude ionosphere. S-310-42 and S-520-27 sounding rocket were launched from Uchinoura Space Center(USC). Trimethylaluminum(TMA)was released in the former and lithium(Li) was released from the latter rocket into the upper atmosphere. Sequential optical observation of changes in these luminescent clouds was operated at each observation point and aircraft. Figure.1 shows the flight path of the aircraft/rockets in the experiment, the observation point, the emission region of TMA and Li, etc.
To calculate the wind speed, we use the images of TMA observed in July 2013 rocket experiment. I analyze the image sequence taken from the aircraft(Figure 2) and those images at USC(Figure 3)as a combination in which the TMA clouds are clearly seen and a long-time optical observations were performed. We use the method of Yokoyama(2011)and Kihara(2015)for caluculating of newtral wind speed.

Method by Yokoyama(2011)[1]
1 From the observed image, the central position of the cloud(TMA gas) is obtained from luminance information. Thereafter, the central axis of the TMA gas is obtained.
2 Choose one of the stars in the observed image as the center star. Also select ten stars around that.
3 Correct the distortion of the lens by using the X,Y coordinates of the stars(right ascension , declination) on the image.
4 Convert the coordinates of the obtained central axis are into celestial spherical coordinates. After that, it converts to earth coordinates using observation point information.
5 From the data of each observation point obtained by the above procedure, wind speed is calculated by using triangulation method.

Method by Kihara(2015)[2]
1 From the observed image, the central position of the cloud(TMA gas) is obtained from luminance information. Thereafter, the central axis of the TMA gas is obtained.
2 Correct distortion of the camera lens. After that, convert the coordinates on the image into the elevation and the azimuth angles.

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3 After applying the correction, the difference information is obtained from two images of the same point at different times. Then, the wind speed is calculated from the difference information.

We carried ou extraction of central axis of a TMA cloud, extraction of stars on the images, conversion to elevation and azimuth angles, then derived an approximate wind speed profile. However, it is thought te error at the time of detecting the center axis of the TMA cloud and the conversion error at azimuth/elevation angles are influenced. In the future, it is also necessary to correct lens distortion, tilt of camera, and aircraft velocity and altitude changes.
In this presentation, we would like to introduce more precise caluculation method of neutral wind speed.
References
[1]Kihara Osaki, "Aircraft observation of lithium resonant scattered light emitted from the observational rocket into the super high-rise atmosphere and development of a daytime thermospheric neutral wind measurement method" 2004 Kochi University graduate special research report, 2015.
[2]Yokoyama Yuki, "Multipoint observation of resonant scattered light by rocket emission Li of S-520-23 and high precision analysis of thermospheric neutral wind" 2008 Kochi University of Technology graduate special research report, 2009.

Keywords: the thermospheric neutral wind, sounding rocket, Trimethylaluminium (C6H18Al2)

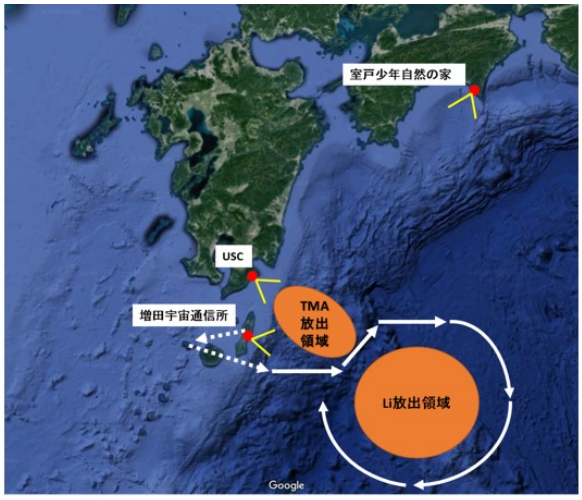


図1 Li、TMAの放出領域、航空機飛行経路、
地上観測点の位置関係



図2 航空機からの観測画像



図3 USCでの観測画像

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Establishment of real-time analysis method in a new HRO interferometer system and operation test of comprehensive meteor observation

*Takumi Sato[1], Seiya Takeda[2], Masa-yuki Yamamoto[1]

1. KOCHI UNIVERSITY OF TECHNOLOGY, 2. Inc.Bascule

Meteors are natural phenomenon that dusts is space with several millimeters to several centimeters in diameter in outer space jump into and collide with upper atmosphere of the earth, vaporizing and getting hot because of adiabatic compression by aerodynamic heating with emitting light at the same time. At the moment, thermal energy by aerodynamic heating make molecules in the atmosphere ionize, with generating a large amount of plasma. This plasma makes a elongated dense-ionized column along the meteoric trajectory. Meteor radio observation is an observation method using scattered radio waves by free electrons in the ionized column. In this research, at Kochi University of Technology (KUT), we conducted Ham-band radio meteor observation (HRO) in forward scattering method using the 53.755 MHz VHF (amateur band) wave that is transmitted stably from Fukui Prefectural University.
The objective of this research is that we apply a new observation method and analyzing algorithm to KUT 5ch meteor radio interferometer and develop meteor research using 5 antennas of the meteor radio interferometer [1]. Because of the limited radio meteor observation in Japan, if we share accurate observation method and observation result with the other observers, we can contribute to the development of study on meteor science.
In this research, we conducted three methods (comprehensive meteor observation [1]) of the new HRO interferometer system (HRO interferometer system), optical observation, and infrasound observation.
In the HRO interferometer system, after the signal received at the antennas was demodulated in their receivers, with making input to an observation PC through an AD board, real-time processing by analysing software on the PC was performed. A group of data set triggered only when exceeding a threshold set in advance on the software are saved as a meteor echo. In the analysis of meteor plasma direction of each meteor with considering intrinsic phase difference, we calculated each phase difference in north-south and east-west directions with baseline length of 0.5 λ and 2.5 λ (λ is observation wavelength), after processing interference calculation among signals of multiple antennas using 5ch meteor radio interferometer [1].
In the optical observation, we used existing high sensitivity B/W CCD camera (WAT-100N) and color 4K camera (Sony, α6300) newly installed with a combination of UFOCaptureV2 and HD2 that are motion capture software. The observation data was analyzed from the information recorded by cameras by analyzing position, velocity, linearity of motion, etc. by using UFOAnalyzerV2 for data stored through UFOCaptureV2 and HD2.
In the infrasound observation, we conducted a unique meteor observation for such as large fireballs by using a group of infrasound sensors that can observe very low frequency sound of less than 20 Hz caused by large scale natural phenomena. It is possible to estimate energy scale of the meteor entry from obtained amplitude and period of the sound wave.
In order to determine the intrinsic phase shift, we searched for the observability of the same phenomenon for the comprehensive meteor observation data.
In this research, we obtained 2 meteor shower data from August 2018 to January 2019. Especially, in 2019 at Quadrantids, three candidates of the intrinsic phase shift was obtained by analysis of comprehensive meteor observation data, but we could not confirm the intrinsic phase shift.

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As a result of this research, we obtained the candidate values necessary for accurate calculation of meteor plasma direction by the interferometer data processing. Due to lack of the observation data, we could not confirm the intrinsic phase shift, thus after checking the analyzing process, we will continue to use the system and obtain more data to establish the intrinsic phase shift and ensure the accuracy and reliability of the observation method.
We applied the new trial called real-time analyzing to KUT 5ch radio meteor interferometer with confirming the validity of the new receiver system, and obtained the candidate values of the intrinsic phase shift necessary for our future research. We shared a part of accurately obtained data on the web and a mailing lists, so as to contribute to the development of meteor science.

References
[1] Satoshi Mizumoto, “Calculation of meteor orbit by multiple-site radio observation and construction of a comprehensive meteor observation system”, Master thesis, 2017.

Keywords: Meteor, Ham-band radio meteor observation, Interferometer

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Solar flare effects of the D-region ionosphere using daytime tweek atmospherics

*Kodai Yamanobe[1], Hiroyo Ohya[2], Hiroyuki Nakata[2], Toshiaki Takano[2], Kazuo Shiokawa[3]

1. Graduate School of Science and Engineering, Chiba University , 2. Graduate School of Science and Engineering, Chiba University, 3. Institute for Space-Earth Environmental Research, Nagoya University

It has been known that intensity and phase of very low frequency (VLF, 3-30 kHz)/low frequency (LF, 30-300 kHz) transmitter signals significantly change due to intense ionization by solar flares [e.g., Mitra, 1974; Thomson et al., 2005]. Santolik and Kolmasova [2017] showed daytime tweek atmospherics (1.5-10.0 kHz) did not become observal for two hours just after a solar flare of M2.2 class, which suggests large absorption due to the solar flare. However, there are little studies for tweeks during solar flares. In this study, we investigate solar flare effects of the D-region ionosphere using tweek atmospherics. We analyzed the daytime tweek atmospherics observed at Kagoshima (31.48N, 130.72E) and Moshiri (44.37N, 142.27E), Japan, during January-July, 2013. The sampling frequency is 20 kHz, and the VLF data were recorded for each two minuteat 20-22 and 50-52 minutes every hour. For two M1.4-class flares, the daytime tweeks were received about 30-40 minutes after the solar flares. For a M5.6-class flare, the daytime tweeks were not observed for about 4 hours after the solar flare. The tweek reflection height had a weak negative correlation (-0.38) with X-ray flux observed by the GOES-13/15 satellites, suggesting that electron density in the D-region ionosphere increased with increasing the X-ray flux.In the presentation, we will discuss the D-region ionization and propagation mechanism of the tweeks during solar flares in more detail.

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[J] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Wed. May 29, 2019 10:45 AM - 12:15 PM JST | Wed. May 29, 2019 1:45 AM - 3:15 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[P-EM16] Physics and Chemistry in the Atmosphere and Ionosphere

convener:Yuichi Otsuka(Institute for Space-Earth Environmental Research, Nagoya University), Takuya Tsugawa(National Institute of Information and Communications Technology), Seiji Kawamura(National Institute of Information and Communications Technology), Chairperson:Yuichi Otsuka, Mitsumu Ejiri(国立極地研究所)

This session covers a broad scope of studies of physics and chemistry in the atmosphere and the ionosphere. Coupling processes between plasma and neutral species, and upward and downward coupling among lower/upper atmosphere, and ionosphere/mesosphere/thermosphere including magnetosphere are discussed. We solicit papers based on experiments with ground-based and/or space-borne instruments, theoretical studies, numerical simulations, and development of new observation techniques.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[PEM16-07] Toward a detection of sporadic-E episodes by ALOS2 ScaSAR InSAR

*Masato Furuya[1], Jun Maeda[2], Kosuke Heki[1] (1.Department of Earth and Planetary Sciences Hokkaido University, 2.Hokkaido University Library)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[PEM16-08] Vertical fine structure and time evolution of plasma irregularities in the E_s layer, observed by a high resolution Ca^+ lidar

*Mitsumu K. Ejiri[1,2], Takuji Nakamura[1,2], Takuo T. Tsuda[3], Takanori Nishiyama[1,2], Makoto Abo[4], Toru Takahashi[1], Katsuhiko Tsuno[5], Takuya Kawahara[6], Takayo Ogawa[5], Satoshi Wada[5] (1.National Institute of Polar Research, 2.SOKENDAI (Department of Polar Science, The Graduate University for Advanced Studies), 3.The University of Electro-Communications, 4.Tokyo Metropolitan University, 5.RIKEN, RAP, 6.Shinshu University Faculty of Engineering)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[PEM16-09] Study of Effects of Stratospheric Sudden Warming on Medium-Scale Traveling Ionospheric Disturbances Using Total Electron Content Data Obtained from World-Wide GPS Receiver Networks

*Yuichi Otsuka[1], Atsuki Shinbori[1], Prayitno Abadi[2], Takuya Tsugawa[3], Michi Nishioka[3] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.LAPAN, 3.National Institute of Information and Communications Technology)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[PEM16-10] Tsunami-generated ionospheric currents inferred from geomagnetic observations at ground level: Case for the 2011 Tohoku Earthquake

*Takuto Minami[1], Masashi Kamogawa[2], Tsutomu Ogawa[1], Makoto Uyeshima[1], Toru Mogi[3], Hiroshi Ichihara[4] (1.Earthquake Research Institute,The University of Tokyo, 2.Department of Physics, Tokyo Gakugei University, 3.Graduate School of Engineering, Hokkaido University, 4.Graduate School of Environmental Studies, Nagoya University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[PEM16-11] Relationship between the magnitude of Sakurajima eruptions and the disturbance of GPS-TEC

*Kiyoto Shoji[1], Hiroyuki Nakata[1], Toshiaki Takano[1], Hiroyo Ohya[1], Takuya Tsugawa[2], Michi Nishioka[2] (1.Graduate School of Science and Engineering, Chiba University, 2.National Institute of Information and Communications Technology)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[PEM16-12] Water vapor estimation using digital terrestriall broadcasting waves - Simultaneous observation with microwave radiometer -

*Hiroshi HANADO[1], Seiji Kawamura[1], Hironori Iwai[1], Shinsuke Satoh[1], Katsuhiro Nakagawa[1], Takuya Tajiri[2], Narihiro Orikasa[2], Yoshinori Shoji[2], Kentaro Araki[2], Hiromu Seko[2] (1.National Institute of Information and Communications Technology, 2.Meteorological Research Institute)

Toward a detection of sporadic-E episodes by ALOS2 ScaSAR InSAR

*Masato Furuya[1], Jun Maeda[2], Kosuke Heki[1]

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Maeda et al. (2016) and Furuya et al. (2017) reported their detections of sporadic-E (Es) episodes in Japan, using L-band interferometric synthetic aperture radar (InSAR). The SAR data images are acquired by Advanced Land Observation Satellite (ALOS) 1/2 launched by JAXA in 2006 and 2014, respectively. The high spatial resolution of InSAR data allow us to examine the detailed structure of Es episode, which will complement the high temporal resolution of GNSS TEC data. The previous two studies are based on stripmap-mode SAR images, which have higher spatial resolution but are limitted in terms of the observation swath-width (Maeda et al., 2016; Furuya et al., 2017). Although the stripmap-mode is the most standard SAR imaging mode, ScanSAR mode is also nearly operational nowadays, and can image the Earth with much wider swath-width by as much as 350 km; the standard stripmap-mode of SM1 for ALOS2 covers only 50 km. Although the ScanSAR mode is a bit worse in terms of the spatial resolution along radar range direction than the stripmap mode image, ScanSAR InSAR image can dramatically improve the observation coverage, and thus help detect both small-scale and large-scale structure of Es. We first check the data availability of ScanSAR images in Japan at any specific areas, and then check if any significant anomalies in either TEC or ROTI are observed via the database provided by NICT. We will report our preliminary results of ScanSAR InSAR imaging of Es in Japan.

Keywords: ionosphere, Sporadic-E, InSAR, ALOS2

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Vertical fine structure and time evolution of plasma irregularities in the E_s layer, observed by a high resolution Ca^+ lidar

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The vertical fine structures and the time evolution of plasma irregularities in the sporadic E (E_s) layer were observed via calcium ion (Ca^+) density measurements using a resonance scattering lidar with a high time-height resolution (5 s and 15 m) at Tachikawa (35.7˚N, 139.4˚E) on December 24, 2014. The observation successfully provided clearer fine structures of plasma irregularities, such as quasi-sinusoidal variation, localized clumps, “cats-eye” structures, and twist structures, in the sporadic Ca^+ (Ca^+_s) layers at around 100 km altitude. These fine structures suggested that the Kelvin-Helmholtz (K-H) instabilities occurred in the neutral atmosphere whose density changed temporarily or spatially. The maximum Ca^+ density in the Ca^+_s layer was two orders of magnitude smaller than the maximum electron density estimated from the critical frequency (f_oE_s) observed by the ionosonde at Kokubunji (35.7˚N, 139.5˚E) simultaneously. The correlation showed a strong positive correlation with a coefficient of 0.91. These results suggest that Ca^+ contributes forming the E_s layer as well as major metallic ions Fe^+ and Mg^+ in the lower thermosphere. Moreover, the formation of a new Ca^+_s layer at 110 km and the upward motions of the Ca^+_s layers at 100 km and 110 km were observed just after the sunrise time at the conjugation point and before the local sunrise. Although the presence or absence of a causal relationship with the sunrise time was not clear, a possible explanation for the formation and the upward motions of the Ca^+_s layers was the occurrence of strong eastward winds at around 100 km, rather than the enhancement of the eastward electric field.

Keywords: resonance scattering lidar, calcium ion density, sporadic E layer, fine structure, The mesosphere and lower thermosphere region

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Study of Effects of Stratospheric Sudden Warming on Medium-Scale Traveling Ionospheric Disturbances Using Total Electron Content Data Obtained from World-Wide GPS Receiver Networks

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Medium-Scale Traveling Ionospheric Disturbances (MSTIDs) are wavy structures of the ionospheric plasma density with horizontal scale-size of hundreds of kilometers. In order to investigate effects of Stratosphere sudden warming (SSW) on MSTIDs, we have analyzed total electron content (TEC) data obtained from GPS receivers at different four longitudinal sectors (east Asia, Europe, and western and eastern America) before and after SSW that occurred on January 2009 and 2013. To obtain perturbation component of TEC, which could be caused by MSTID, we have subtracted 1-hour running average from the original TEC time series for each pair of satellites and receivers, and converted the slant to vertical TEC. We have defined MSTID activity as dI/I, where dI is the standard deviation of the perturbation component within 1 hour, and I is 1-hour average absolute vertical TEC. In this study, we applied the same method to the GPS-TEC data at mid-latitudes before and after major Stratospheric Sudden Warming (SSW) events that occurred on January 2009 and 2013. We have found that MSTID activity during daytime is high before SSW events and low after SSW events. On the other hand, the nighttime MSTID activity does not show such a difference between before and after SSW events. These results suggest difference of mechanisms generating MSTIDs between daytime and nighttime. The daytime MSTIDs could be caused by gravity waves propagating upward from below into the thermosphere. Recent simulations suggest that these gravity waves are secondary waves generated from dissipation of the primary waves in the MLT region. Miyoshi et al. (JGR, 2015) have reported that the generation of secondary gravity waves is more active when the strato-mesospheric jet is strong, and that the generation of secondary waves is inactive when the strato-mesospheric jet is attenuated or becomes westward. Consequently, low MSTID activity after January 24 could be caused by weaker generation of secondary gravity wave during weaker or westward strato-mesospheric jet. On the other hand, gravity waves propagating from below does not contribute to generation of MSTIDs during nighttime.

Keywords: GPS, TID, Stratospheric Sudden Warming

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Tsunami-generated ionospheric currents inferred from geomagnetic observations at ground level: Case for the 2011 Tohoku Earthquake

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It is known that large earthquakes cause atmospheric gravity/acoustic waves reaching the ionosphere and drive ionospheric dynamo currents at the altitude (e.g. Iyemori et al. 2005). Related phenomena were detected by observations of total electron content (TEC) (e.g. Tsugawa et al. 2011) and reported by numerical simulations (e.g. Kherani et al. 2013). However, the form of electric currents due to the coseismic ionospheric dynamo has never been revealed from the perspective of geomagnetic observations at ground level.

We investigated 1-min sampling magnetic data at nineteen on-land stations on the Japan Arc and at one ocean-bottom magnetometer ~200 km off the Tohoku, to reveal the form of coseismic electric currents in the ionosphere during the 2011 Tohoku earthquake (Mw 9.0). First, we subtracted the effects of non-seismic components of ionospheric and magnetospheric origins from the geomagnetic data, using magnetic transfer functions between the stations of interest along the Japan Arc and a reference site in China, Changchun. Second, we subtracted the oceanic dynamo effects due to the tsunami by a time-domain finite element simulation in the same manner as Minami et al. (2017). By rotating the coordinate system at each station to that consisting of radial and transverse axes in terms of the tsunami centre, we recognized a clear concentric propagation of a trough in the radial magnetic component with a phase velocity of ~ 1 km/sec and a trough amplitude of ~ 7 nT. This propagation happens in all the directions and the propagation velocity is almost the same as that of the slow coseismic ionospheric disturbances (CID) observed by TEC observations (e.g. Kakinami et al., 2013). The radial propagation of a trough in the radial component indicates presence of anti-clockwise electric currents in the ionosphere.

In the presentation, we report our analysis of the geomagnetic data at ground level and the inferred characteristics of the coseismic electric currents in the ionosphere. We also plan to show some results of spectral analyses of the propagation features involved in the geomagnetic data.

Keywords: tsunami, dynamo, magnetic observations, The 2011 Tohoku Earthquake

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Relationship between the magnitude of Sakurajima eruptions and the disturbance of GPS-TEC

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It is reported that ionospheric disturbances are caused by ground and atmospheric perturbations, e.g. earthquakes, typhoons and volcanic eruptions. Even though the volcanic eruptions excite the atmospheric waves, there is little reports of ionospheric disturbances caused by volcanic eruptions. Therefore, in this study, we analyzed the ionospheric disturbances caused by volcanic eruption using Total Electron Content (TEC) determined by GNSS system.
We analyzed TEC data observed in GNSS Earth Observation Network (GEONET) which is maintained by Geospatial Information Authority of Japan. We assumed that the ionospheric pierce points (IPP) are located at the altitude of 300 km. The 30-second TEC data are obtained in about 1200 points of GEONET. The mask angle is 30 degrees. We analyzed four events of Sakurajima eruptions (7:45 UT on Oct.-3-2009, 1:07 UT on Sep.-19-2012, 20:25 UT on Dec.-9-2012 and 20:21 UT on Feb.-12-2014). The magnitudes of the eruptions are estimated by the infrasound meter located at Higawa-Korimoto.
The TEC disturbances are larger in the larger magnitude of the events.
It is expected that the TEC disturbance is inversely correlated with the distance from the crater as the energy of the atmospheric wave spreads according to the distance from the crater. Examining the relationship between TEC disturbances and the distances of IPPs from the crater. There was an inverse correlation with the distance in one events out of four events. However, no correlation was found in the other three events. This may be due to the directions of the magnetic field and the wave normal of the disturbance to the GPS satellite-receiver. In order to correct these effect, we calculated two coupling coefficients of the directions of the atmospheric wave from the calculation results of the acoustic ray tracing the one is related to the direction of the magnetic field, and the other is to the direction between the transmitters (satellites) and GNSS receivers. After this connection, an inverse correlation between TEC disturbances and the distance from the crater was appeared in three events.
However, some data showed higher values than the expected values. In the IPPs where the corrected values are high, the correction coefficients are very small. Therefore, the cause of the high values is too effective correction.

Keywords: ionosphere, volcanic eruptions, Total Electron Content

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Water vapor estimation using digital terrestriall broadcasting waves - Simultaneous observation with microwave radiometer -

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1. Introduction

NICT is developing a method that can observe water vapor in a wide area and efficiently. Water vapor is an important quantity along with wind velocity and temperature in the weather prediction. Solid / liquid phase water in the atmosphere can be observed with weather radars, but water vapor, water in gas phase, can not be observed with radars. Water vapor observation methods in a wide area are limited. Currently, GPS / GNSS precipitable water observation which is used as water vapor data in a weather numerical model uses the delay amount of the L-band radio waves from the GPS / GNSS satellites. NICT have demonstrated that similar measurements are possible with the terrestrial digital broadcast wave in UHF [1]. The method is that using delay profile decorded from scattered pilot signals embedded in the terrestrial digital broadcast wave, the reflected wave scattered from the surrounding reflector, building or towers, is separated from the direct wave. By using phase difference between the reflected wave and direct one, the influence of the phase noise of the reference signal at the broadcast station / reception point is canceled, and the propagation delay of the UHF band radio wave is measured with accuracy of picosecond level.

2. Simultaneous observation with microwave radiometer

We installed a microwave radiometer and terrestrial digital broadcasting wave receiver on the roof of the Meteorological Research Institute, Tsukuba, in February 2017, and we are continuing long-term observation. The microwave radiometer is an instrument capable of observing the amount of water vapor accumulated in the vertical direction above the measurement point. On the other hand, water vapor observation by the terrestrial digital broadcast wave means the amount of water vapor along the horizontal direction near surface. These observation volumes are different in size and shape. Therefore, by combining the two sensors, complementary observation of the water vapor amount is expected. In terms of time resolution, the microwave radiometer is not so good as it directs the antenna beams in a plurality of directions and estimates from the received thermal noise powers. In the water vapor estimation by terrestrial digital reception, more than 50 samples are measured per second, and it has a rather high temporal resolution. In this presentation, we will compare the variation of water vapor observed by microwave radiometer and terrestrial digital broadcasting wave for about one and a half years, and introduce the analysis results focusing on the difference in characteristics.

Keywords: water vapor, digital terrestrial broadcasting wave, propagation delay

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[J] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Wed. May 29, 2019 1:45 PM - 3:15 PM JST | Wed. May 29, 2019 4:45 AM - 6:15 AM UTC | 201A 2F

[P-EM18] Heliosphere and Interplanetary Space

convener:Ken Tsubouchi(University of Electro-Communications), Masaki N Nishino(Japan Aerospace Exploration Agency, Institute of Space and Astronautical Science), Yasuhiro Nariyuki(Faculty of Human Development, University of Toyama), Kazumasa Iwai(Institute for Space?Earth Environmental Research (ISEE), Nagoya University), Chairperson:Yasuhiro Nariyuki, Kazumasa Iwai

This session aims to secure comprehensive insights into physical processes of plasmas and fields in the heliosphere. Presentations of the recent studies from any approaches (integrated observations/theoretical modeling/massive numerical simulation) are welcomed. Topics are not restricted to any specific issues: phenomenological studies on solar flares/CME/solar wind, and related fundamental physics problems such as shocks/waves/turbulence/particle transport and acceleration can be the main target, including heliospheric high-energy phenomena and their impact on the Earth's environment.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[PEM18-01] Problems in determining structures of interplanetary magnetic flux ropes

*Katsuhide Marubashi[1], Yuki Kubo[1], Nobuhiko Nishimura[2], Munetoshi Tokumaru[2], Nada Al-Haddad[3] (1.National Institute of Information and Communications Technology , 2.ISEE, Nagoya University, 3.IACS, Catholic University of America)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[PEM18-02] Validation of estimated interplanetary flux rope axial direction using internal plasma motions: benchmark test

*Nobuhiko Nishimura[1], Munetoshi Tokumaru[1], Katsuhide Marubashi[2] (1.Institute for Space Earth Environmental Research, 2.National Institute of Information and Communications Technology)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[PEM18-03] Effect of line-of-sight integration on locations of coronal mass ejection in the sky projection map of interplanetary scintillation observations

*Munetoshi Tokumaru[1], Ken'ichi Fujiki[1], Kazumasa Iwai[1] (1.Institute for Space-Earth Environmental Research, Nagoya University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[PEM18-04] Estimation of spatial structure of whistler mode wave packets in Earth’s bow shock by multiple spacecraft analysis

*Chika Umegaki[1], Takanobu Amano[1], Naritoshi Kitamura[1] (1.The university of tokyo)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[PEM18-05] Experimental Test for Stochastic Shock Drift Acceleration Theory

*Takanobu Amano[1], Takuma Katou[1], Naritoshi Kitamura[1], Mitsuo Oka[2], Yosuke Matsumoto[3], Masahiro Hoshino[1] (1.Department of Earth and Planetary Science, University of Tokyo, 2.Space Sciences Laboratory, University of California, Berkeley, 3.Department of Physics, Chiba University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[PEM18-06] Radial structure of heliospheric boundary region

*Shuichi Matsukiyo[1], Gary P. Zank[2], Haruichi Washimi[3], Tohru Hada[1] (1.Faculty of Engineering Sciences, Kyushu University, 2.The Center for Space Plasma and Aeronomic Research, University of Alabama in Huntsville, 3.International Center for Space Weather Science and Education, Kyushu University)

Problems in determining structures of interplanetary magnetic flux ropes

*Katsuhide Marubashi[1], Yuki Kubo[1], Nobuhiko Nishimura[2], Munetoshi Tokumaru[2], Nada Al-Haddad[3]

1. National Institute of Information and Communications Technology , 2. ISEE, Nagoya University, 3. IACS, Catholic University of America

The interplanetary magnetic flux ropes (IFRs) are ejected from the Sun to interplanetary space in association with the coronal mass ejections (CMEs). Their magnetic structure is an important research subject which provides information on the mechanism of CMEs. On the other hand, The IFRs often cause strong geomagnetic storms because of intense southward magnetic fields carried from the solar atmosphere. Thus, the IFRs have long been studied since they were discovered more than 30 years ago. It is the first step for such studies to determine the 3-D geometries and internal magnetic field structures of IFRs. We need to assume a physical model of the IFR and compare the model structure with observations. There are 2 representative analysis methods which are currently used along the line. They are: (1) a fitting method to models of force-free magnetic field configurations, and (2) a reconstruction method of magnetic field structures based on the Grad-Shafranov (GS) equation. Recently, Al-Haddad et al. (Solar Phys. 2018) examined the mutual agreement between the results from the two methods for 13 well-determined IFRs carefully selected. They found that the agreement is relatively good in only 6 cases, and thus concluded that the compatibility of different models with specific IFR structures must be taken into account.

The present study is an extension of the work by Al-Haddad et al. In the GS method, 2-D structure (essentially a cylindrical structure) is assumed, and the axis orientation is determined so that the symmetry condition is satisfied between inbound and outbound crossings of the IFR. If the IFR fields satisfy the force-free condition, the internal structures obtained by the 2 methods agree with each other. Actually, however, the GS method includes the effect of plasma pressure while the force-free model neglects the plasma pressure. This can cause the discrepancy between the two. With this idea in mind, we started to examine how the axis orientations deviate from each other. However, we encounter an unexpected problem, that is, it is not easy to point start and end times of an IFR from the observed data. Especially in the GS method, the selection of the IFR interval is strongly affected by the symmetry condition. In this presentation we show results of our trial to determine the axis orientation for many possible IFR intervals.

Keywords: interplanetary flux rope, force-free model, Grad-Shafranov equation

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Validation of estimated interplanetary flux rope axial direction using internal plasma motions: benchmark test

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Interplanetary flux rope (IFR) is a structure with helical magnetic field lines wrapping around a central axis to form a flux rope structure. Accurate estimation of this structure is important for improving the space weather forecasting and understanding the evolution of IFR. Local structures of IFRs have been investigated by many model fittings and reconstruction method. However, the outputs of these model fittings and reconstruction method are often different. The chirality and magnetic flux of corresponding flux rope at the Sun are often compared with those of IFR to check the validity of estimation of IFR properties, but it is questionable whether this consistency check guarantees the validity of IFR axis direction which is one of the important properties of IFR. In this study, we propose a method that validates IFR axial direction based on plasma motion. It is known that the radius of IFRs often expand or sometimes contract during the passage of IFR through a spacecraft and if the expansion or contraction exist, the direction of plasma motion in IFR may be perpendicular to IFR axis in the frame comoving with the IFR. This suggests that plasma velocity in IFR reflects the axial direction of IFR. We test the method for a well-investigated IFR event on May 21-22, 2007. The magnetic field structure of this event has already been investigated by Liu et al. (2008) using multi-spacecraft measurements at STEREO-B, ACE, Wind, and STEREO-A and other researches (e.g. Kilpua et al. 2009) which report similar axial directions to that of Liu et al. (2008). Herein, We consider that the axial direction determined by them is correct since Liu et al. (2008) found that output from reconstruction at STEREO-B agrees fairly well with the observations at ACE and Wind. We fit the cylindrical and toroidal IFR models (Marubashi et al. 2007) to this event and then apply our validation method proposed in this study to the outputs from the fittings. We checked whether the outputs with the correct axial direction are judged to be valid and vice versa. We find that the fitting result with correct axial direction is judged valid. However, our validation method also judged some fitting results with wrong axial direction to be valid. We need to improve our validation method to make it work well.

Keywords: interplanetary flux rope, interplanetary space, space weather

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Effect of line-of-sight integration on locations of coronal mass ejection in the sky projection map of interplanetary scintillation observations

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The g-value derived from interplanetary scintillation (IPS) observations abruptly enhances when a high density (i.e. shocked) plasma associated with a coronal mass ejection (CME) intersects the line-of-sight (LOS). The plane-of-sky location of the line-of-sight, which shows the g-value enhancement, provide information of the radial distance of the CME-driven shock, and enables determination of the shock transit speed in the solar wind between the Sun and the Earth. It should be noted here that IPS measurements include an effect of the LOS integration, and the plane-of-sky location of g-value enhancements is affected significantly by this effect for some cases. The most significant bias is expected for an Earth-directed event. In this study, we investigated the dependence of the LOS integration effect on the radial distance, the angular width, and the non-uniform expansion for an Earth-directed CME. We made calculations of the sky projection map of g-value using the CME model (Tokumaru et al., 2003). As the result, we found that the plane-of-sky location of g-value enhancements tends to underestimate the actual distance of CME, and that this tendency is distinct in the region near the Sun, being less as the CME moves further from the Sun. This means that apparent acceleration is observed for an Earth directed CME propagating with a constant speed. The degree of this tendency is significant for a case with a small angular extent of CME and also for a case with the non-uniform expansion. Such apparent acceleration of CME near the Sun has seldom reported from IPS measurements for Earth-directed CMEs. This fact may suggest that the CME detected by IPS has a sufficiently large angular width, and hence that the acceleration effect is counterbalanced or overwhelmed by intrinsic deceleration of CME during propagation.

Keywords: interplanetary scintillation, solar wind, coronal mass ejection, space weather

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Estimation of spatial structure of whistler mode wave packets in Earth’s bow shock by multiple spacecraft analysis

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1. The university of tokyo

There have been a lot of unresolved issues in the generation mechanism of nonthermal charged particles observed ubiquitously in space plasmas. The Fermi acceleration at a shock wave is one of the leading mechanisms for the nonthermal particle acceleration. In this mechanism, it is necessary to confine charged particles in the vicinity of the shock wave while charged particles are being accelerated, which requires pitch angle scattering due to wave-particle interactions. In the case of electrons, whistler mode waves are considered to play a major role in the pitch angle scattering. Whistler mode waves are electromagnetic waves that are right-hand circularly polarized with respect to the background magnetic field. They are thought to contribute to the scattering of electrons by interacting with counter-streaming electrons. In fact, there have been reports of coherent whistler mode waves propagating parallel to the magnetic field in the vicinity of the shock wave (Hull et al., 2012). Recently, it was found that such whistler mode waves are indeed resonantly interacting with suprathermal electrons (Oka et al., 2017). However, it has been known that the acceleration of electrons at the shock is rare, and the relation between whistler mode waves and electron scattering (or acceleration) efficiency has not yet been clarified. The applicability of the standard quasi-linear theory for the electron scattering efficiency by coherent whistler mode waves seen in the shock transition region is not understood very well. For this purpose, one has to identify the spatio-temporal scale of coherent whistler wave packets.
In this study, we aim to estimate the spatial scale of the coherent whistler mode waves around bow shock. For instance, by estimating the scale size of whistler mode wave packets in the direction perpendicular to the magnetic field, we may impose a limit for the energy of electrons being scattered by the wave. This is because gyroradii of electrons must be sufficiently smaller than the perpendicular size of wave packets otherwise the conventional cyclotron resonance theory should not be applicable. For this purpose, simultaneous observations by multiple spacecraft are necessary. In this study, we performed an analysis for high-frequency (~100 Hz) electromagnetic waves observed during bow shock crossings with enhanced energetic electron flux observed by NASA's MMS (Magnetospheric MultiScale) spacecraft.
In particular, we report results for the following two bow shock crossing events: 11:44 UT on October 7, 2015 (Event 1), and 10:29 UT on December 6, 2016 (Event 2). The spacecraft separation was 20 km and 7 km for the Event 1 and Event 2, and comparison between the two may enable us to estimate the scale size of whistler mode wave packets. We applied a band pass filter with for the frequency range 100-250 Hz (fce > 1 kHz) for Event 1, and 50-150 Hz (fce ~ 300 Hz) for Event 2 where prominent peaks were observed in the magnetic field power spectra. We confirmed that whistler mode waves appeared sporadically as wave packets with a short duration (50 - 100 ms). We used MVA (Minimum Variance Analysis) for determining the wave propagation direction. Note that we eliminated the 180-degree ambiguity by referring the Poynting vector direction. Also, we estimated the wavelength from the wave electric-to-magnetic field amplitude ratio using Faraday’s law. The obtained wavelengths of the whistler mode waves were roughly 10 km. This indicates that the spacecraft separations were larger (smaller) than the wavelength for the Event 1 (2). By doing the same analysis for each spacecraft, we found that wave packets observed during Event 1 were almost always uncorrelated. On the other hand, both correlated and uncorrelated wave packets were found for Event 2. This suggests that the whistler mode wave packets have spatial scale of a few km. In this report, we will estimate the spatial scale sizes of wave packets in parallel and perpendicular to the magnetic field direction.

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Keywords: whistler wave, MMS spacecraft

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Experimental Test for Stochastic Shock Drift Acceleration Theory

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High-energy charged particles are ubiquitous in space. They have energies orders of magnitude higher than the thermal energy and often exhibit a power-law distribution in a wide energy range. The collisionless shock is one of the leading mechanisms that may produce such high-energy non-thermal particles. Indeed, radio, X-ray, and gamma-ray observations strongly suggest that shock waves associated with supernova remnants, pulsar winds, relativistic jets in active galactic nuclei and gamma-ray burst are accelerating relativistic electrons. On the other hand, in-situ observations in the heliosphere (at planetary bow shocks, or interplanetary shocks driven by coronal mass ejections) have shown that the acceleration of electrons is, in general, weak or even absent in many of the shock crossings.

We have recently proposed a theory for electron acceleration at shocks that may resolve the observational controversy. The theory referred to as stochastic shock drift acceleration (SSDA) assumes stochastic pitch-angle scattering during electrons are interacting with a collisionless shock. The energy gain comes from the gradient-B drift (due to the magnetic field compression in the shock transition layer) in the direction anti-parallel to the convection electric field and is not associated with the assumed scattering. The scattering is, however, essential to confine the accelerated electrons in the shock transition layer for a long time, because, otherwise they would quickly escape from the system. In other words, the theory assumes that the electron transport obeys the diffusion-convection equation with an energy gain term determined only by the magnetic field gradient. It successfully explains the formation of a power-law energy spectrum, with a maximum energy cut-off determined by the rate of pitch-angle scattering. We here present the result of an experimental test using NASA's MMS (Magnetospheric MultiScale) spacecraft observation of an Earth's bow shock crossing event on December 9, 2016.

In particular, we have checked the following points that are predicted by the theory: (1) exponential increase in energetic particle intensity toward downstream within the shock transition layer, (2) nearly isotropic pitch-angle distribution. We find that both are reasonably satisfied in a thin layer (~7 sec. or ~350 km assuming a shock propagation speed of ~50 km/s) within the shock transition region. The result is then used to estimate the rate of pitch-angle scattering as a function of energy. We find that the pitch-angle scattering rate increases as increasing the particle energy from just above the thermal energy up to a few keV, beyond which it saturates to a nearly constant value. We find that the observed maximum energy cut-off (~30 keV) in the electron energy spectrum is consistent with that predicted by the theory based on the observed pitch-angle scattering rate. All of these results strongly indicate that the observed non-thermal electrons are accelerated by the SSDA.

Keywords: shock, particle acceleration, non-thermal particle

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Radial structure of heliospheric boundary region

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The kinetic structure of the heliospheric boundaries is investigated using one-dimensional full PIC (Particle-In-Cell) simulations. Both the termination shock and the heliopause are simultaneously reproduced in the simulation. The spatial scale of the heliopause increases as the angle between the heliopause normal and local magnetic field (referred to as the normal angle, hereafter) becomes increasingly oblique. The VLISM region, out side the heliopause, contains compressible flucturations in both magnetic field and plasma density. The fluctuations are originated from the inner heliosheath, the region between the termination shock and the heliopause, pass the heliopause, and propagate away from it. The total pressure, including the plasma pressure and magnetic pressure, at the heliopause is not constant when the normal angle is oblique in contrast to predictions based on MHD theory. In the oblique case, the solar wind plasma and interstellar plasma are able to inter-penetrate by moving along the local magnetic field. Since their bulk velocities along the magnetic field differ from each other, the distributions overlap in phase space so that the effective local plasma pressure parallel to the magnetic field is enhanced. This results in an increase that resembles a hump in the density and parallel pressure of the local plasma, which is not seen in magnetic field.

Keywords: heliospheric boundaries, full particle-in-cell simulation

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[J] Oral | P (Space and Planetary Sciences)：P-CG Complex & General

Wed. May 29, 2019 9:00 AM - 10:30 AM JST | Wed. May 29, 2019 12:00 AM - 1:30 AM UTC | 105 1F

[P-CG24] New Developments of Planetary Sciences with ALMA

convener:Takayuki Muto(Division of Liberal Arts, Kogakuin University), Munetake Momose(The College of Science, Ibaraki University), Hideo Sagawa(Faculty of Science, Kyoto Sangyo University), Masumi Shimojo(National Astronomical Observatory of Japan), Chairperson:Takayuki Muto

The Atacama Large Millimeter/Submillimeter Array (ALMA) starated its science operation in 2011, and long-baseline observations have become available since 2014. With its high sensitivity and resolution, ALMA has provided us with qualitatively new information on star and planet formation and small bodies in our Solar System. For example, in the observations of protoplanetary disks, ring-like structures have been commonly found and the structures with the scale of several-AU are discovered in several systems. In our solar system, 60km pixel-scale non-uniform brightness distribution and the rotation of the asteroid Juno are detected. Spatially-resolved thermal mapping of Europa icy surface enables us to search for thermal anomaly in possible plume source regions. As of Cycle 4, Solar observations are available, enabling us, for example, to determine the physical parameters of plasmoid quantitatively. In this session, we overview the latest results of ALMA observations in the field of planetary sciences. We also accept any theoretical and experimental works that are closely related to the observations and discuss the impact on the planetary science community.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[PCG24-01] Understanding solar atmosphere by ALMA observations

★Invited Papers

*Tomoko Kawate[1], Takenori J Okamoto[2], Kazumasa Iwai[3], Satoshi Masuda[3], Masumi Shimojo[2] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.National Astronomical Observatory of Japan, 3.Nagoya University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[PCG24-02] Multi-thermal structures in a spicule observed with ALMA, IRIS, and AIA/SDO

*Masumi Shimojo[1], Tomoko Kawate[2], Takenori Okamoto[1], Takaaki Yokoyama[3] (1.National Astronomical Observatory of Japan, 2. Institute of Space and Astronautical Science , 3.University of Tokyo)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[PCG24-03] Observing the 2018 global dust storm on Mars with ALMA

Shohei Aoki[2], *Hideo Sagawa[1], Kazi Rigl[3], Geronimo L. Villanueva[4], Bill Dent[5], Hiroyuki Maezawa[6], Severine Robert[2], Hiromu Nakagawa[7], Frank Daerden[2], Takeshi Kuroda[8], Marco Giuranna[10], Kazuya Saigo[9], Michael J. Mumma[4], Yasumasa Kasaba[7], Ann Carine Vandaele[2] (1.Kyoto Sangyo University, 2.Royal Belgian Institute for Space Aeronomy, 3.Italian ALMA Regional Centre, INAF-Istituto di Radioastronomia, 4.NASA Goddard Space Flight Center, USA, 5.ESO ALMA, Chile, 6.Osaka Prefecture University, 7.Tohoku University, 8.NICT Big Data Integration Research Center, 9.NAOJ Chile Observatory, 10.Istituto di Astrofisica e Planetologia Spaziali, Italy)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[PCG24-04] Atmospheric observation of submillimeter wave and the thermal evolution of ice giants

★Invited Papers

*Kenji Kurosaki[1], Masahiro Ikoma[2] (1.Department of Physics, Nagoya University , 2.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

10:00 AM - 10:30 AM JST | 1:00 AM - 1:30 AM UTC

[PCG24-05] Planetary-system formation revealed with ALMA

★Invited Papers

*Misato Fukagawa[1] (1.National Astronomical Observatory of Japan)

Understanding solar atmosphere by ALMA observations

*Tomoko Kawate[1], Takenori J Okamoto[2], Kazumasa Iwai[3], Satoshi Masuda[3], Masumi Shimojo[2]

1. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2. National Astronomical Observatory of Japan, 3. Nagoya University

ALMA started solar observations with Bands 3 and 6 from Cycle 4. Millimeter waves at 100 GHz (band 3) and 240 GHz (band6) are radiated by free-free emission in the chromosphere, and brightness temperatures are directly related with electron temperatures by the Planck function. Before ALMA, observations of the chromosphere are mainly performed by absorption lines from UV to near IR. These lines are formed under non-local thermodynamically equilibrium, and it is difficult to interpret brightness temperatures directly with electron temperatures. Thus, ALMA opens a new window for temperature diagnostics in the solar atmosphere.

Although intensities in millimeter wave in a quiet sun are directly related with electron temperatures, where these emissions come from is not well understood. Numerical and observational comparisons between millimeter waves and UV lines are performed in the past. However, temperature structures in the solar atmosphere are complex and full of varieties. We cannot simply estimate the formation region of millimeter waves from the case studies. In order to understand temperature structures in solar atmosphere by ALMA, it is crucial not only to compare between multiwavelength observations but also to understand radiative processes of millimeter waves and chromospheric lines in multiple regions in the solar atmosphere.

We analyze ALMA data of a plage region observed in Cycle 4. We compare the ALMA data with vector magnetic field in the photosphere by Hinode/SP, transition-region images and spectra by IRIS, and chromospheric and coronal images by SDO/AIA. As a result, velocities of a moving feature in a stripe structure in ALMA data correspond to sound speeds in the chromosphere, and it is reasonable to interpret that millimeter waves are emitted from the mid-chromosphere. However, we do not find the same structures between millimeter waves and chromospheric images. In this presentation, we review the preceding studies on the formation region of millimeter waves in the solar atmosphere, introduce the plage observation, compare with numerical simulation of radiative transfer of millimeter wave and chromospheric lines, and discuss what ALMA is looking in the solar atmosphere.

Keywords: Sun, radiative processes, chromosphere

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Multi-thermal structures in a spicule observed with ALMA, IRIS, and AIA/SDO

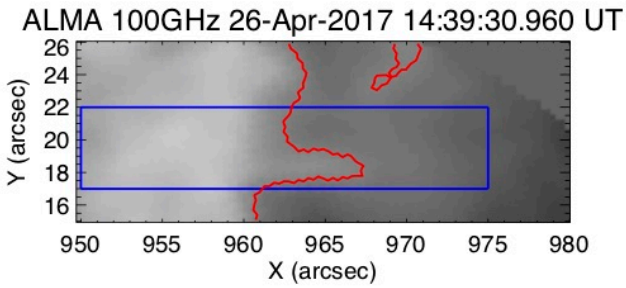
*Masumi Shimojo[1], Tomoko Kawate[2], Takenori Okamoto[1], Takaaki Yokoyama[3]

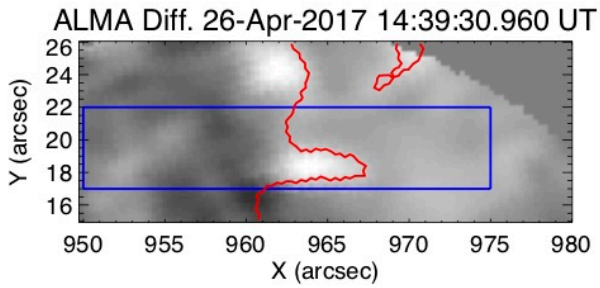
1. National Astronomical Observatory of Japan, 2. Institute of Space and Astronautical Science , 3. University of Tokyo

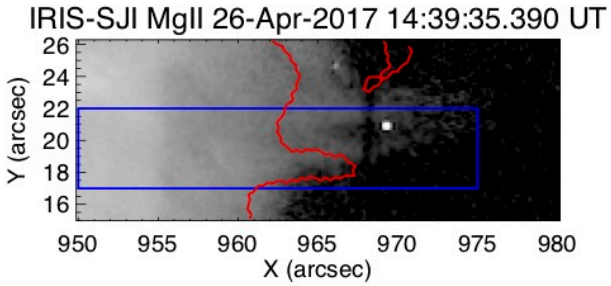
A spicule is a key phenomenon for understanding the solar atmosphere. We succeeded in observing a large spicule with ALMA, IRIS, and AIA/SDO simultaneously, and report the details of the spicule in the paper. While an eruption of a blob-like structure shown in the 100 GHz images started just before appearing a spicule in the He II and Mg II images, a spicule seen in 100 GHz image itself began about one minute after beginning the spicule in the He II and Mg II images. The spicule in the 100 GHz images can be seen as an absorbing structure in the Fe XII images. The maximum height and width of the Mg II/He II spicule are larger than those of the 100 GHz/Fe XII spicule. The 100 GHz/Fe XII spicule is included in the Mg II/He II spicule and is located at the southern edge of the Mg II/He II spicule. The rising velocities of the spicule in the Mg II and He II image, and the erupted blob in the 100 GHz images are ~70 km/s. On the other hand, the rising velocity of the spicule in the 100 GHz and Fe XII images is ~40 km/s. Considering of the differences of the structures shown in the Mg II/He II and 100 GHz/Fe XII images, and the typical formation temperature of each band, the 100 GHz and Fe XII images show a cold and dense component of the spicule. The conclusion is consistent with the recently radiative MHD simulations, and we can explain why the 100 GHz spicule is delayed, shorter, and slower than the Mg II/He II spicule. The solar limb observations with ALMA are very few. Hence, it would be not accidentally that the blob-like eruptions are associated with both two large spicules observed with ALMA. The fact might suggest that large spicules included a cold and dense component is produced by magnetic reconnection that is induced by a plasmoid eruption, like a corona jet.

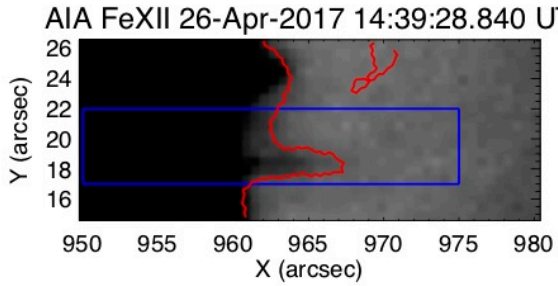
Keywords: Sun, Chromosphere, Millimeter wave, Jet, ALMA

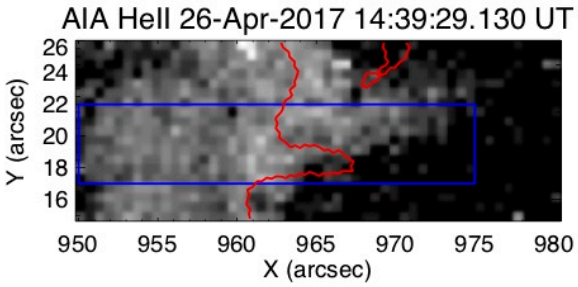
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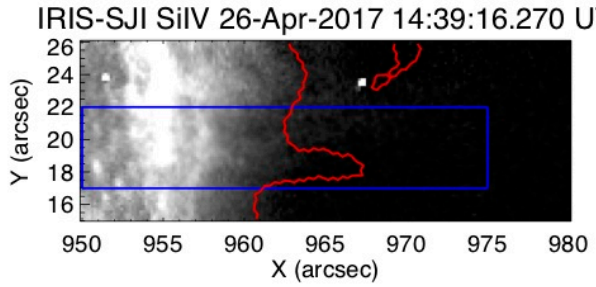












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Observing the 2018 global dust storm on Mars with ALMA

Shohei Aoki[2], *Hideo Sagawa[1], Kazi Rigl[3], Geronimo L. Villanueva[4], Bill Dent[5], Hiroyuki Maezawa[6], Severine Robert[2], Hiromu Nakagawa[7], Frank Daerden[2], Takeshi Kuroda[8], Marco Giuranna[10], Kazuya Saigo[9], Michael J. Mumma[4], Yasumasa Kasaba[7], Ann Carine Vandaele[2]

1. Kyoto Sangyo University, 2. Royal Belgian Institute for Space Aeronomy, 3. Italian ALMA Regional Centre, INAF-Istituto di Radioastronomia, 4. NASA Goddard Space Flight Center, USA, 5. ESO ALMA, Chile, 6. Osaka Prefecture University, 7. Tohoku University, 8. NICT Big Data Integration Research Center, 9. NAOJ Chile Observatory, 10. Istituto di Astrofisica e Planetologia Spaziali, Italy

One of the most striking features in Martian atmosphere is a very large (planet-encircling) storm, "global dust storm". The storm lifts the dust particles from the surface into the air, where the dust particles block sunlight from reaching the surface. This brings a decrease of the surface temperature. In contrast, the thickened dust layer absorbs the radiation, and directly leads to heating the atmosphere. Such a drastic change in the thermal structure in the atmosphere induces significant modulation in the dynamics as well as in the composition.

Starting from the middle of June 2018, a global dust storm has occurred on Mars for the first time in the past 11 years. Taking this unique opportunity, we observed Mars with ALMA on 30 June 2018 and 16 July 2018 that correspond to active periods of the global dust storm.

Observing with submillimeter wavelength has a good advantage compared to other optical and infrared wavelengths, since the dust opacity becomes transparent at the submillimeter wave and the emission from deep inside the global dust storm can be detected. We used Band 5 (183 GHz) and 6 (220 and 230 GHz) on 30 June, and only Band 6 on 16 July. Band 6 measurements allow us to investigate maps of temperature vertical profiles and wind fields from the CO lines. Band 5 measurements enable us to investigate maps of water vapor vertical profiles. The preliminary results from these ALMA observations will be discussed in the presentation.

Keywords: Global dust storm, ALMA, Ground-based observation

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Atmospheric observation of submillimeter wave and the thermal evolution of ice giants

*Kenji Kurosaki[1], Masahiro Ikoma[2]

1. Department of Physics, Nagoya University , 2. Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo

Our solar system has two ice giants: Uranus and Neptune. Voyager II explored Uranus in 1986 and Neptune in 1989 and observed the effective temperature and the gravitational moments that are important to understand the atmospheric and interior structure. Recently by use of ground telescope submillimeter absorption features are observed. Submillimeter observations showed that Uranus did not have remarkable feature while Neptune had absorption features of HCN and CO. That is, atmospheric structures are different between Uranus and Neptune. Since the amount of CO is related to the atmospheric O/H, the observation is expected to restrict the metal enrichment of ice giants. Moreover, the atmospheric structure affects the thermal evolution of the ice giants. In this talk, we focus on ice giants in our solar system.

Keywords: Ice giant, Atmosphere

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Planetary-system formation revealed with ALMA

*Misato Fukagawa[1]

1. National Astronomical Observatory of Japan

I review the current understanding of planetary-system formation that has primarily been obtained from observations of protoplanetary disks, the birthplaces of planets, with the radio astronomical telescope, Atacama Large Millimeter/submillimeter Array (ALMA). High angular resolution is one of the most important observing capabilities to address planetary-system formation, given the spatial scale of the planetary systems including the Solar system (30 au to Neptune), and considering the distance to the nearest star forming regions (>100 pc) where we can observe young planet-forming disks. The resolution of ~5 au at least would be necessary to obtain the spatial distribution of disk material (various gas species, dust grains) which are ingredients of planets. ALMA is the interferometer consisting of multiple antennas, providing us the resolution of about 5 au recently. ALMA has provided at least 43 12-m antennas for recent observations, providing also high sensitivity and good image quality.

The ALMA observations have so far shown that (1) rings are common for protoplanetary disk and (2) the diversity in disk structure is still seen including spiral arms and strong non-axisymmetry. Rings and other disk structures often interpreted as the sign of planet-forming activity and these observations have stimulated theoretical study on how planetesimals (km-sized bodies) form and how planet formation proceeds in an entire region of the disk. The detection of various rare molecules including organic ones is another highlight. The emission from such molecules is quite faint and the detections were owing to the ALMA's high sensitivity. Other ALMA results include finding the possible new tool to probe grain growth using polarization, and detections of tenuous gas that may be produced by collisions of cometary or planetary bodies in more evolved debris disks. Those results also give us an insight on the fruitful future in comparative study with the distribution of various material in the Solar system.

Keywords: Exoplanets, Planet formation, ALMA, Astronomy

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[J] Oral | P (Space and Planetary Sciences)：P-CG Complex & General

Wed. May 29, 2019 10:45 AM - 12:15 PM JST | Wed. May 29, 2019 1:45 AM - 3:15 AM UTC | 105 1F

[P-CG24] New Developments of Planetary Sciences with ALMA

convener:Takayuki Muto(Division of Liberal Arts, Kogakuin University), Munetake Momose(The College of Science, Ibaraki University), Hideo Sagawa(Faculty of Science, Kyoto Sangyo University), Masumi Shimojo(National Astronomical Observatory of Japan), Chairperson:Munetake MOMOSE(Ibaraki University)

The Atacama Large Millimeter/Submillimeter Array (ALMA) starated its science operation in 2011, and long-baseline observations have become available since 2014. With its high sensitivity and resolution, ALMA has provided us with qualitatively new information on star and planet formation and small bodies in our Solar System. For example, in the observations of protoplanetary disks, ring-like structures have been commonly found and the structures with the scale of several-AU are discovered in several systems. In our solar system, 60km pixel-scale non-uniform brightness distribution and the rotation of the asteroid Juno are detected. Spatially-resolved thermal mapping of Europa icy surface enables us to search for thermal anomaly in possible plume source regions. As of Cycle 4, Solar observations are available, enabling us, for example, to determine the physical parameters of plasmoid quantitatively. In this session, we overview the latest results of ALMA observations in the field of planetary sciences. We also accept any theoretical and experimental works that are closely related to the observations and discuss the impact on the planetary science community.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[PCG24-06] Probing dust aggregate structure in protoplanetary disks by millimeter-wave polarization

*Ryo Tazaki[1], Hidekazu Tanaka[1], Takayuki Muto[2], Akimasa Kataoka[3], Satoshi Okuzumi[4] (1.Tohoku University, 2.Kogakuin University, 3.NAOJ, 4.Tokyo Institute of Technology)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[PCG24-07] A CONSTRAINT ON THE AMOUNT OF HYDROGEN FROM THE CO CHEMISTRY IN DEBRIS DISKS

*Hiroshi Kobayashi[1], Kazunari Iwasaki[2,4], Aya Higuchi[3] (1.Department of Physics, Nagoya University, 2.NAOJ, 3.RIKEN, 4.Osaka University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[PCG24-08] Structure of the protoplanetary disk around V1094 Sco obtained from dust continuum emission and SED

*Sanemichi Takahashi[1,2], Takayuki Muto[1], Takashi Tsukagoshi[2], Jun Hashimoto[2] (1.Kogakuin University, 2.NAOJ)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[PCG24-09] The Synthetic ALMA Multiband Analysis of the Dust Properties of the TW Hya Protoplanetary Disk

*Seongjoong Kim[1], Hideko Nomura[1], Takashi Tsukagoshi[2], Ryohei Kawabe[2,3,4], Takayuki Muto[5] (1.Department of Earth and Planetary Sciences, Tokyo Institute of Technology, 2.National Astronomical Observatory of Japan, 3.The Graduate University for Advanced Studies (SOKENDAI), 4.Department of Astronomy, School of Science, University of Tokyo, 5.Division of Liberal Arts, Kogakuin University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[PCG24-10] Dust evolution in the protoplanetary disk around TW Hya

*Takayuki Matsuura[1], Satoshi Okuzumi[1] (1.Tokyo Institute of Technology)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[PCG24-11] Discovery of a localized excess in the millimeter emission of the protoplanetary disk around TW Hya

*Takashi Tsukagoshi[1], Takayuki Muto[2], Hideko Nomura[3], Ryohei Kawabe[1,4,5], Kazuhiro Kanagawa[9], Satoshi Okuzumi[3], Shigeru Ida[10], Catherine Walsh[6], Tom J Millar[7], Sanemichi Takahashi[2,1], Jun Hashimoto[8], Taichi Uyama[5], Motohide Tamura[5,8] (1.Division of Radio Astronomy, National Astronomical Observatory of Japan, 2.Division of Liberal Arts, Kogakuin University, 3.Department of Earth and Planetary Sciences, Tokyo Institute of Technology, 4.The Graduate University for Adnvanced Studies, 5.School of Science, University of Tokyo, 6.School of Physics and Astronomy, University of Leeds, 7.Astrophysics Research Centre, Queen's University Belfast, 8.Astrobiology Center, National Institutes of Natural Sciences, 9.Research Center for the Early Universe, University of Tokyo, 10.Earth-Life Science Institute, Tokyo Institute of Technology)

Probing dust aggregate structure in protoplanetary disks by millimeter-wave polarization

*Ryo Tazaki[1], Hidekazu Tanaka[1], Takayuki Muto[2], Akimasa Kataoka[3], Satoshi Okuzumi[4]

1. Tohoku University, 2. Kogakuin University, 3. NAOJ, 4. Tokyo Institute of Technology

Dust coagulation in protoplanetary disks is the first step of planetesimal formation and a pathway from dust aggregates to planetesimals remains unclear. Both laboratory and numerical studies have so far shown that the structure of a dust aggregate plays important roles in planetesimal formation. However, the aggregate structure has been poorly constrained by disk observations. Recently, ALMA opens a new window to observe (sub-)millimeter-wave polarization of disks, which is expected to provide additional constraints on dust aggregate properties. In this study, we perform 3D radiative transfer simulations in order to study how the structure of dust aggregates affects millimeter-wave polarization from disks. As a result, it is found that relatively compact particles are favorable to explain observed millimeter-wave scattering polarization of disks, whereas highly porous and fractal particles fail to explain the observations.

Keywords: Protoplanetary disks, Millimeter-wave polarization, Dust

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A CONSTRAINT ON THE AMOUNT OF HYDROGEN FROM THE CO CHEMISTRY IN DEBRIS DISKS

*Hiroshi Kobayashi[1], Kazunari Iwasaki[2,4], Aya Higuchi[3]

1. Department of Physics, Nagoya University, 2. NAOJ, 3. RIKEN, 4. Osaka University

The faint CO gases in debris disks are easily dissolved into C by UV irradiation so that the ratio of C to CO may show the reformation rate of CO depending on the amount of underlying hydrogen molecules. We conduct radiative transfer calculations with chemical reactions for debris disks. We find the C/CO ratio is proportional to the far UV flux and the hydrogen nucleus number density. Using the deriving formula for the C/CO ratio, we give a constraint on the amount of hydrogen for debris disks around 49 Ceti with age ~ 40 Myr; the hydrogen nucleus density ~ 2x10^{-8} cm^{-3}. That implies that the debris disk contains tenuous gases caused by the depletion of a protoplanetary disk.

Keywords: Gas depletion in protoplanetar disks, Gaseous debris disks, planet formation

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Structure of the protoplanetary disk around V1094 Sco obtained from dust continuum emission and SED

*Sanemichi Takahashi[1,2], Takayuki Muto[1], Takashi Tsukagoshi[2], Jun Hashimoto[2]

1. Kogakuin University, 2. NAOJ

Understanding the structure of protoplanetary disks is important for revealing the environment of planet formation. Recent ALMA observations have found that detailed structures are formed in protoplanetary disks. In this work, we investigate the structure of the protoplanetary disk around V1094 Sco. We performed numerical calculations of radiative transfer and compared the results with dust continuum emission obtained from ALMA Band 8 observations and SED. According to the dust continuum emission, we found that the disk consists of two regions, inner optically thick region (< 100 au) and outer optically thin region (> 100 au) . We also found that the results can reproduce the SED observations well when (1) disk inner edge is puffed up and the shadow is formed behind it and (2) the small grain (< 1 um) is depleted in the inner region.

Keywords: protoplanetary disks

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The Synthetic ALMA Multiband Analysis of the Dust Properties of the TW Hya Protoplanetary Disk

*Seongjoong Kim[1], Hideko Nomura[1], Takashi Tsukagoshi[2], Ryohei Kawabe[2,3,4], Takayuki Muto[5]

1. Department of Earth and Planetary Sciences, Tokyo Institute of Technology, 2. National Astronomical Observatory of Japan, 3. The Graduate University for Advanced Studies (SOKENDAI), 4. Department of Astronomy, School of Science, University of Tokyo, 5. Division of Liberal Arts, Kogakuin University

Analyzing multiband observations of dust continuum emission is one of the useful tools to constrain dust properties which help us to understand the physical properties of the disks. We perform the synthetic ALMA multiband analysis to find the best ALMA band set for constraining the dust properties of the TW Hya protoplanetary disk. We find that the Band [10,6,3] set is the best set among the possible combinations of ALMA Band [3,4,5,6,7,8,9,10]. We also find two conditions for the good ALMA band sets providing narrow constraint ranges on dust properties; (1) Band 9 or 10 is included in the band set and (2) Enough frequency intervals between the bands. These are related with the conditions which give good constraints on dust properties: the combination of optically thick and thin bands are required, and large β (β is the power-law index of dust opacity, $\kappa_\nu \propto \nu^\beta$) and low dust temperature are preferable. To examine our synthetic analysis results, we apply the multiband analysis to ALMA archival data of the TW Hya disk at Band 4, 6, 7, and 9. Band [9,6,4] set provides the dust properties close to the model profile, while Band [7,6,4] set gives the dust properties deviating from the model at all radii with too broad constraint range to specify the accurate values of dust temperature, optical depth, and β. Since these features are expected by the synthetic multiband analysis, we confirm that the synthetic multiband analysis is well consistent with the results derived from real data.

Keywords: methods: observational, protoplanetary disks, stars: individual (TW Hydrae)

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Dust evolution in the protoplanetary disk around TW Hya

*Takayuki Matsuura[1], Satoshi Okuzumi[1]

1. Tokyo Institute of Technology

Protoplanetary disks are places of planet formation. Therefore, researching construction and evolution of protoplanetary disks is important when we discuss planet formation. In particular, TW Hya is one of the best interesting stars to understand dust evolution in protoplanetary disks. It is a young star with a protoplanetary disk, and the disk has been observed at various wavelengths due to the good observation condition. Particularly, the latest high resolution imaging observation by ALMA revealed that the disk around TW Hya has gaps at 22 au and 37 au.
Various mechanisms of gap formation have been proposed. One of them is due to gravitational interaction between a planet and a disk. Accordingly, considering existence of planets, simulations on disk evolution are carried out. Those simulations show that dust is depleted and a gap forms at planetary orbit. However, the results of the simulations have different tendencies compared with the observation by ALMA, such as dust inside a gap is less than outside, and much dust accumulates on an outer edge of a gap.
Therefore, in this study, we aim to clarify what kind of physical characteristics the disk around TW Hya has in order to reproduce the dust distribution of TW Hya. For that, we simulate dust evolution in a disk and search for parameter ranges that reproduce the radial distribution of brightness temperature and spectral index obtained by ALMA. We assume that planets exist at 22 au and 37 au. We set the planet masses and the fragmentation velocity of dust to free parameters.
As the result, when the planet masses are 4—10 earth masses and the fragmentation velocity is 0.5 m s^{-1} , the simulation result reproduces observation by ALMA roughly. When we assume faster fragmentation velocity than the value that reproduce observation, dust is depleted inner the gap and more dust accumulates on the outer edge of the gap. When we assume heavier planets, more dust accumulates on the outer edge of the gaps and the contrasts of the gaps grow in excess. Thereby the observation is not reproduced.
The fragmentation velocity obtained in this study is slower than the value that has considered from a conventional growth theory of dust in disk. That suggests a possibility that monomers composing dust are large size of 10 μm or more(Wada et al.,2013), or monomers are covered by CO_2 ice(Musiolik et al.,2016). Additionally, the result suggests a possibility that planetesimals formed with the assumption different form scenario that dust coalesces into planetesimals.

Keywords: protoplanetary disk, TW Hya

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Discovery of a localized excess in the millimeter emission of the protoplanetary disk around TW Hya

*Takashi Tsukagoshi[1], Takayuki Muto[2], Hideko Nomura[3], Ryohei Kawabe[1,4,5], Kazuhiro Kanagawa[9], Satoshi Okuzumi[3], Shigeru Ida[10], Catherine Walsh[6], Tom J Millar[7], Sanemichi Takahashi[2,1], Jun Hashimoto[8], Taichi Uyama[5], Motohide Tamura[5,8]

1. Division of Radio Astronomy, National Astronomical Observatory of Japan, 2. Division of Liberal Arts, Kogakuin University, 3. Department of Earth and Planetary Sciences, Tokyo Institute of Technology, 4. The Graduate University for Adnvanced Studies, 5. School of Science, University of Tokyo, 6. School of Physics and Astronomy, University of Leeds, 7. Astrophysics Research Centre, Queen's University Belfast, 8. Astrobiology Center, National Institutes of Natural Sciences, 9. Research Center for the Early Universe, University of Tokyo, 10. Earth-Life Science Institute, Tokyo Institute of Technology

Planets are formed from dust and gas in circumstellar disks around young stars.
Observations of dust and gas in circumstellar disks can provide fundamental information on planet formation processes, and high-resolution (sub-)millimeter imaging is now revealing the dust substructure likely generated by forming planets in disks.
Here we report the detection of an excess in dust continuum emission at 233 GHz (1.3 mm in wavelength) in the circumstellar disk around TW Hya, the closest such system to Earth, revealed through high-sensitivity observations with the Atacama Large Millimeter/submillimeter Array (ALMA).

We have carried out 3 au resolution continuum observations at 233 GHz (Band6) toward the protoplanetary disk (PPD) around TW Hya using ALMA in 2016 and 2017.
The sensitivity has been improved by a factor of 3 than that of our previous cycle 3 observations.
The overall structure is axisymmetric, and there are apparent gaps at 25 and 41 au as previously reported.
The most remarkable new finding is a few au scale excess emission at the south-west part of the PPD.
The excess emission is located at 52 au from the disk center and is 1.5 times brighter than the surrounding PPD.
The extracted emission after subtracting the axisymmetric PPD emission has a size of 4.4x1.0 au and a total flux density of 250 micro-Jy, corresponding to a dust mass of 0.03 earth masses.
Since the excess emission can also be marginally identified in the Band 7 image at almost the same position, the blob is unlikely a background source.
The excess emission can be explained by a massive CPD around a Neptune mass forming-planet or a dust clump accumulated in a small elongated vortex.

Keywords: Planet formation, Protoplanetary disk, ALMA

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

Wed. May 29, 2019 9:00 AM - 10:30 AM JST | Wed. May 29, 2019 12:00 AM - 1:30 AM UTC | 102 1F

[A-AS04] Atmospheric Chemistry

convener:Tomoki Nakayama(Graduate School of Fisheries and Environmental Sciences, Nagasaki University), Yoko Iwamoto(Graduate School of Biosphere Science, Hiroshima University), Sakae Toyoda(Department of Chemical Science and Engineering, Tokyo Institute of Technology), Nawo Eguchi(Kyushu University), Chairperson:Fumiko Nakagawa(名古屋大学)

This session provides a forum for the presentation of the broad spectrum of tropospheric and stratospheric chemistry, including various research topics (e.g., dynamical processes, air quality and climate), approaches (modeling, field measurements, remote sensing, and laboratory studies), and species (gas and aerosol). This session also provides an opportunity for discussing possible future collaboration with other research fields relevant to atmospheric chemistry. We strongly encourage authors to prepare presentation slides and a poster in English.

9:00 AM - 9:30 AM JST | 12:00 AM - 12:30 AM UTC

[AAS04-01] Reconstruction and fluctuation mechanism of past aerosols preserved in ice cores

★Invited Papers

*Iizuka Yoshinori[1], Ryu Uemura[2], Koji Fujita[3], Shohei Hattori[4], Osamu Seki[1], Naga Oshima[5], Hiroshi Ohno[6], Sumito Matoba[1] (1.Institite of Low Temperature Science, Hokkaido University, 2.Department of Chemistry, Biology, and Marine Science, Faculty of Science, University of the Ryukyus, 3.Graduate School of Environmental Studies, Nagoya University, 4.Department of Chemical Science and Engineering, School of Materials and Chemical Technology, Tokyo Institute of Technology,, 5.Meteorological Research Institute, 6.Kitami Institute of Technology)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[AAS04-02] The 60 years history of atmospheric formation pathways responsible for sulfate based on triple oxygen isotopic composition of sulfate preserved in SE-Dome ice core

*Shohei Hattori[1], Iizuka Yoshinori[2], Koji Fujita[3], Ryu Uemura[4], Sakiko Ishino[1], Naga Oshima[5], Nozomi Suzuki[1], Sumito Matoba[2], Asuka Tsuruta[1], Joel Savarino[6], Naohiro Yoshida[1] (1.Department of Chemical Science and Engineering, School of Materials and Chemical Technology, Tokyo Institute of Technology, 2.Institute of Low Temperature Science, Hokkaido University, 3.Graduate School of Environmental Studies, Nagoya University, Nagoya, Japan., 4.Department of Chemistry, Biology, and Marine Science, Faculty of Science, University of the Ryukyus, 5.Meteorological Research Institute, 6.Institut des Geoscience de l'Environnement, Universite Grenoble Alpes/CNRS)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[AAS04-03] Estimation of high sulfate aerosol sources in 2012 spring at Cape Hedo, Okinawa

*Syuichi Itahashi[1], Shiro Hatakeyama[2], Kojiro Shimada[3], Akinori Takami[4] (1.Central Research Institute of Electric Power Industry, 2.Center for Environmental Science in SaitamaCenter for Environmental Science in Saitama, 3.School of Creative Science and Engineering, Waseda University, 4.National Institute for Environmental Studies)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[AAS04-04] Isotopic constrains on sources and formation pathways of atmospheric nitrate in Mt. Everest

*Kun Wang[1,2,4], Shohei Hattori[2], Shichang Kang[1,3,4], Mang Lin[2], Naohiro Yoshida[2,5] (1.Northwest Institute of Eco-Environment and Resources, Chinese Academy of Sciences , 2.Department of Chemical Science and Engineering, School of Materials and Chemical Technology, Tokyo Institute of Technology, 3.CAS Center for Excellence in Tibetan Plateau Earth Sciences, 4.University of Chinese Academy of Sciences, 5. Earth-Life Science Institute, Tokyo Institute of Technology)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[AAS04-05] Development of a large volume sampling system for measuring stable isotope analysis of carbonyl sulfide and field observation

*Kazuki Kamezaki[1], Shohei Hattori[1], Naohiro Yoshida[1,2] (1.Department of Chemical Science and Engineering, School of Materials and Chemical Technology, Tokyo Institute of Technology, 4259 Nagatsuta-cho, Midori-ku, Yokohama, Kanagawa 226-8502, Japan, 2.Earth-Life Science Institute, Tokyo Institute of Technology, 2-12-1-IE-1 Ookayama, Meguro-ku, Tokyo 152-8550, Japan)

Reconstruction and fluctuation mechanism of past aerosols preserved in ice cores

*Iizuka Yoshinori[1], Ryu Uemura[2], Koji Fujita[3], Shohei Hattori[4], Osamu Seki[1], Naga Oshima[5], Hiroshi Ohno[6], Sumito Matoba[1]

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Ice cores can reconstruct past atmospheric environment. One of advantages for ice core archive is to reconstruct past gas and aerosols, which are important factors for evaluation of global warming. Antarctica and Greenland ice sheets have some ice domes (summit), where are useful sites for ice core drilling due to high elevation. Highland in the ice sheets can reconstruct wider emission area around the drilling sites.

At first, we will review some famous papers how reconstruct past aerosols from Antarctic dome ice cores. Antarctic dome cores can reconstruct recent 800 kyr BP, and aerosol fluctuation preserves in the cores along eight glacial-interglacial periods. Ice core community turns for obtain old ice archive in inland Antarctica (oldest ice project), so that Antarctic deep ice cores are one of topics for the ice core community.

Then, we will talk about our present project of Greenland SouthEastern Dome shallow ice core project (SE-Dome project). The SE-Dome has a huge accumulation rate (about 1.0 m water equivalent per year), where is about 4 time compared to ordinal Greenlandic dome ice cores, and 30 times to Antarctic ice cores. High accumulation dome has an advantage to reconstruct high-time resolution (e.g. seasonal scale) of recent epoch such as Anthropocene (AD 1750 to present). We obtained a 90 m ice core from the SE-Dome site in 2015, and then reconstructed aerosol fluctuations with seasonal scale from 1960 to 2014. As a result, sulfate flux responds to the decreasing trend of SOx emissions, but the nitrate flux does not follow the decrease in NOx. We have a plan in 2020 for next drilling of about 300 m ice core to reconstruct aerosol fluctuation with seasonal scale over the Anthropocene. We are looking for new joint studies using the ice core with members in the community of atmospheric chemistry.

Keywords: ice core, paleoenvironmental reconstruction, aerosol

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The 60 years history of atmospheric formation pathways responsible for sulfate based on triple oxygen isotopic composition of sulfate preserved in SE-Dome ice core

*Shohei Hattori[1], Iizuka Yoshinori[2], Koji Fujita[3], Ryu Uemura[4], Sakiko Ishino[1], Naga Oshima[5], Nozomi Suzuki[1], Sumito Matoba[2], Asuka Tsuruta[1], Joel Savarino[6], Naohiro Yoshida[1]

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The atmospheric sulfate is important for both climate change and air quality; it influences radiation forcing and cloud's lifetime, and accounts for major components in fine particulate matter mass in urban regions with affecting visibility and public health. The emitted SO_2 is oxidized by OH radicals in the gas-phase, but modeling studies suggest that the large proportions (~80%) of global sulfate production were occurred in the aqueous-phase. However, the treatment of aqueous-phase in cloud pH set in atmospheric chemistry-transport models had the largest impact for atmospheric sulfate concentrations. Due to the lack of critical understanding for the chemical processes responsible for sulfate production, it is difficult to predict future changes in [SO_4^{2-}] and its effects on climate and air quality.

To help address this, here we use mass-independent oxygen isotopic composition ($\Delta^{17}O$) of sulfate providing insight into past oxidation pathways responsible for sulfate formation. We present $\Delta^{17}O$ of SO_4^{2-} obtained from a 90.45 m depth ice core drilled at a high-elevation dome site in southeast Greenland called SE-Dome, covering the last 60 years. We found that $\Delta^{17}O$ of SO_4^{2-} with low during the 1960s-1970s and high in after the 2000s. This increase in $\Delta^{17}O$ of SO_4^{2-} indicates that sulfate formation pathways responsible for sulfate changed after 1960 to the present along with declining SO_2 emission. In the presentation, we will discuss the enhanced role of a oxidation processes contributing to increase $\Delta^{17}O$ of SO_4^{2-}, and its implication to the changes in atmospheric chemistry though the changes in anthropogenic activities. This provides insight into direct and indirect effects of anthropogenic activities to the air quality by changing sulfate formation pathways. These functions, so called "chemical feedback", should be considered for making efficient mitigation policy for climate change and air quality by controlling emission of anthropogenic pollutants.

Keywords: stable isotope, Sulfate, Triple oxygen isotopes, Chemical feedback

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Estimation of high sulfate aerosol sources in 2012 spring at Cape Hedo, Okinawa

*Syuichi Itahashi[1], Shiro Hatakeyama[2], Kojiro Shimada[3], Akinori Takami[4]

1. Central Research Institute of Electric Power Industry, 2. Center for Environmental Science in SaitamaCenter for Environmental Science in Saitama, 3. School of Creative Science and Engineering, Waseda University, 4. National Institute for Environmental Studies

Air quality in Asia can cause regional-to-global environmental issues. Intensive observation campaigns approximately 1 week long have been conducted periodically from March 2010 to November 2015 at Cape Hedo, Okinawa, Japan. The period-averaged sulfate aerosol (SO_4^{2-}) concentrations for each campaign ranged from 0.34 to 6.97 $\mu g\ m^{-3}$, and the average concentration of all observations was 3.13 $\mu g\ m^{-3}$. The maximum daily mean concentrations surpassed 15 $\mu g\ m^{-3}$ in springtime 2012. The sources of this high SO_4^{2-} concentrations were estimated by using the air quality model with the tagged tracer method in this study. The main source of the high SO_4^{2-} concentrations in March was volcanoes and that in April was anthropogenic emissions from China. In March, the prevailing northerly wind transported a volcanic SO_2 plume with a low conversion ratio to Cape Hedo. The impacts of 15 volcanoes in Japan were estimated in this study, and a substantial impact of Sakurajima, which accounted for more SO_2 than anthropogenic emissions from Japan, was found. Throughout April, source apportionments from anthropogenic emissions from China were found; hence, the source was further divided into 31 provincial scales. Shandong and Jiangsu provinces, which are the first and seventh largest emission sources in China, were identified as important sources at Cape Hedo. These sources showed day-to-day variation, and the highest contribution from Shandong province was on April 23, whereas that from Jiangsu province was on April 22.

Keywords: Sulfate aerosol, Source contribution, Air quality model

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Isotopic constrains on sources and formation pathways of atmospheric nitrate in Mt. Everest

*Kun Wang[1,2,4], Shohei Hattori[2], Shichang Kang[1,3,4], Mang Lin[2], Naohiro Yoshida[2,5]

1. Northwest Institute of Eco-Environment and Resources, Chinese Academy of Sciences , 2. Department of Chemical Science and Engineering, School of Materials and Chemical Technology, Tokyo Institute of Technology, 3. CAS Center for Excellence in Tibetan Plateau Earth Sciences, 4. University of Chinese Academy of Sciences, 5. Earth-Life Science Institute, Tokyo Institute of Technology

Studies on the sources and formation pathways of nitrate is crucial to better understand nitrogen cycle and atmospheric oxidation capacity. Tibetan Plateau (TP) and surroundings, referred to as the Third Pole and “Asia water tower”, contain the largest number of glaciers outside the polar regions and are largely experiencing shrinkage. A complete understanding on the source and formation mechanisms of atmospheric nitrate in the TP is important to indicate the impact of human activities on the environment and also crucial to investigate nitrogen cycle in glacier-hydrology systems of this region. Besides, it can supply information on interpreting ice core records to understand the past atmosphere chemistry. Here we collected aerosol samples from the Everest through pre-monsoon (April-May) and monsoon season (June-August) in 2018, and measured for the first time the isotopic compositions ($\delta^{15}N$, $\delta^{18}O$ and $\Delta^{17}O$) of nitrate in this region, allowing insights into their sources and potential formation mechanism. The results show that the seasonal variations in both $\delta^{15}N$ and $\Delta^{17}O$ values have a similar trends with maximum during pre-monsoon season and minimum during monsoon season. The relatively high values of $\delta^{15}N$ in pre-monsoon seasons, maybe indicate the enhanced contribution from fossil fuel combustions in South Asia which can be transported to our sampling sites across the Himalayas by the mountain/valley wind system. The $\Delta^{17}O$ (NO_3^-) value, which is dependent on both the $\Delta^{17}O$ (NO_2) value and the oxidation pathways (O_3 and OH) of NO_2 to NO_3^-, show that the O_3 oxidation pathway is dominant during pre-monsoon season, resulting in higher values of both $\delta^{18}O$ and $\Delta^{17}O$. In contrast, during monsoon season, formation involving HO_2/RO_2 radicals becomes important, producing lower values of $\delta^{18}O$ and $\Delta^{17}O$. To better understand the oxidation process of past atmosphere in the Everest region, observations of oxygen-17 excess of nitrate and sulfate in ice cores collected from this region in the future are recommended.

Keywords: Atmospheric nitrate, the Everest, Isotope, Aerosol, Oxidation pathways

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Development of a large volume sampling system for measuring stable isotope analysis of carbonyl sulfide and field observation

*Kazuki Kamezaki[1], Shohei Hattori[1], Naohiro Yoshida[1,2]

1. Department of Chemical Science and Engineering, School of Materials and Chemical Technology, Tokyo Institute of Technology, 4259 Nagatsuta-cho, Midori-ku, Yokohama, Kanagawa 226-8502, Japan, 2. Earth-Life Science Institute, Tokyo Institute of Technology, 2-12-1-IE-1 Ookayama, Meguro-ku, Tokyo 152-8550, Japan

Carbonyl sulfide (OCS) is the most abundant sulfur-containing gas in the ambient atmosphere, with an average mixing ratio of 500 parts per trillion (ppt) by volume in the troposphere. OCS is suggested as a sulfur source of the stratospheric sulfate aerosols (SSA) which plays an important role for Earth of radiation budget and for ozone depletion. Moreover, since leaves consume OCS whenever they are assimilating CO_2 with same process but plant does not emit OCS to atmosphere by respiration, OCS provides a means to partition net ecosystem exchange into gross primary production (GPP) and respiration on land. Nevertheless, current figures for tropospheric OCS sources and sinks carry large uncertainties.

Isotope analysis is a useful tool to trace sources and transformations of trace gases. Very recently, Angert et al. (2019 Sci. Rep.) reported $d^{34}S$ value at Israel and Canary Island for tropospheric OCS using a gas chromatograph (GC)/multi collector-inductively coupled plasma mass spectrometer (MC-ICP-MS). For the measurement of sulfur isotope ratios of OCS in our laboratory, an online method measuring on a GC/isotope ratio (IR)-MS using S^+ fragmentation ions had been developed (Hattori et al., 2015). This method supports simple analysis of sulfur isotopic compositions of OCS over 8 nmol. However, application this method for atmospheric samples has yet to be done by this GC/IR-MS method, because of the large sample amounts that are necessary (i.e. 500 L of 500 pmol mol^{-1} OCS). Therefore, we developed a large volume air sampling system to apply S^+ IR-MS method for atmospheric samples and we observed $d^{34}S$ value in Suzukakedai campus at Yokohama (Kamezaki et al., 2019 Atmos. Meas. Tech.).

We will discuss the difference between the result of Angert et al. (2019) and our observation. Additionally, we also report the result in field campaign using our developed method.

Keywords: Carbonyl sulfide, Sulfur isotope, atmospheric trace components

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

Wed. May 29, 2019 1:45 PM - 3:15 PM JST | Wed. May 29, 2019 4:45 AM - 6:15 AM UTC | 102 1F

[A-AS04] Atmospheric Chemistry

convener:Tomoki Nakayama(Graduate School of Fisheries and Environmental Sciences, Nagasaki University), Yoko Iwamoto(Graduate School of Biosphere Science, Hiroshima University), Sakae Toyoda(Department of Chemical Science and Engineering, Tokyo Institute of Technology), Nawo Eguchi(Kyushu University), Chairperson:Takashi Maki(気象研究所)

This session provides a forum for the presentation of the broad spectrum of tropospheric and stratospheric chemistry, including various research topics (e.g., dynamical processes, air quality and climate), approaches (modeling, field measurements, remote sensing, and laboratory studies), and species (gas and aerosol). This session also provides an opportunity for discussing possible future collaboration with other research fields relevant to atmospheric chemistry. We strongly encourage authors to prepare presentation slides and a poster in English.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[AAS04-06] Observations of aerosol optical properties by sky radiometers at SKYNET Southeast and South Asian sites

*Al Mashroor Fatmi[1], Hitoshi Irie[1], Hossain Mohammed Syedul Hoque[1], Alessandro Damiani[1], Pradeep Khatri[2], Tamio Takamura[1], Thanawat Jurupongsaku[3], Govindan Pandithurai[4] (1.Center for Environmental Remote Sensing Chiba University , 2.Tohoku University, 3.Chulalongkorn University, 4.Indian Institute of Tropical Metereology)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[AAS04-07] Analysis of factors causing variations in the absorption Ångström exponent of aerosols in Japan using skyradiometers

*Kodai Yamaguchi[1], Hitoshi Irie[1], Pradeep Khatri[2], Toshihiko Takemura[3], Hirokazu Yamamoto[4] (1.Chiba University, 2.Tohoku University, 3.Kyushu University, 4.National Institute of Advanced Industrial Science and Technology)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[AAS04-08] Sources of atmospheric black carbon and related carbonaceous components at Rishiri Island, Japan

*Chunmao Zhu[1], Yugo Kanaya[1], Hisayuki Yoshikawa[2], Tomohisa Irino[2], Osamu Seki[2], Yasunori Tohjima[3] (1.Japan Agency for Marine-Earth Science and Technology, 2.Hokkaido University, 3.National Institute for Environmental Studies)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[AAS04-09] Black Carbon and Inorganic Aerosols in Snowpack over the Arctic

*Tatsuhiro Mori[1], Kumiko Goto-Azuma[2,3], Yutaka Kondo[2], Yoshimi Ogawa-Tsukagawa[2], Kazuhiko Miura[1], Motohiro Hirabayashi[2], Naga Oshima[4], Makoto Koike[5], Kaarle Kupiainen[6], Nobuhiro Moteki[5], Sho Ohata[7], Sinha Puna Ram[8], Konosuke Sugiura[9], Teruo Aoki[10], Martin Schneebeli[11], Konrad Steffen[11], Atsushi Sato[12], Akane Tsushima[13], Vladimir Makarov[14], Satoshi Omiya[15,16], Atsuko Sugimoto[17], Shinya Takano[17] (1.Tokyo University of Science, 2.National Institute of Polar Research, 3.The Graduate University for Advanced Studies, 4.Meteorological Research Institute, 5.Depertment of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 6.Environmental Protection Department Ministry of the Environment, 7.Institute for Space–Earth Environmental Research (ISEE), Nagoya University, 8.Department of Space Indian Space Research Organization, 9.University of Toyama, 10.Okayama University, 11.WSL Institute for Snow and Avalanche Research, 12.former Snow and Ice Research Center, 13.Reserach Institute for Humanity and Nature, 14.Melnikov's Permafrost Institute, 15.Institute of Low Temperature Science, Hokkaido University, 16.Civil Engineering Research Institute for Cold Region, 17.Graduate School of Environmental Science, Hokkaido University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[AAS04-10] The single-particle extinction and scattering method for online characterization of submicron particles: Principles and applications to aerosol research

*Nobuhiro Moteki[1] (1.The Univerisity of Tokyo)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[AAS04-11] High spatial resolution vehicular emissions inventory for China using VEIN model

*Sergio Ibarra Espinosa[1], Xuelei Zhang[1], Aijun Xiu[1], Edmilson Dias de Freitas[2] (1.Research Group of Regional Atmospheric Environment, Northeast Institute of Geography and Agroecology, Chinese Academy of Sciences, P. R. China, 2.Department of Atmospheric Sciences, University of São Paulo, Brazil.)

Observations of aerosol optical properties by sky radiometers at SKYNET Southeast and South Asian sites

*Al Mashroor Fatmi[1], Hitoshi Irie[1], Hossain Mohammed Syedul Hoque[1], Alessandro Damiani[1], Pradeep Khatri[2], Tamio Takamura[1], Thanawat Jurupongsaku[3], Govindan Pandithurai[4]

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Direct and scattered sunlight measurements using sky radiometers were performed at two SKYNET sites –Phimai (15.18˚N, 102.56˚E) in Thailand and New Delhi (28.63˚N, 77.17˚E) in India. Phimai is a rural site and during the dry season (January to April), the site is affected by biomass burning. New Delhi is an urban site and expected to be influenced by vehicular and industrial emissions and agricultural waste burning. Depending on the data availability, aerosol optical properties during the year 2012 and 2016 were analyzed for New Delhi and Phimai, respectively. During the dry season in 2016 at Phimai, enhanced aerosol absorption optical depth (AAOD) was observed corresponding to the influence of biomass burning. The wavelength dependence of AAOD was quantified using the absorption Ångström exponent (AAE). The mean AAE at Phimai during the dry season in 2016 was 1.5±0.2, indicating the presence of organic brown carbon aerosols. This was consistent with coincident multi-axis differential absorption spectroscopy measurements showing higher concentration of organic compounds (formaldehyde and glyoxal) during the dry season, corresponding to biomass burning. At New Delhi, the mean AAE values during winter (December ~ February) and monsoon season (June ~ August) were 1.51±0.23 and 0.88± 0.24, respectively. The higher AAE during winter indicates the significant injection of organic brown carbon, probably due to transportation of carbonaceous materials from agricultural waste burning from Northern India. Thus, deduction of AAE, retrieved through sky radiometers observations, is expected to be useful for better understanding the physical and optical properties of light absorbing organic aerosols.

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Analysis of factors causing variations in the absorption Ångström exponent of aerosols in Japan using skyradiometers

*Kodai Yamaguchi[1], Hitoshi Irie[1], Pradeep Khatri[2], Toshihiko Takemura[3], Hirokazu Yamamoto[4]

1. Chiba University, 2. Tohoku University, 3. Kyushu University, 4. National Institute of Advanced Industrial Science and Technology

Aerosols have brought the most significant uncertainty in predicting future climate change. To reduce the uncertainty, it is essential to better understand the optical properties of aerosols. Organic aerosols and mineral dust, which are the main aerosols, have been considered to cause only a weak light absorption, and their radiative forcing has been negative in most climate models. However, recent laboratory experiments and observations indicated that there should be aerosols (such as brown carbon) causing a strong light absorption in particular in the ultraviolet-to-visible wavelength regions. Although the Absorption Ångström exponent (AAE) was used as a useful index for representing the wavelength dependence of such light absorption, its observation has been limited. Under this circumstance, we made long-term observations using skyradiometers of SKYNET at 6 sites in Japan (Chiba, Fukue, Kasuga, Miyakojima, Sendai, and Takayama). Using our newly developed analysis algorithm package (SR-CEReS), we retrieved AAE values for the 6 sites to investigate factors causing their variations. While the theoretical AAE value of black carbon is considered to be unity, our analysis shows that the annual averages of AAE were in the range from 1.15 to 1.51, indicating the presence of aerosols having strong light absorption in the ultraviolet-to-visible wavelength regions at all the 6 sites. Moreover, urban sites tended to show higher AAE values. We additionally analyzed nitrogen dioxide and sulfur dioxide concentration data taken by the Multi-Axis Differential Optical Absorption Spectroscopy (MAX-DOAS) observations, which were conducted simultaneously with the skyradiometer. Then, it was suggested that the AAE could be enhanced by emissions from ships, factories, or steelworks.

Keywords: Aerosol, Skyradiometer, Absorption Ångström exponent (AAE)

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Sources of atmospheric black carbon and related carbonaceous components at Rishiri Island, Japan

*Chunmao Zhu[1], Yugo Kanaya[1], Hisayuki Yoshikawa[2], Tomohisa Irino[2], Osamu Seki[2], Yasunori Tohjima[3]

1. Japan Agency for Marine-Earth Science and Technology, 2. Hokkaido University, 3. National Institute for Environmental Studies

A field study was conducted to clarify sourcesof atmospheric black carbon and related carbonaceous components at Rishiri Island, Japan. We quantified equivalent black carbon (eBC) particle mass and the absorption Ångström exponent (AAE), atmospheric CO and CH_4, in addition to levoglucosan in total suspended particles, a typical tracer of biomass burning. Sixteen high eBC events were identified attributable to either anthropogenic sources or biomass burning in Siberia/China. These events were often accompanied by increases of co-emitted gases such as $CH_4$and CO. Specifically, we observed pollution events with elevated eBC, AAE, levoglucosan, and CH_4–CO slope in late July 2014, which were attributed to forest fires in Siberia by reference to the FLEXPART model footprint and fire hotspots. In autumn, drastic increases of eBC, AAE, and levoglucosan were observed, accompanied by an eBC–CO slope of >15 ng m^{-3}/ppb, resulting from long-range transport of emissions from extensive burning of crop residue on the Northeast China Plain. Other than the sources of fossil fuel combustion in China and forest fires in Siberia, we also report that pollution events in northern Japan are caused by crop residue burning in China. This study elucidated valuable information that will improve understanding of the effects of biomass burning in East Asia on atmospheric carbonaceous components.

Keywords: Aerosols, Biomass burning, Levoglucosan, Black carbon, FLEXPART

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Black Carbon and Inorganic Aerosols in Snowpack over the Arctic

*Tatsuhiro Mori[1], Kumiko Goto-Azuma[2,3], Yutaka Kondo[2], Yoshimi Ogawa-Tsukagawa[2], Kazuhiko Miura[1], Motohiro Hirabayashi[2], Naga Oshima[4], Makoto Koike[5], Kaarle Kupiainen[6], Nobuhiro Moteki[5], Sho Ohata[7], Sinha Puna Ram[8], Konosuke Sugiura[9], Teruo Aoki[10], Martin Schneebeli[11], Konrad Steffen[11], Atsushi Sato[12], Akane Tsushima[13], Vladimir Makarov[14], Satoshi Omiya[15,16], Atsuko Sugimoto[17], Shinya Takano[17]

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Black carbon (BC) deposited on snow lowers snow albedo, potentially contributing to the warming in the Arctic. The distributions of inorganic aerosols (ions), which contribute to direct and indirect aerosol effects, are also greatly influenced by deposition. It is critically important to measure the spatial distributions of BC and ions in snowpack in different regions of the Arctic to quantify these effects. Because accurate measurements of BC and ions in snowpack are very limited, we measured the mass concentrations of size-resolved BC (C_{MBC}) and ions in snowpack over Finland, Alaska, Siberia, Greenland, and Spitzbergen in early spring during the period of 2012 –2016 by using a single-particle soot photometer and ion chromatography, respectively. BC deposition amounts (DEP_{MBC}) during snow accumulation periods were derived from C_{MBC} and snow water equivalent (SWE). Detailed analyses have shown that the spatial distributions of the anthropogenic BC flux and topography strongly influenced the latitudinal variations of C_{MBC} and BC size distributions. The average size distributions of BC in snowpack shifted to smaller sizes with the decrease in C_{MBC}, likely due to an increase in the removal efficiency of BC with the increase in BC diameter during transport from major BC sources. The present C_{MBC} were much lower than previous C_{MBC} measured by using an Integrating Sphere/Integrating Sandwich spectrophotometer by a factor of about 13. The present accurate data of C_{MBC}, SWE, and DEP_{MBC} are very useful in constraining climate model to estimate the effect of BC on the climate of the Arctic.

Keywords: Black carbon, Wet deposition, Arctic

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The single-particle extinction and scattering method for online characterization of submicron particles: Principles and applications to aerosol research

*Nobuhiro Moteki[1]

1. The Univerisity of Tokyo

We will introduce the single-particle extinction and scattering (SPES) method as a new fundamental tool for online measurements of submicron particles and its applications to aerosol research. The SPES method accurately determines the amplitude and phase of the forward-scattered wave from a single particle on the basis of the interference patterns between the scattered and the incident fields when the particle traverses a tightly-focused laser beam. The complex refractive index and volume of the detected particle can be estimated from the SPES data using our original data-processing algorithm. In the presentation, we will talk about the measurement principle, the theoretical framework of data analysis including the potential effects of particle shape, the performance tests, and some applications to black carbon and mineral particles.

Keywords: aerosol, dust, black carbon, biological particles, marine suspended particles, measurement technique

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High spatial resolution vehicular emissions inventory for China using VEIN model

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Vehicular emissions are an important source of pollution in China. These and other anthropocentric emissions, with poor meteorological conditions enhance critic episodes of high concentrations of air pollutants (Wang S. and Hao J., 2012). Environmental policies seeks to improve air quality by diminishing and cutting emissions, making the emissions characterization of crucial importance. Even more, air quality modelers needs emissions inventories as inputs, which usually suffer of limited temporal and spatial representation and over simplification. Under these circumstances, it is not expected good air quality simulations. I other words, garbage-in, garbage-out.

This study aims to improve the temporal and spatial representation of vehicular emissions. This will be achieve using the VEIN model (Ibarra-Espinosa *et al.,* 2017), initially with a top-down approach. The method and data is described as follows: stock vehicles will be obtained for 31 provinces (National Bureau of Statistics (NBS), 2016) considering vehicle survival pattern and average age of use of the fleet (HAO *et al*, 2011; Wang H. *et al*, 2012). NBS data is aggregated without discriminating taxis and motorcycles, therefore, the vehicular composition and activity will be obtained with the percentages of Wang H. *et* al, (2008): Passenger Cars (PC), Taxi, Motorcycle, Moped, Bus, Small Trucks, Medium Trucks and Heavy Trucks by type of fuel. Furthermore, we will divide traffic at peak and off peak hours and by Freeways, Arterial and residential roads, shown on Fig.1, in each province to obtain the representative speed in each case, based on the driving cycles obtained by Wang Q. *et al*, (2008). We will use Copert (Ntziachristos and Samaras, 2016) emissions factors inside VEIN correcting by chemical composition of fuel and deterioration factors. Cold starts and evaporative emissions will be obviously included. To ensure consistency with the emissions and fuel consumed on each province, activity will be calibrated in order that fuel consumption estimation or CO_2 estimations matches with statistics of automotive fuel sales or CO_2 emissions, depending on the availability of data. Top-down emissions will be spatially dis-aggregated by length of type of road from OpenStreetMap in each province as shown by Andrade *et al*, (2015).

Vehicular, Emissions, VEIN, China

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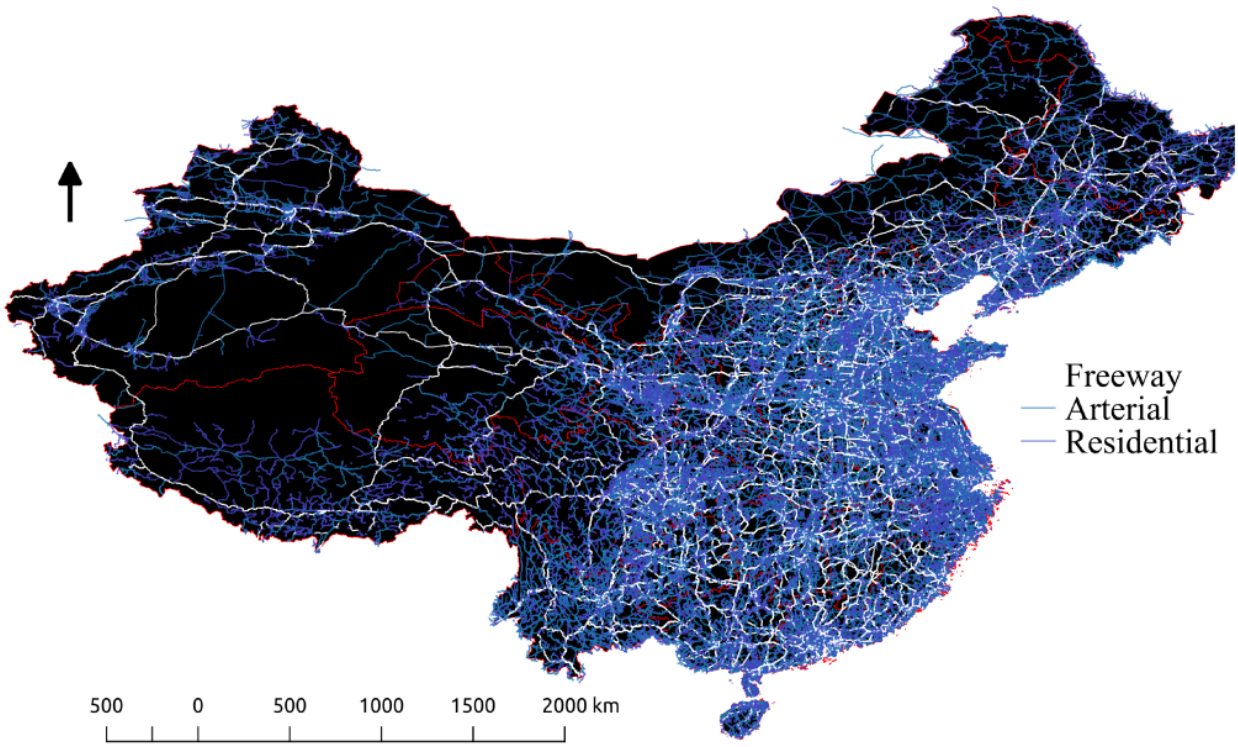
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Keywords: Vehicular emissions, VEIN, China



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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

Wed. May 29, 2019 3:30 PM - 5:00 PM JST | Wed. May 29, 2019 6:30 AM - 8:00 AM UTC | 102 1F

[A-AS04] Atmospheric Chemistry

convener:Tomoki Nakayama(Graduate School of Fisheries and Environmental Sciences, Nagasaki University), Yoko Iwamoto(Graduate School of Biosphere Science, Hiroshima University), Sakae Toyoda(Department of Chemical Science and Engineering, Tokyo Institute of Technology), Nawo Eguchi(Kyushu University), Chairperson:Kentaro Ishijima(気象研究所)

This session provides a forum for the presentation of the broad spectrum of tropospheric and stratospheric chemistry, including various research topics (e.g., dynamical processes, air quality and climate), approaches (modeling, field measurements, remote sensing, and laboratory studies), and species (gas and aerosol). This session also provides an opportunity for discussing possible future collaboration with other research fields relevant to atmospheric chemistry. We strongly encourage authors to prepare presentation slides and a poster in English.

3:30 PM - 4:00 PM JST | 6:30 AM - 7:00 AM UTC

[AAS04-12] Effect of land use change on GHG fluxes of tropical peat forests in Borneo island

★Invited Papers

*Ryuichi Hirata[1], Habura Borjigin[1], Tomohiro Shiraishi[1], Takashi Hirano[2], Lulie Melling[3] (1.National Institute for Environmental Studies, 2.Hokkaido University, 3.Sarawak Tropical Peat Research Institute)

4:00 PM - 4:30 PM JST | 7:00 AM - 7:30 AM UTC

[AAS04-13] Remote sensing of carbon assimilation function of terrestrial ecosystem by Earth-observation satellite

★Invited Papers

*Hibiki M Noda[1], Yukio Yoshida[1], Haruki Oshio[1], Tomoki Kiyono[1], Tatsuya Miyauchi[1], Tsuneo Matsunaga[1] (1.NIES National Institute of Environmental Studies)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[AAS04-14] Analysis of the carbon dioxide in the upper troposphere and lower stratosphere by the data from GOSAT TANSO-FTS TIR

*Nawo Eguchi[1], Akihiro Honda[1], Naoko Saitoh[2], Yosuke Niwa[3] (1.Kyushu University, 2.Chiba University, 3.National Institute for Environmental Studies)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[AAS04-15] Seasonal and interannual variations of the Atmospheric Potential Oxygen over the Western North Pacific observed by using a cargo aircraft C-130H

*Shigeyuki Ishidoya[1], Kazuhiro Tsuboi[2], Yosuke Niwa[3], Shohei Murayama[1], Hidekazu Matsueda[2], Yousuke Sawa[2], Nobuyuki Aoki[1], Kentaro Ishijima[2], Kentaro Kozumi[4], Genta Umezawa[4], Kazuya Yukita[4], Shigeharu Nishida[4], Megumi Yamamoto[4] (1.National Institute of Advanced Industrial Science and Technology (AIST), 2.Meteorological Research Institute, 3.National Institute for Environmental Studies, 4.Japan Meteorological Agency)

Effect of land use change on GHG fluxes of tropical peat forests in Borneo island

*Ryuichi Hirata[1], Habura Borjigin[1], Tomohiro Shiraishi[1], Takashi Hirano[2], Lulie Melling[3]

1. National Institute for Environmental Studies, 2. Hokkaido University, 3. Sarawak Tropical Peat Research Institute

Borneo island, which is located in southeast Asia, has a rich forest and it store a huge carbon in biomass and soil. It is well known that peat, which is large carbon reservoir, widely spreads in the island. While tropical peat forest occupies only 0.25% of surface area on globe, it accounts 3% of soil organic carbon on earth. Tropical peat forest, in which forest grows on peat which depth from 1 to 10 m. Recently, the area of tropical peat forest is rapidly decreasing because of fire or plantation and has resulted in large carbon lost. Therefore, carbon management and control for tropical peat forest is very important with the objective of development, conservation and disaster prevention. In this study, we will introduce the studies to evaluate the effects of land use change on greenhouse gas fluxes of tropical peat lands from site scale to regional scale various methods i.e. flux observation of eddy covariance and chamber methods, remote sensing and numerical simulation under several projects.

Keywords: flux observation, remote sensing, model

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Remote sensing of carbon assimilation function of terrestrial ecosystem by Earth-observation satellite

*Hibiki M Noda[1], Yukio Yoshida[1], Haruki Oshio[1], Tomoki Kiyono[1], Tatsuya Miyauchi[1], Tsuneo Matsunaga[1]

1. NIES National Institute of Environmental Studies

Since industrial evolution, global warming has progressed owing to increase of CO_2 emitted by human activities. To deal effectively with this issue by mitigation and adaptation, it is necessary to monitor emission and sequestration of GHGs with their underlying mechanisms including biogeochemical processes. Plant photosynthesis is one of the important factors to drive carbon cycling between atmosphere and biosphere. The terrestrial ecosystems assimilate about 30 % of anthropogenic CO_2 through photosynthesis. Since the photosynthetic process is quite sensitive to climatic conditions such as temperature, radiation and precipitation, there are still uncertainty in the estimation of photosynthetic production of regional to global scale. This uncertainty would be lager under climate change condition in near future. Thus, it is necessary to obtain the temporal dynamics of the photosynthetic production in large area.
Satellite remote sensing has been used to monitor the spatial and temporal dynamics of terrestrial ecosystems that are responsible for such photosynthetic CO_2 absorption. Such observation provides us with geographical information on the potential distribution of carbon sequestration by the aid of ecosystem models. In these years, advent of the spectroradiometer, which has high wavelength resolution, such as TANSO FTS on Greenhouse Gases Observing Satellite (GOSAT) enable us to observe solar-induced chlorophyll fluorescence (SIF) emitted from the terrestrial ecosystems. Since the chlorophyll fluorescence is emitted from photosynthetic process itself, SIF remote sensing is drawn considerable attention as a new technique to observe the photosynthetic activity of the vegetation. SIF has been measured by gas-measurement satellites, such as GOSAT, GOSAT-2, OCO-2 and GOME2 on MetOp A and B.
In this talk, we will introduce our previous and on-going studies about estimation of photosynthetic production of the terrestrial ecosystem. We also discuss about future perspective about SIF studies in GOSAT and GOSAT-2 projects.

Keywords: vegetation remote sensing, solar-induced chlorophyll fluorescence, GOSAT

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Analysis of the carbon dioxide in the upper troposphere and lower stratosphere by the data from GOSAT TANSO-FTS TIR

*Nawo Eguchi[1], Akihiro Honda[1], Naoko Saitoh[2], Yosuke Niwa[3]

1. Kyushu University, 2. Chiba University, 3. National Institute for Environmental Studies

Stratospheric cooling was reported, it could be caused by increasing the carbon dioxide (CO_2), which is a major greenhouse gas. While, the concentration of CO_2 in the stratosphere is not well understood, nor are the exchange processes between the upper troposphere and lower stratosphere (UT/LS ; 250-100hPa). The present study investigated the intra-seasonal, seasonal and inter-annual variations of CO_2 to understand the CO_2 concentration at UT/LS and the Stratosphere and Troposphere exchange process.

We used the vertical profile data (Level 2) of CO_2 derived from thermal infrared (TIR) region (Band 4: 5.5 - 14.3 μm) of the Thermal And Near-infrared Sensor for carbon Observation (TANSO) - Fourier Transform spectrometer (FTS) on board Greenhouse gas Observing SATellite (GOSAT). The analysis period is four years from January 2010 to December 2013. We adapted the bias correction values derived from Saitoh et al. [AMT, 2016] which validated the TIR CO_2 profiles at UT/LS region with the Comprehensive Observation Network for TRace gases by AIrLiner (CONTRAIL). For reference, the atmospheric transport model, NIES-TM (ver.5) and the Nonhydrostatic Icosahedral Atmospheric Model (NICAM)–based Transport Model (TM) were used [Niwa et al., 2011; 2017].

The growth rate of CO_2 concentration at UT/LS were approximately 2 ppmv/year, which one at southern hemisphere were relatively larger than one at northern hemisphere. The seasonal variation of CO_2 concentration, showed that the maximum peak existed after a few month with respect to the peak at the middle or lower troposphere. The inter-annual variations were affected by the ENSO cycle; the higher (lower) CO_2 concentration at UT were seen during La Nina (Normal / El Nino) period. Finally, the intra-seasonal variation CO_2 concentration at UT/LS were associated with both the vertical and horizontal transportation due to the deep convection and the Asian monsoon anticyclonic circulation, respectively. To clarify the dynamics of CO_2 concentration on the time scale within the area and season within which we could not observe by aircraft observation or balloon observation, the results are used for verification of physicochemical process of global model and also for their development can do.

Keywords: greenhouse gases, stratosphere-troposphere exchange, GOSAT satellite

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Seasonal and interannual variations of the Atmospheric Potential Oxygen over the Western North Pacific observed by using a cargo aircraft C-130H

*Shigeyuki Ishidoya[1], Kazuhiro Tsuboi[2], Yosuke Niwa[3], Shohei Murayama[1], Hidekazu Matsueda[2], Yousuke Sawa[2], Nobuyuki Aoki[1], Kentaro Ishijima[2], Kentaro Kozumi[4], Genta Umezawa[4], Kazuya Yukita[4], Shigeharu Nishida[4], Megumi Yamamoto[4]

1. National Institute of Advanced Industrial Science and Technology (AIST), 2. Meteorological Research Institute, 3. National Institute for Environmental Studies, 4. Japan Meteorological Agency

The cargo aircraft C-130H flies once per month from Atsugi Base (35.45˚N, 139.45˚E), Kanagawa, Japan, to Minamitorishima (MNM; 24.28˚N, 153.98˚E), and air samples are collected during the level flight (~6 km) and the descent portion at MNM. The air samples have been analyzed for $O_2/N_2$and Ar/N_2ratios and stable isotopic ratios of N_2, $O_2$and Ar since May 2012. The analysis indicated a significant artificial fractionation due to thermal diffusion during the air sample collection. Nevertheless we succeeded to correct the effects of the fractionation on the observed O_2/N_2ratio precisely by using the observed Ar/N_2 ratio (Ishidoya et al., 2014). The corrected O_2/N_2ratio showed a secular decrease accompanied by a prominent seasonal cycle. The average secular change rate of the mid-tropospheric corrected O_2/N_2ratio was found to be -25.2±0.5 per meg $yr^{-1}$for the period 2012 –2018, which agreed well with that observed at La Jolla, USA by Scripps O_2program (Keeling and Manning, 2014). As the uncertainty of the change rate, we considered the spatial difference of the rates and the stability of the O_2/N_2ratio of standard air.

The Atmospheric Potential Oxygen ($APO=O_2+1.1xCO_2$), calculated by using the corrected O_2/N_2ratio, also showed prominent seasonal cycles, and the amplitude of the mid-tropospheric seasonal APO cycle observed at 25.5˚N was found to be 55 and 31 % of those observed at 33.5˚N and the surface MNM (Ishidoya et al., 2017), respectively. On the other hand, the corresponding seasonal amplitude of CO_2at 25.5˚N was found to be 72 and 93 % of those at 33.5˚N and the surface MNM, respectively. An atmospheric transport model (Niwa et al., 2017) reproduced general features of the observed seasonal APO and CO_2cycles, and its tagged simulation suggested that the mid-tropospheric seasonal APO cycle in the northern low latitudes was reduced significantly by the anti-phase seasonal APO cycle from the southern hemisphere. The observed APO showed interannual variations superimposed on secular downward trends, and the temporal change rates take maxima from the end of 2014 to the beginning of the 2015 at the surface MNM and in the mid-troposphere at 29 –34 ˚N. A comparison between the observed and simulated interannual variations of APO suggested that an interannual variation of the atmospheric transport contributed about 30 % of the observed variation.

Acknowledgments

We thank the staff of Japan Meteorological Agency for their work to collect the air samples onboard a cargo aircraft C-130H. This study was partly supported by the JSPS KAKENHI Grant Number 15H02814, and the Global Environment Research Coordination System from the Ministry of the Environment, Japan.

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Keywords: Atmospheric Potential Oxygen (APO), aircraft observation

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

Wed. May 29, 2019 9:00 AM - 10:30 AM JST | Wed. May 29, 2019 12:00 AM - 1:30 AM UTC | 201B 2F

[A-AS05] Stratosphere-troposphere Processes And their Role in Climate

convener:Yoshio Kawatani(Japan Agency for Marine-Earth Science and Technology), Shingo Watanabe(Japan Agency for Marine-Earth Science and Technology), Takashi Sekiya(Japan Agency for Marine-Earth Science and Technology), Kaoru Sato(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Chairperson:Watanabe Shingo(海洋研究開発機構)

The Stratosphere-troposphere Processes And their Role in Climate (SPARC) is one of the
major projects of the World Climate Research Programme (WCRP), and is characterized
by its focus on chemical and dynamical coupling in the stratosphere and troposphere. In
this session, we welcome presentations on various processes in the stratosphere and tro
posphere.

9:00 AM - 9:10 AM JST | 12:00 AM - 12:10 AM UTC

Introduction

9:10 AM - 9:40 AM JST | 12:10 AM - 12:40 AM UTC

[AAS05-01] Turbulent kinetic energy dissipation rates depending on the polar vortex and on synoptic-scale disturbances in the UTLS region in the Antarctic

★Invited Papers

*Masashi Kohma[1], Kaoru Sato[1], Koji Nishimura[2], Masaki Tsutsumi[2] (1.Department of Earth and Planet Science, Graduate School of Science, The University of Tokyo, 2.National Institute of Polar Research and The Graduate University for Advanced Studies (SOKENDAI))

9:40 AM - 9:55 AM JST | 12:40 AM - 12:55 AM UTC

[AAS05-02] Momentum budget of semiannual oscillation around the tropical stratopause

*Yoshihiro Tomikawa[1,2], V. Lynn Harvey[3], John A. Knox[4], Masatomo Fujiwara[5] (1.National Institute of Polar Research, 2.SOKENDAI, 3.University of Colorado Boulder, 4.University of Georgia, 5.Hokkaido University)

9:55 AM - 10:10 AM JST | 12:55 AM - 1:10 AM UTC

[AAS05-03] A study on sources of gravity waves that reach the summer stratosphere and mesosphere based on high-resolution radiosonde data

*Haruka Okui[1], Masashi Kohma[1], Kaoru Sato[1] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

10:10 AM - 10:25 AM JST | 1:10 AM - 1:25 AM UTC

[AAS05-04] Stratospheric initial conditions provide seasonal predictability of the North Atlantic and Arctic Oscillations

*Yu Nie[1], Adam Scaife[2,3], Hong-Li Ren[1,4], Ruth Comer[2], Martin Andrews[2] (1.Laboratory for Climate Studies, National Climate Center, China Meteorological Administration, Beijing, China, 2.Met Office Hadley Centre, Exeter, UK, 3.College of Engineering, Mathematics and Physical Sciences, University of Exeter, Exeter, UK, 4.Department of Atmospheric Science, School of Environmental Studies, China University of Geoscience, Wuhan, China)

10:25 AM - 10:30 AM JST | 1:25 AM - 1:30 AM UTC

Discussion

Turbulent kinetic energy dissipation rates depending on the polar vortex and on synoptic-scale disturbances in the UTLS region in the Antarctic

*Masashi Kohma[1], Kaoru Sato[1], Koji Nishimura[2], Masaki Tsutsumi[2]

1. Department of Earth and Planet Science, Graduate School of Science, The University of Tokyo, 2. National Institute of Polar Research and The Graduate University for Advanced Studies (SOKENDAI)

The turbulence kinetic energy dissipation rate (TKEDR) is a fundamental parameter describing atmospheric turbulence. Our previous study reported the first estimation of the TKEDR in the free atmosphere in the Antarctic from atmospheric radar measurements at Syowa Station, and showed that the TKEDR in the 10–15 km height range became large in May through October. This fact suggests that the seasonal evolution of polar vortex has impact on the TKEDR in the upper troposphere and lower stratosphere (UTLS). The present study investigates the dependence of the TKEDR on the relative location to the polar vortex and on each phase of synoptic scale disturbances during austral winter in the UTLS region using the radar measurements at Syowa Station. First, the TKEDR is obtained as a function of the relative distance from the edge of the polar vortex. The edge of the polar vortex was determined from Ertel’ s potential vorticity on 475-K isentropic surface (Nash et al., 1996). The result showed that the TKEDR is significantly large near the polar vortex edge compared to that outside and deep inside the polar vortex. Furthermore, it is clarified that the TKEDR largely depends on synoptic-scale PV perturbation around the tropopause (300-K isentropic surface).

Keywords: turbulent kinetic energy dissipation rate, polar vortex, atmospheric radar

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Momentum budget of semiannual oscillation around the tropical stratopause

*Yoshihiro Tomikawa[1,2], V. Lynn Harvey[3], John A. Knox[4], Masatomo Fujiwara[5]

1. National Institute of Polar Research, 2. SOKENDAI, 3. University of Colorado Boulder, 4. University of Georgia, 5. Hokkaido University

Meteorological reanalysis data have been updated and improved in the past decade, which are pretty useful for climate and meteorological studies. Their comprehensive evaluation is going underway as the SPARC Reanalysis Intercomparison Project (S-RIP). This study reports the momentum budget of semiannual oscillation around the tropical stratopause for four kinds of the latest reanalysis data (i.e., MERRA, MERRA2, ERA-Interim, and JRA55) as a part of S-RIP. They showed that, while the westerly acceleration is primarily due to unresolved wave drag (i.e. gravity wave drag), the easterly acceleration is induced by momentum transport due to meridional circulation and resolved wave drag. This feature is consistent with previous studies based on simulation and observation. However, the contribution of unresolved wave drag is maximized in MERRA/MERRA2 later than in ERA-Interim/JRA55. We discuss the difference between the latest reanalyses and its impact on the tropical dynamics.

Keywords: stratopause, semiannual oscillation, reanalysis

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A study on sources of gravity waves that reach the summer stratosphere and mesosphere based on high-resolution radiosonde data

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Gravity waves (GWs) are mainly generated in the troposphere and play a crucial role in the momentum transport in the stratosphere and mesosphere. Several possible main sources of GWs are suggested by theoretical, numerical and observational studies; topography and jet-front systems in winter, and strong convection in summer (e.g. Sato *et al.*, 2009). In addition, theoretical work by Bühler *et al.* (1999) indicated that the Kelvin-Helmholtz (KH) shear instability can cause significant emission of GWs in summer. Having critical layers in the lower stratosphere, orographic waves hardly propagate into the summer stratosphere and mesosphere. On the other hand, most GWs emitted from the KH instability above the tropopausal jet do not encounter their critical layer and can reach the stratosphere and mesosphere. However, observational studies from this view point are insufficient. In this study, using high-resolution radiosonde data from 9 stations in Japan, the generation and propagation of GWs with short vertical wave length ($\leq$ 4 km) in the troposphere and lower stratosphere are investigated. The parameters describing the wave structure are estimated by a hodograph analysis. Drawing a comparison with GWs observed in winter, source and propagation characteristics of GWs in summer are highlighted. The latitude-height distribution of wave amplitudes and phase velocity characteristics suggests that orographic waves are not dominant in summer in contrast with those in winter. The vertical direction of wave energy propagation shows that summer GWs propagate upward and downward from the 10-15 km height region, where the occurrence frequency of the events with Richardson number (Ri) less than 0.25 (which is a necessary condition for the KH instability) is high. In addition, wave amplitudes in the lower stratosphere are relatively large above the peak of the occurrence frequency of $Ri < 0.25$, which is located around the latitude and height region of 30°N-35°N, 12-15 km. These results suggest that the KH instability is one of major sources of GWs in the summer stratosphere. The KH instability tends to occur when the vertical wind shear is large and the static stability is low. In summer, the vertical shear associated with the jet is stronger at higher latitudes and the static stability is lower at lower latitudes. The peak of occurrence frequency of $Ri < 0.25$ as mentioned above is situated at the middle latitudes inbetween. Therefore, it can be inferred that this region is climatologically important for shear-generated GWs which can reach the summer stratosphere.

Keywords: middle atmosphere, gravity waves

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Stratospheric initial conditions provide seasonal predictability of the North Atlantic and Arctic Oscillations

*Yu Nie[1], Adam Scaife[2,3], Hong-Li Ren[1,4], Ruth Comer[2], Martin Andrews[2]

1. Laboratory for Climate Studies, National Climate Center, China Meteorological Administration, Beijing, China, 2. Met Office Hadley Centre, Exeter, UK, 3. College of Engineering, Mathematics and Physical Sciences, University of Exeter, Exeter, UK, 4. Department of Atmospheric Science, School of Environmental Studies, China University of Geoscience, Wuhan, China

The North Atlantic Oscillation (NAO), the regional manifestation of the Arctic Oscillation (AO), dominates winter climate variability in Europe and North America. Skilful seasonal forecasting of the winter NAO/AO has been demonstrated recently by dynamical prediction systems. However, the role of initial conditions in this predictability remains unknown. Using a latest generation seasonal forecasting system and reanalysis data, we show that the initial upper stratospheric zonal wind anomaly contributes to winter NAO/AO predictability through downward propagation of initial conditions. An initial polar westerly/easterly anomaly in the upper stratosphere propagates down to the troposphere in early winter, favoring a poleward/equatorward shift of the tropospheric mid-latitude jet. This tropospheric anomaly persists well into the late winter and induces the positive/negative phase of NAO/AO in the troposphere. Our results imply that good representation of stratospheric initial condition and stratosphere-troposphere coupling in models is important for winter climate prediction.

Keywords: Seasonal Prediction, Stratosphere, NAO/AO

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

Wed. May 29, 2019 10:45 AM - 12:15 PM JST | Wed. May 29, 2019 1:45 AM - 3:15 AM UTC | 201B 2F

[A-AS05] Stratosphere-troposphere Processes And their Role in Climate

convener:Yoshio Kawatani(Japan Agency for Marine-Earth Science and Technology), Shingo Watanabe(Japan Agency for Marine-Earth Science and Technology), Takashi Sekiya(Japan Agency for Marine-Earth Science and Technology), Kaoru Sato(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Chairperson:Takashi Sekiya

The Stratosphere-troposphere Processes And their Role in Climate (SPARC) is one of the
major projects of the World Climate Research Programme (WCRP), and is characterized
by its focus on chemical and dynamical coupling in the stratosphere and troposphere. In
this session, we welcome presentations on various processes in the stratosphere and tro
posphere.

10:45 AM - 11:15 AM JST | 1:45 AM - 2:15 AM UTC

[AAS05-05] Transport of trace gases into the extratropical upper troposphere/lower stratosphere

★Invited Papers

*Yoichi Inai[1], Ryo Fujita[2,1], Toshinobu Machida[3], Hidekazu Matsueda[4], Yousuke Sawa[4], Kazuhiro Tsuboi[4], Keiichi Katsumata[3,5], Shinji Morimoto[1], Shuji Aoki[1], Takakiyo Nakazawa[1] (1.Tohoku Univ., 2.Imperial College London, 3.NIES, 4.MRI, 5.Takachiho Chem. Industrial)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[AAS05-06] Possible impacts of stratospheric ozone on circulation changes in the tropical tropposphere following a stratospheric sudden warming event

*Makoto Deushi[1] (1.Department of Atmospheric Environment and Applied Meteorology, Meteorological Research Institute)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[AAS05-07] **Stratosphere-troposphere exchange of ozone and carbon monoxide over the northern Pacific Ocean in northern winter using two chemical reanalysis data sets**

*Haosen Xi[1], Masatomo Fujiwara[1], Kazuyuki Miyazaki[2] (1.Graduate School of Environmental Science, Hokkaido University, 2.NASA Jet Propulsion Laboratory, California Institute of Technology, USA)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[AAS05-08] **Inter-comparison of Upper Air Temperature in China between Satellite MSU and Radiosonde Datasts**

*Yanjun GUO[1], Cheng-zhi Zou[2], Panmao Zhai[3], Guofu Wang[1] (1.National Climate Center(NCC), China Meteorological Administration(CMA) , 2.Center for Satellite Applications and Research, NOAA/NESDIS, 3.Chinese Academy of Meteorolgical Sciences (CAMS), China Meteorological Administration (CMA))

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[AAS05-09] Environmental Characterization of the Atmosphere Using WACCM-X

*Rose Tseng[1], Michelle Kanipe[1], Brian Urbancic[1], Robert Tournay[1], Omar Nava[1], Daniel Emmons[1], Robert Loper[1], Charlton Lewis[1] (1.Air Force Institute of Technology)

Transport of trace gases into the extratropical upper troposphere/lower stratosphere

*Yoichi Inai[1], Ryo Fujita[2,1], Toshinobu Machida[3], Hidekazu Matsueda[4], Yousuke Sawa[4], Kazuhiro Tsuboi[4], Keiichi Katsumata[3,5], Shinji Morimoto[1], Shuji Aoki[1], Takakiyo Nakazawa[1]

1. Tohoku Univ., 2. Imperial College London, 3. NIES, 4. MRI, 5. Takachiho Chem. Industrial

To investigate the seasonal characteristics of chemical tracer distributions in the extratropical upper troposphere and lower stratosphere (ExUTLS) as well as stratosphere–troposphere exchange processes, origin fractions of air masses originating in the stratosphere, tropical troposphere, mid-latitude lower troposphere (LT), and high-latitude LT in the ExUTLS are estimated using 10-year backward trajectories calculated with European Centre For Medium-Range Weather Forecasts (ECMWF) ERA-Interim data as the meteorological input. Time-series of chemical tracers obtained from ground-based and airborne observations are incorporated into the trajectories, thus reconstructing spatiotemporal distributions of chemical tracers in the ExUTLS. The reconstructed tracer distributions are analysed with the origin fractions and the stratospheric age of air (AoA) estimated using the same backward trajectory. The reconstructed distributions of CO and CO_2 in the ExUTLS are affected primarily by tropospheric air masses because of the short chemical lifetime of the former and large seasonal variations in the troposphere of the latter. Distributions of CH_4, N_2O, and SF_6 are controlled primarily by seasonally varying air masses transported from the stratosphere. For CH_4 and N_2O distributions, their seasonally varying photochemical decay along the average pathway from the source region are particularly important. This study developed and demonstrated a unique and effective method to exploit the advantages of observational data in combination with trajectory analysis. This method provides a means to understand both air mass transport and chemical decay for photochemical active substances from a new perspective.

Keywords: Transport, Earth atmosphere, Trajectory analysis

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Possible impacts of stratospheric ozone on circulation changes in the tropical troppposphere following a stratospheric sudden warming event

*Makoto Deushi[1]

1. Department of Atmospheric Environment and Applied Meteorology, Meteorological Research Institute

Many studies have shown that there are significant impacts of the stratospheric ozone on dynamical coupling between the stratosphere and troposphere (S-T) at middle and high latitudes, especially in the Southern hemisphere (e.g. Marshall *et al.*, JC, 2006; Thompson *et al.*, Nature Geo, 2011). In contrast, little attention has been given to role of the stratospheric ozone in modulating S-T dynamical coupling in the tropics (and sub-tropics) so far. Recently, there has been an increasing interest in the S-T dynamical coupling in the tropics because it has been recognized that this coupling has significant influences on moist convection and organized convective systems in the tropics (e.g. Son *et al.*, JC, 2017; Nishimoto and Yoden, JAS, 2017).
In this study, possible impacts of the stratospheric ozone on tropospheric circulation and precipitation in the tropical and sub-tropical regions were examined, focusing on a period of several months following a major stratospheric sudden warming (SSW) event. As a case study, the major SSW occurred in the winter of 2003/2004 was investigated. A set of ensemble re-forecasts was performed by using a chemistry-climate model (CCM) and an atmospheric general circulation model (AGCM) to elucidate radiative effects of the stratospheric ozone anomalies induced by the major SSW on the troposphere at low latitudes. The ensemble re-forecasts were conducted using the Lagged Averaged Forecasting (LAF) method with 60 ensemble members, where the initial-times were set just before the occurrence of the major SSW. The CCM resolves well full stratospheric and tropospheric chemistry processes, and considers online radiative feedbacks from the simulated atmospheric ozone. The CCM ensemble re-forecast was compared to the AGCM ensemble re-forecast in which climatological monthly mean ozone was forced. The CCM ensemble re-forecast reproduced well significant ozone decrease in the lower tropical stratosphere due to rapidly enhanced upward Brewer-Dobson circulation there after the major SSW. About two weeks after the occurrence of the major SSW, systematic differences with statistical significance between the two ensemble re-forecasts were simulated in the tropospheric circulation and precipitation especially in the northern tropics and sub-tropics. The northern cell of the Hadley circulation became stronger in the CCM ensemble re-forecast than in the AGCM one, with the larger amount of precipitation over the Intertropical Convergence Zone (ITCZ). To confirm these impacts of the stratospheric ozone on the (sub-) tropical troposphere, other major SSW events are also investigated.

Keywords: stratosphere-troposphere coupling, stratospheric ozone, tropical tropospheric circulation, stratospheric sudden warming

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Stratosphere-troposphere exchange of ozone and carbon monoxide over the northern Pacific Ocean in northern winter using two chemical reanalysis data sets

*Haosen Xi[1], Masatomo Fujiwara[1], Kazuyuki Miyazaki[2]

1. Graduate School of Environmental Science, Hokkaido University, 2. NASA Jet Propulsion Laboratory, California Institute of Technology, USA

Stratosphere-troposphere exchange (STE) is one of the important factors that determine the distribution of constituents in the troposphere and stratosphere. Two-way airmass exchange between the lower stratosphere and the troposphere occurs in association with mid-latitude weather disturbances, with the net transport from the stratosphere to troposphere. In this study, we analyze the STE over the northern hemisphere Pacific Ocean in northern winter, focusing on transport of ozone and carbon monoxide (CO) using two chemical reanalysis data sets, the Tropospheric Chemical Reanalysis version 1 (TCR-1; Miyazaki et al., 2015) and the Monitoring Atmospheric Composition and Climate (MACC; Inness et al., 2013). The TCR-1 is a 10-year chemical reanalysis data set for the period from 2005 to 2014, while the MACC is for 2003 to 2012. Both reanalyses assimilate major satellite chemistry data during the respective periods. We calculate the amount of CO transported from the troposphere to stratosphere (TST) and ozone transported from the stratosphere to troposphere (STT) on the 350-K isentropic surface, by using 4 PVU potential vorticity to evaluate irreversible transport across the tropopause (e.g., Homeyer and Bowman, 2013). Results from the analysis of TCR-1 data are as follows. The amount of ozone transport per case maximizes in November and minimizes in February, and that in years 2005-2008 is significantly smaller than that in years 2009-2014 with the maximum in the 2010 winter (i.e., from November 2010 to March 2011). The amount of CO transport per case maximizes in March and minimizes in November, and that in years 2005-2009 is significantly larger than that in years 2010-2014 with the maximum in the 2009 winter. Results from MACC data are qualitatively similar. In the presentation we will also show the results with additional criteria for irreversibility by using trajectory calculations.

Keywords: ozone, carbon monoxide, stratosphere troposphere exchange

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Inter-comparison of Upper Air Temperature in China between Satellite MSU and Radiosonde Datasts

*Yanjun GUO[1], Cheng-zhi Zou[2], Panmao Zhai[3], Guofu Wang[1]

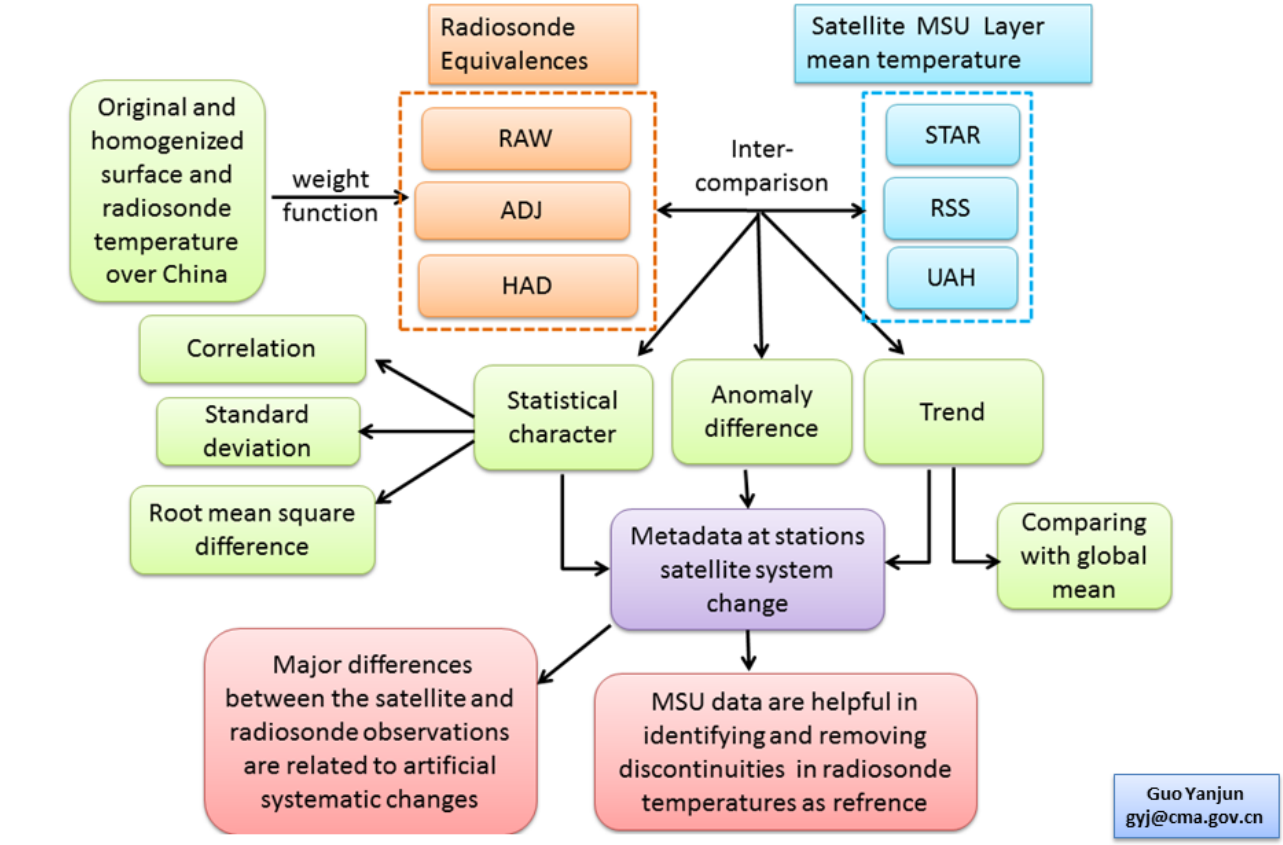
1. National Climate Center(NCC), China Meteorological Administration(CMA) , 2. Center for Satellite Applications and Research, NOAA/NESDIS, 3. Chinese Academy of Meteorolgical Sciences (CAMS), China Meteorological Administration (CMA)

Reconciling upper-air temperature trends derived from radiosonde and satellite observations is a necessary step to confidently determine the global warming rate. This study examines the raw and homogenized radiosonde observations over China and compares them with layer-mean atmospheric temperatures derived from satellite microwave observations for the lower-troposphere (TLT), mid-troposphere (TMT), upper troposphere (TUT), and lower stratosphere (TLS) by three research groups. The comparisons are for averages over China, excluding Tibetan Plateau, and at individual stations where metadata contain information on radiosonde instrument changes. It is found that major differences between the satellite and radiosonde observations are related to artificial systematic changes. The radiosonde system updates in early 2000s over China caused significant discontinuities and led the radiosonde temperature trends to exhibit less warming in the middle and upper troposphere and more cooling in the lower stratosphere than the satellite temperatures. Homogenized radiosonde data have been further adjusted using shift-point adjustment approaches to match with satellite products for China average. The obtained trends during 1979-2015 from the re-adjusted radiosonde observation are respectively 0.203±0.066, 0.128±0.044, 0.034±0.039, and -0.329±0.135 K Decade^{-1} for TLT, TMT, TUT, and TLS equivalents. Compared to satellite trends, the re-adjusted radiosonde trends are within 0.01 K Decade^{-1} for TMT and TUT, and 0.054 K Decade^{-1} warmer for TLT and 0.051 K Decade^{-1} cooler for TLS. The results suggest that the use of satellite data as a reference are helpful in identifying and removing inhomogeneities of radiosonde temperatures over China and reconciling their trends to satellite microwave observations. Future efforts are to homogenize radiosonde temperatures at individual stations over China using similar approaches.

Keywords: upper air, temperature, satellite, radiosonde, China, trend

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Inter-comparison of Upper Air Temperature in China between Satellite MSU and Radiosonde Datasets



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Environmental Characterization of the Atmosphere Using WACCM-X

*Rose Tseng[1], Michelle Kanipe[1], Brian Urbancic[1], Robert Tournay[1], Omar Nava[1], Daniel Emmons[1], Robert Loper[1], Charlton Lewis[1]

1. Air Force Institute of Technology

Researching the characteristics of the whole atmosphere can yield a variety of weather and climate understanding for the terrestrial and space environments. Of particular interest are the neutral species, wind, and temperature distributions from the surface to the middle atmosphere and across multiple latitudes. This is accomplished using data from the Whole Atmosphere Community Climate Model-Extended (WACCM-X) with the ionosphere, a model developed by inter-divisional collaboration at the University Corporation for Atmospheric Research. Presented here are the vertical profiles of neutral species, wind speed, and temperature of the troposphere and middle atmosphere up to 80 km. Preliminary results from a 10-year period show all three parameters vary temporally and spatially, particularly across latitudes and seasons. Ongoing work includes rigorous analysis, utilizing all years of WACCM-X data available.

Keywords: Whole Atmosphere, Climate

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

Wed. May 29, 2019 1:45 PM - 3:15 PM JST | Wed. May 29, 2019 4:45 AM - 6:15 AM UTC | 201B 2F

[A-AS05] Stratosphere-troposphere Processes And their Role in Climate

convener:Yoshio Kawatani(Japan Agency for Marine-Earth Science and Technology), Shingo Watanabe(Japan Agency for Marine-Earth Science and Technology), Takashi Sekiya(Japan Agency for Marine-Earth Science and Technology), Kaoru Sato(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Chairperson:Yoshio Kawatani

The Stratosphere-troposphere Processes And their Role in Climate (SPARC) is one of the major projects of the World Climate Research Programme (WCRP), and is characterized by its focus on chemical and dynamical coupling in the stratosphere and troposphere. In this session, we welcome presentations on various processes in the stratosphere and tro posphere.

1:45 PM - 2:15 PM JST | 4:45 AM - 5:15 AM UTC

[AAS05-10] Diagnostics of a WN2-type major sudden stratospheric warming event in February 2018 using a new three-dimensional wave activity flux

★Invited Papers

*Yayoi Harada[1], Kaoru Sato[2], Takenari Kinoshita[3], Ryosuke Yasui[2], Toshihiko Hirooka[4], Hiroaki Naoe[1] (1.Meteorological Research Institute, 2.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 3.Japan Agency for Marine-Earth Science and Technology, 4.Department of Earth and Planetary Sciences, Kyushu University)

2:15 PM - 2:45 PM JST | 5:15 AM - 5:45 AM UTC

[AAS05-11] Response of the Southern Hemisphere atmosphere to the QBO from winter to early summer

★Invited Papers

*Yousuke Yamashita[1], Hiroaki Naoe[2], Makoto Inoue[3], Masaaki Takahashi[4] (1.Japan Agency for Marine-Earth Science and Technology, 2.Meteorological Research Institute, 3.Akita Prefectural University, 4.National Institute for Environmental Studies)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[AAS05-12] Influence of QBO-like Oscillation on Tropical Convective Systems in a Three-Dimensional Minimal Model Framework of the Stratosphere-Troposphere Coupled System

*Shigeo Yoden[1], Hai Bui[2], Takahiro Banno[1] (1.Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University, 2.Geophysical Institute, University of Bergen)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[AAS05-13] Downward Propagation of Planetary Wave Packets from the Stratosphere to the Troposphere During Northern Hemisphere Winter

*Matsuyama Yuya[1], Toshihiko Hirooka[2] (1.Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2.Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University)

Diagnostics of a WN2-type major sudden stratospheric warming event in February 2018 using a new three-dimensional wave activity flux

*Yayoi Harada[1], Kaoru Sato[2], Takenari Kinoshita[3], Ryosuke Yasui[2], Toshihiko Hirooka[4], Hiroaki Naoe[1]

1. Meteorological Research Institute, 2. Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 3. Japan Agency for Marine-Earth Science and Technology, 4. Department of Earth and Planetary Sciences, Kyushu University

Observational features of atmospheric fields during a zonal wavenumber two (WN2) type major sudden stratospheric warming (MSSW) event that occurred in February 2018 (MSSW18) are analyzed using the Japanese 55-year Reanalysis, satellite measurements by a microwave limb sounder, and a new three-dimensional wave activity flux. MSSW18 was characterized by a clear polar vortex split, continuance of easterlies with remarkable double peaks, clear planetary-wave propagation in the easterly region of the upper stratosphere and extraordinary upward propagation of WN2 planetary waves from the upper troposphere whose peak was comparable to that during an MSSW event that occurred in January 2009 (MSSW09), although MSSW18 showed relatively modest warming, unclear disappearance of the stratopause and weak stratopause elevation compared to those during MSSW09. Further analyses revealed that wave packets propagated upward simultaneously in both the Eastern and Western Hemispheres. Those observed in the Eastern Hemisphere converged strongly at the western edge of the Aleutian High and most of them did not propagate into the upper stratosphere. The wave packets observed in the Western Hemisphere locally propagated into the upper stratosphere over North America despite the fact that easterlies were predominant there in the mature stage of MSSW18. Furthermore, our results revealed that the regions and levels of wave-packet attenuation corresponded well to the area of weak eastward phase tilt or the quasi-barotropic condition of smaller-scale waves during MSSW18, whereas during MSSW09 the westward phase tilts of smaller-scale waves were clearly visible in the upper stratosphere.

Keywords: Sudden stratospheric warming, Zonal wavenumber two, Wave activity flux

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Response of the Southern Hemisphere atmosphere to the QBO from winter to early summer

*Yousuke Yamashita[1], Hiroaki Naoe[2], Makoto Inoue[3], Masaaki Takahashi[4]

1. Japan Agency for Marine-Earth Science and Technology, 2. Meteorological Research Institute, 3. Akita Prefectural University, 4. National Institute for Environmental Studies

The equatorial quasi-biennial oscillation (QBO) is dominant variability in the tropical stratosphere and is characterized by the oscillation of downward propagating easterly and westerly wind regimes. Several studies have examined possible linkages between the QBO and atmospheric circulations, such as the meridional circulation around tropics and the polar vortex intensity in the Northern Hemisphere (NH), which are related to the changes of waves and circulations in the stratosphere (e.g., Plumb and Bell 1982, Holton and Tan 1980). On the other hand, the mechanism by which the QBO modulates extratropical circulation over the Southern Hemisphere (SH) is poorly understood, as the various studies employed different height levels and metrics to define the phase of the QBO (e.g., Garcia and Solomon 1987; Baldwin and Dunkerton 1998; Naito 2002; Hitchman and Huesmann 2009). Previous studies employed composite analysis that possibly includes signals other than the response to the stratospheric QBO, such as the responses to solar cycle and El Niño-Southern Oscillation (ENSO). In this study, we examined the response of atmospheric circulation over the SH to the stratospheric QBO, using multiple linear regression analysis for the long-term Japanese 55-year Reanalysis (JRA-55) dataset to separate the influences of the QBO and other factors on the SH polar vortex. In addition to the terms of middle- and lower-stratospheric QBO, the multiple linear regression includes equivalent effective stratospheric chlorine (EESC), solar cycle, ENSO, and volcanic aerosol terms as explanatory variables. Analyses of the regression coefficients associated with both middle- and lower-stratospheric QBO suggest an influence on the SH polar vortex from SH winter through early summer in the seasonal evolution. One possible pathway is that the middle-stratospheric QBO results in the SH low latitudes stratospheric response through the QBO-induced mean meridional circulation, leading to a high-latitude response. This favors delayed downward evolution of the axis of SH polar vortex at high latitudes (around 60˚S) from August to November during the westerly phase of the QBO. Although this pathway is inconsistent with weakening of the SH polar vortex in August, the other possible pathway is unveiled from the detailed analysis. The other possible pathway involves the response to lower stratospheric QBO that induces the increase in upward propagation of planetary waves from the SH extratropical troposphere to stratosphere in August. This pathway is consistent with weakening of the SH polar vortex in August.

Keywords: quasi-biennial oscillation, Southern Hemisphere polar vortex, multiple linear regression

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Influence of QBO-like Oscillation on Tropical Convective Systems in a Three-Dimensional Minimal Model Framework of the Stratosphere-Troposphere Coupled System

*Shigeo Yoden[1], Hai Bui[2], Takahiro Banno[1]

1. Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University, 2. Geophysical Institute, University of Bergen

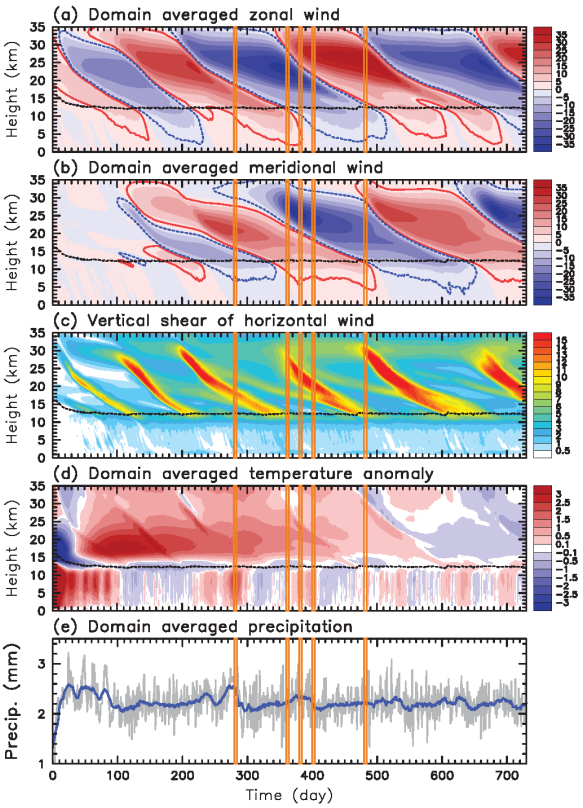
We report on the three-dimensional minimal model of the stratosphere-troposphere coupled system that produces a self-sustained oscillation reminiscent of the quasi-biennial oscillation (QBO) in a radiative-moist convective quasi-equilibrium state. The computational domain is rectangular (640 km x 160 km, 5 km grid size; Bui et al., 2019), or square (100 km x 100 km, 1 km grid size), without Coriolis effects under doubly periodic boundary conditions. After initial transient time, a QBO-like oscillation with a period of about 300 days emerges in the stratosphere, both in the domain-averaged zonal wind and meridional wind (Figure-left). Synchronization of the zonal and meridional winds is characterized as an anti-clockwise rotation of a skewed spiral feature with height in the horizontal wind hodograph (Figure-right).

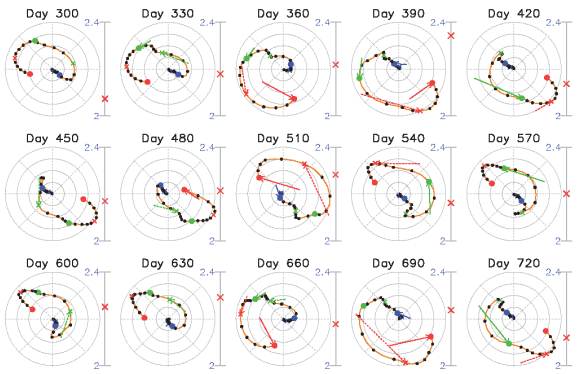
The QBO-like wind oscillation penetrates into the troposphere with large reduction of oscillation amplitude, and influences tropospheric temperature anomalies and precipitation with an irregular period of about 100 days. Heavy precipitation is associated with positive temperature anomalies. The simulation reveals three types of precipitation patterns; isolated quasi-stationary type clusters, fast-moving back-building type and squall-line type patterns. The quasi-stationary type is newly identified in the present three-dimensional model, and the zonal-height cross sections of the meridionally averaged clouds and relative humidity for this pattern show clear-sky areas without shallow clouds and with low humidity, whereas shallow clouds exist over the entire domain including non-precipitating areas with high humidity for the fast-moving back-building type or squall-line type patterns. Intermittent self-organization of convective systems into quasi-stationary type and transition back to the fast-moving back-building type or squall-line type are fundamental characteristics of self-aggregation in the three-dimensional minimal model framework.

Reference

Bui H., S. Yoden, and E. Nishimoto, 2019: QBO-like Oscillation in a Three-Dimensional Minimal Model Framework of the Stratosphere–Troposphere Coupled System. *SOLA*, **15**, 59–62.

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Downward Propagation of Planetary Wave Packets from the Stratosphere to the Troposphere During Northern Hemisphere Winter

*Matsuyama Yuya[1], Toshihiko Hirooka[2]

1. Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2. Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University

Downward propagation of planetary wave packets from the stratosphere to the troposphere is often observed during Northern Hemisphere winter and their influence on the tropospheric circulation has been also reported by various authors. Recent observational studies show that the downward propagation into the troposphere frequently occurs over the North America centered around 90W. Hence, we investigate the frequency distribution of downward propagation events of planetary wave packets and its relationship to the background field using the Japanese 55-year Reanalysis (JRA-55) data. We calculate Plumb’ s (1985) wave activity flux (WAF) and extract the downward propagation events over the analysis period (1958-2016) based on a specified criterion value for the vertical component of WAF at 30 hPa. Next, we investigate the longitudinal location of each downward propagation event and classify it into eight sectors of 45 degrees along the longitudinal circle to make a composite analysis of the classified events. Resultantly, around 500 events are extracted during the analysis period and it is found that about more than 80% of the events occurred in three sectors between 135W to 0E; these events are shown to be intimately related to the development of the Aleutian High in the stratosphere, which is located in the west of the downward propagation region. As for the other events, a developed anticyclone was also observed in the west of each downward propagation region.

Keywords: planetary wave packet, downward propagation, wave activity flux

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Wed. May 29, 2019 1:45 PM - 3:15 PM JST | Wed. May 29, 2019 4:45 AM - 6:15 AM UTC | 301A 3F

[A-OS14] Coastal physical processes associated with mixing, eddies, internal waves

convener:Eiji Masunaga(Ibaraki University), Taira Nagai(Graduate School of Science, The University of Tokyo), TSUTSUMI EISUKE(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Eiji Masunaga, Eisuke Tsutsumi

Recently developed observational and numerical approaches have revealed details of physical processes in coastal regions, which is a key to understanding global ocean circulations and ecosystems. This session aims to provide discussions of mixing, eddies, nonlinear internal waves in coastal and marginal oceans, estuaries and lakes. Observations, numerical modeling and laboratory experiments associated with these phenomena are encouraged to submit an abstract to this session. In addition, studies that consider linkages between coastal physical processes and large scale open ocean processes, e.g., the Kuroshio, global ocean circulations.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[AOS14-01] The cooling of sea surface temperature in the southern Indonesian Seas due to a combination of the Ekman transport and tidal mixing in narrow straits

*Taira Nagai[1], Toshiyuki Hibiya[1] (1.Graduate School of Science, The University of Tokyo)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[AOS14-02] A reanalysis of regional circulations in the Southern South China Sea using a HYCOM-ROMS downscaling ocean model

*Naru Takaura[1], Yusuke Uchiyama[1], Nizamani Zafarullah[2], Akihiko Nakayama[2] (1.Kobe Univ, 2.Tunku Abdul Rahman University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[AOS14-03] Nutrient and phytoplankton dynamics in the continental slope region of the East China Sea associated with the Kuroshio frontal eddy

*Naoki Yoshie[1], Anri Kabe[1], Kazuki Ohgi[1], Eisuke Tsutsumi[2], Shigenobu Takeda[3], Joji Ishizaka[4], Xinyu Guo[1] (1.Center for Marine Environmental Studies, Ehime University, 2.Research Institute for Applied Mechanics, Kyushu University, 3.Faculty of Fisheries, Nagasaki University, 4.Institute for Space-Earth Environmental Research, Nagoya University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[AOS14-04] Dissipation and transport due to internal tides generated by multiple submarine canyons

*Qiang Li[1], Xianzhong Mao[1], Ran Liao[1] (1.Tsinghua University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[AOS14-05] Measurement of Physical structure in Kasumigaura using high resolution tow-yo instrument

*Daiki Asaoka[1], Eiji Masunaga[1], Shunsuke Komuro[2], Shunichi Matsumoto[2], Masahiko Ono[3], Hiroaki Banba[3] (1.Ibaraki University, 2.Ibaraki Kasumigaura Environmental Science Center, 3.Ministry of Land, Infrastructure, Transport and Tourism)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[AOS14-06] Mixing and baroclinic structure in a stratified shallow lake, Lake Kasumigaura, Japan

*Eiji Masunaga[1], Daiki Asaoka[1], Shunsuke Komuro[2], Shunichi Matsumoto[2], Masahiko Ono[3], Hiroaki Banba[3] (1.Ibaraki University, 2.Ibaraki Kasumigaura Environmental Science Center, 3.Ministry of Land, Infrastructure, Transport and Tourism)

The cooling of sea surface temperature in the southern Indonesian Seas due to a combination of the Ekman transport and tidal mixing in narrow straits

*Taira Nagai[1], Toshiyuki Hibiya[1]

1. Graduate School of Science, The University of Tokyo

The Indonesian archipelago is characterized by the warmest sea surface temperatures (SSTs) in the world and is a key region of the world climate system. Kida and Wijffels (2012) reported that SST cooling around the Nusa Tenggara Islands (NTIs) located at the southern Indonesia plays a crucial role in the seasonal variation of SST over a large area in the Indonesian Seas. Although they suggested that both the monsoonal winds and tidal mixing might significantly impact such SST cooling, their numerical model settings were somewhat idealized.

In this study, to investigate the mechanisms of SST cooling around the NTIs, we carry out a numerical simulation using a regional ocean model where the realistic distribution of vertical diffusivity estimated from a high resolution baroclinic tide model is incorporated. The simulated results show that significant mixing in the narrow tidal straits between the NTIs creates well-mixed waters, which spread out northward (southward) during Austral summer (winter) and finally causes significant SST cooling over a large area of southern Indonesian Seas.

We therefore carry out numerical experiments where either of the monsoonal wind or localized tidal mixing in the narrow straits is switched off. These numerical experiments show that well-mixed waters in the narrow straits are continuously advected by the northward (southward) flow driven by the western (eastern) monsoonal wind during Austral summer (winter) until the Indonesian Throughflow spreads them out over a large area of southern Indonesian Seas, demonstrating the importance of the combined effect of the Ekman transport and tidal mixing.

Keywords: SST in the Indonesian Seas, Tidal mixing in narrow straits, Ekman transport

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A reanalysis of regional circulations in the Southern South China Sea using a HYCOM-ROMS downscaling ocean model

*Naru Takaura[1], Yusuke Uchiyama[1], Nizamani Zafarullah[2], Akihiko Nakayama[2]

1. Kobe Univ, 2. Tunku Abdul Rahman University

A high-resolution, high-precision downscaling oceanic circulation model for the Southern China Sea (SCS) was developed based on the Regional Oceanic Modeling System (ROMS) at a lateral resolution of 5 km, initialized and forced by the Hybrid Coordinate Ocean Model (HYCOM) global reanalysis product. A multi-year reanalysis was conducted for the four-year period from 2012 to 2015 with the HYCOM-ROMS system that properly accounts for wind stress and heat budget at surface, freshwater influences from the atmosphere and major rivers, and tidal variability.
The model results were confirmed to agree well with satellite and in situ measurement, and generally consistent with the findings in previous studies. For instance, prevailing strong meridional currents are provoked along the continental shelves between China and the southern Vietnam, which are driven by seasonally varying monsoons dominated in the winter and summer, followed by current separation to the east off the southern Vietnam occurred in summer.
Prospective applications of the system include assessments of oceanic dispersal of wastewater, quantification of marine ecosystem network, analyses of micro plastic transport, its coastal accumulation and maintenance of offshore structure. In the present study, we utilized the model outcome to evaluate external forcing conditions on offshore oil platforms along the coast of the Malay Peninsular and Borneo Island by using extreme value statistics for surface currents and wind. The maximum surface velocity was found to occur off the coast of Borneo Island, which is influenced by the Mindanao Current. It was suggested that water mass exchange between the Pacific and the SCS is extremely significant as it subsequently controls regional circulations in the coastal margins in the SCS.

Keywords: South China Sea, mass transport, HYCOM-ROMS, seasonal circulation

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Nutrient and phytoplankton dynamics in the continental slope region of the East China Sea associated with the Kuroshio frontal eddy

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1. Center for Marine Environmental Studies, Ehime University, 2. Research Institute for Applied Mechanics, Kyushu University, 3. Faculty of Fisheries, Nagasaki University, 4. Institute for Space-Earth Environmental Research, Nagoya University

The lower-trophic level ecosystem in the continental slope region of the East China Sea (ECS) during summer generally shows typical subtropical features, i.e., small size pico-phytoplankton such as cyanobacteria dominates in the euphotic layer under the oligotrophic condition due to the stable stratification. It is also known that such stable physical and chemical conditions are often disturbed by the Kuroshio frontal eddy. In this study, we investigated the phytoplankton dynamics associated with the passing of Kuroshio frontal eddies. We conducted comprehensive observations with the high horizontal resolution (7km) around the continental slope region in the ECS in the late-July, 2018. We observed drastic changes in the depth of subsurface chlorophyll maximum (SCM) and nitrate concentrations around the SCM, and micro-phytoplankton such as diatom mainly changed around SCM. We found cyclonic frontal eddies with 15-35 km diameter around the 40-80 m depth near the drastic change of the SCM. These changes were caused by the horizontal advection of nutrient-rich shelf water associated with the passing of the cyclonic frontal eddies.

Keywords: frontal eddy, nutrient, phytoplankton, East China Sea

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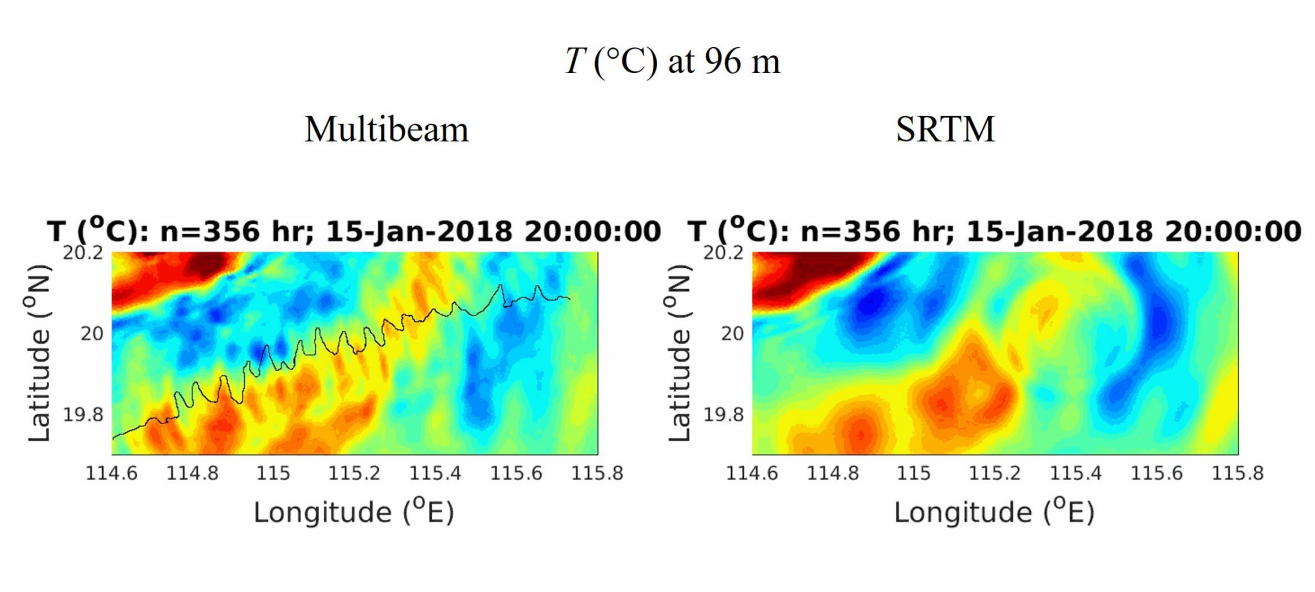
Dissipation and transport due to internal tides generated by multiple submarine canyons

*Qiang Li[1], Xianzhong Mao[1], Ran Liao[1]

1. Tsinghua University

Rough seafloor is a major source to generate internal waves in the ocean. High-resolution multibeam survey reveals detailed seafloor with complicated features, however, some are not shown in commonly used topography datasets, such as Smith and Sandwell (1997). A group of canyons on the continental shelf of the northern South China Sea were recently discovered during a geographic survey. Interaction between barotropic tides and concave-shape canyons generates internal tides, showing complex interference patterns. A linear model, based on normal-mode decomposition, reveals complex beam generation and interaction inside and between the canyons. Then, a very high resolution and three dimensional numerical model is employed to validate the linear model result and estimate local energy dissipation for internal wave generation by a group of canyons. Instead of complicated turbulence models, constant viscosity coefficients are used. Nonlinear interaction or shear instability during internal tide generation and propagation causes local diapycnal mixing, which is one of the key processes to drive material transport in continental shelf. Transport due to internal tides in the canyon region is also calculated and its relationship with local internal tide generation and propagation is discussed.

Keywords: internal waves, canyons, mixing



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Measurement of Physical structure in Kasumigaura using high resolution tow-yo instrument

*Daiki Asaoka[1], Eiji Masunaga[1], Shunsuke Komuro[2], Shunichi Matsumoto[2], Masahiko Ono[3], Hiroaki Banba[3]

1. Ibaraki University, 2. Ibaraki Kasumigaura Environmental Science Center, 3. Ministry of Land, Infrastructure, Transport and Tourism

This study shows physical processes in Lake Kitaura, Kasumigaura, using field observations by YODA Profiler and Mooring system. Hypoxia and eutrophication have a bad influence on ecosystems in the study area. Understanding physical processes is essential to understand ecosystems in lakes and oceans. Lake Kitaura is a long lake in the north-south direction with 25 km and 4 km in the east-west. The stratified layer is generated due to strong incoming heat flux during the summer season. Mooring observation results show that the thin mixed layer was gradually thickened due to the wind stress and disappeared within several hours. Details of this mixing processes were further investigated by making use of a high-resolution tow-yo instrument, the YODA Profiler. The warm surface water was transported toward on the downwind side due to the wind stress. Small scale K-H instability like motions were observed during this event. According to the data from the YODA Profiler, the Wedderburn number can roughly explain the baroclinic and mixing structures in the east-west direction. However, the Wedderburn number is not able to be used for explaining quantitative vertical displacements of the thermocline, because the complexity of the observed density distribution. The vertical isotherm displacements can be simply explained by wind stress. Time series of the mixed layer depth were calculated to evaluate mixing in the lake. The mixed layer reached the bottom when the daily-averaged wind speed exceeded 8 m/s, resulting in complete vertical mixing. Results from the north-south long transect survey show wavy like baroclinic (or stripe-shaped) temperature distribution with a horizontal scale of several km. In addition, three dimensional numerical simulations were conducted using the SUNTANS. Model results also show a wavy like baroclinic structure in the north-south direction caused by the complicated coastal shape and east-west wind stress. The wavy like baroclinic structure is generated by convergence of warm water into bay-shaped areas.

Keywords: Thermocline, Mixed layer, Wind stress

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Mixing and baroclinic structure in a stratified shallow lake, Lake Kasumigaura, Japan

*Eiji Masunaga[1], Daiki Asaoka[1], Shunsuke Komuro[2], Shunichi Matsumoto[2], Masahiko Ono[3], Hiroaki Banba[3]

1. Ibaraki University, 2. Ibaraki Kasumigaura Environmental Science Center, 3. Ministry of Land, Infrastructure, Transport and Tourism

This study presents mixing and baroclinic structure associated with hypoxia in a shallow lake, Lake Kasumigaura, using field observations and numerical simulations. Hypoxia in stratified lakes is one of the pressing issues for maintaining water environment and ecosystems. Mooring observations show that hypoxia events occur when the stratification is enhanced by the surface heat flux. The stratification (N^2) is controlled by the ratio between the surface wind stress and surface heat (buoyanvy) flux. The strength of the stratification/mixing can be simply explained by the Monin-Obukov length scale, L_{MO}. N^2 is linearly related with L_{MO} in a log scale with a correlation coefficient of approximately 0.7. According to the heat budget analysis, the bottom sediment heat flux toward the bottom significantly contribute to the heat content as well as the surface heat flux. The heat flux toward the bottom is roughly an order of 100 W m^{-2} during the summer season, which suppresses mixing near the bottom. The internal wave-like baroclinic structure was observed by high resolution survey using the YODA Profiler. Baroclinic motions are enhanced by the surface wind stress, and they transport the hypoxic water, suspended sediments and phytoplanktons. In addition to field surveys, three-dimensional simulations were conducted with SUNTANS to further investigate physical processes in the lake. Numerical results well agree to observational results and show that baroclinic motions influence in the whole of the lake basin. The wind-induced baroclinic energy is generated in the middle of the lake basin and propagate to the onshore. This study suggests that mixing and baroclinic motions due to buoyancy and wind effects play an important role in the oxygen distribution in Lake Kasumigaura.

Keywords: Mixing, Hypoxia, Internal waves

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Wed. May 29, 2019 3:30 PM - 5:00 PM JST | Wed. May 29, 2019 6:30 AM - 8:00 AM UTC | 301A 3F

[A-OS14] Coastal physical processes associated with mixing, eddies, internal waves

convener:Eiji Masunaga(Ibaraki University), Taira Nagai(Graduate School of Science, The University of Tokyo), TSUTSUMI EISUKE(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Eiji Masunaga, Taira Nagai

Recently developed observational and numerical approaches have revealed details of physical processes in coastal regions, which is a key to understanding global ocean circulations and ecosystems. This session aims to provide discussions of mixing, eddies, nonlinear internal waves in coastal and marginal oceans, estuaries and lakes. Observations, numerical modeling and laboratory experiments associated with these phenomena are encouraged to submit an abstract to this session. In addition, studies that consider linkages between coastal physical processes and large scale open ocean processes, e.g., the Kuroshio, global ocean circulations.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[AOS14-07] Turbulent mixing and vertical nitrate flux in the Bungo Channel, Japan

*TSUTSUMI EISUKE[1], Naoki Yoshie[2], Takashi Mano[3], Kanda Taisei[3], Naoki Fujii[4], Xinyu Guo[2] (1.Research Institute for Applied Mechanics, Kyushu University, 2.Center for Marine Environmental Studies, Ehime Univeristy, 3.Graduate School for Science and Engineering, Ehime University, 4.Faculty of Agriculture, Saga Univerisity)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[AOS14-08] Numerical Analysis of Submerged Turbulent Buoyant Jet in River Mouth

*Yen-Chen Mou[1], Gene You[1], Chih-Chieh Young[2] (1.National Taiwan University, 2.National Taiwan Ocean University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[AOS14-09] Implementing regional downscaling capability in the STEAMER radionuclide dispersion prediction system based on multi-nested ROMS model

*Kamidaira Yuki[1], Hideyuki Kawamura[1], Takuya Kobayashi[1], Yusuke Uchiyama[2] (1.Japan Atomic Energy Agency, 2.Kobe University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[AOS14-10] Transport processes around the Izu-chain islands investigated with a Lagrangian particle tracking model

*Waku Kimura[1], Eiji Masunaga[1], Taichi Kosako[2], Yusuke Uchiyama[3] (1.Ibaraki University, 2.Port and Airport Research Institute, 3.Kobe University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[AOS14-11] Fates and dynamical roles of pinch-off mesoscale eddies originated from the Kuroshio Extension Jet

*Yusuke Uchiyama[1], Nobue Okada[1], Changming Dong[2] (1.Graduate School of Engineering, Kobe University, 2.Nanjing University of Information Science & Technology)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

Discussion

Turbulent mixing and vertical nitrate flux in the Bungo Channel, Japan

*TSUTSUMI EISUKE[1], Naoki Yoshie[2], Takashi Mano[3], Kanda Taisei[3], Naoki Fujii[4], Xinyu Guo[2]

1. Research Institute for Applied Mechanics, Kyushu University, 2. Center for Marine Environmental Studies, Ehime Univeristy, 3. Graduate School for Science and Engineering, Ehime University, 4. Faculty of Agriculture, Saga Univerisity

Turbulent mixing plays a key role in primary production in coastal seas through supplying nutrients to the euphotic zone from deeper layers and to the ocean from rivers. Understanding of turbulent dynamics in coastal seas is therefore essential for prediction, conservation and management of coastal ecosystems. Here, we studied turbulent mixing and the associated vertical nitrate transport in a tidally-energetic channel between the Kuroshio region and the Seto Inland Sea (Bungo Channel, Japan). Takeoka [1993] hypothesized that strong vertical mixing and the associated secondary circulation in the channel maintains primary production through supplying large amount of nutrients coming from the Kuroshio region. We conducted simultaneous measurements of turbulence and nitrate concentration along a section in the Bungo Channel using a microstructure turbulence profiler (TurboMAP-5, JFE Advantech) and optical nitrate sensor (SUNA-V2, Sea-Bird Scientific) on 27 August, 2017. We found nitrate-rich cold waters in the bottom of the southern part of the section, which coincide with a typical bottom intrusion from the Kuroshio region. Largest vertical eddy diffusivity of O(10^{-2}) m^2 s^{-1} and the associated upward nitrate flux of O(10) mmol m^{-2} day^{-1} were obtained at 20-30 m depth south of deep and narrow strait (Hoyo Strait). Also, subsurface maximum in chlorophyll fluorescence is observed just above the strong turbulence layer, possibly suggesting phytoplankton blooms in response to the high turbulent nitrate flux. The strong vertical turbulent diffusion was associated with density overturns and elevated vertical shear, indicating internal wave breaking. We hypothesis that internal tides generated in the Hoyo Strait is one of the key processes in enhancement of turbulent mixing and nutrient transport in the Bungo Channel.

Keywords: turbulent mixing, vertical nitrate flux, internal tides

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Numerical Analysis of Submerged Turbulent Buoyant Jet in River Mouth

*Yen-Chen Mou[1], Gene You[1], Chih-Chieh Young[2]

1. National Taiwan University, 2. National Taiwan Ocean University

The purpose of this study is to investigate the characteristics of submerged turbulent buoyant jet in river mouth by simulating basic fluid mechanisms. The numerical model composes two-dimensional continuity equation, momentum equation, and advective diffusion equation. Since our model is building on basic fluid mechanics formulas, we can test the movement of buoyant jet in the river mouth depends on different parameters, such as environmental and geometrical factors. One of our focuses will be how the phenomena be influenced by inflow hydrograph and sediment concentration, as well as real events and analyze their effect submerged turbulent buoyant jet motion pattern.

Our model will be applied to simulated several characteristic behaviors that are consistent with prior knowledge, including: (1) the inflow concentration is higher at the fixed inflow rate and calculation time, the formed buoyant jet has a large influence range and higher concentration; (2) when the inflow rate is high in a fixed flow concentration and calculation time, the generated buoyant jet has a large influence range and that shape more bulging. Moreover, we will adjust the downstream boundary conditions. When the downstream water level is high, the range and the duration time of the buoyant jet are great. As expected, the concentration of the same location is also higher than other situation that has a lower downstream water level. So far, this model will progress to the extent that it can capture the overall trend of buoyant jet movements, and this simulation is based only on the physical mechanism of the sand-containing fluid itself.

Keywords: Submerged Turbulent Buoyant Jet, River Mouth, Numerical Analysis, Finite-Difference Methods, Buoyancy, Plume

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Implementing regional downscaling capability in the STEAMER radionuclide dispersion prediction system based on multi-nested ROMS model

*Kamidaira Yuki[1], Hideyuki Kawamura[1], Takuya Kobayashi[1], Yusuke Uchiyama[2]

1. Japan Atomic Energy Agency, 2. Kobe University

Oceanic regional downscaling capability was implemented into Short-Term Emergency Assessment system of Marine Environmental Radioactivity (STEAMER) developed by Japan Atomic Energy Agency (JAEA) to enable us to predict more realistically the oceanic dispersion of radionuclides at higher spatiotemporal resolutions for broader applications. The system consisted of double-nested Regional Ocean Modeling System (ROMS) with tidal forcing embedded in the Multivariate Ocean Variational Estimation system for the Western North Pacific (MOVE-WNP), assimilative reanalysis/forecast product and an oceanic radionuclide dispersion model SEA-GEARN developed by JAEA. Surface wind stress was provided by the Grid Point Value of the Global Spectral Model (GPV-GSM) atmospheric reanalysis/forecast while surface heat and freshwater fluxes are from the Comprehensive Ocean-Atmosphere Data Set (COADS) monthly climatology. Ten principal tidal constituents from the TPXO 7.0 global tidal reanalysis were additionally imposed on the sea surface height as boundary condition along the perimeter to include barotropic tides and the resultant intrinsic baroclinic tides. The horizontal grid spacing was decreased from ~10 km in the outermost MOVE-WNP, to 3 km in the intermediate ROMS-L1 model, and further down to 1 km in the innermost ROMS-L2 model. The model results showed reasonable agreement with tidal observations. The system was used to comparatively examine downscaling and tidal effects on the dispersion of radionuclides hypothetically released from the Fukushima Daiichi Nuclear Power Plant. The simulated dissolved ^{137}Cs distribution had seasonal variability and was different from that obtained using coarser-resolution models because downscaling enhanced both horizontal and vertical mixing. Temporal ^{137}Cs fluctuations were slightly amplified as a result of the suppression of horizontal mixing and enhancement of vertical mixing by tides. In addition, the submesoscale effects strengthened the three-dimensional ^{137}Cs fluctuations by <10 times, while the tidal effects promoted slightly increased the intensity of three-dimensional ^{137}Cs fluctuations by approximately 3-30%. This indicated that the submesoscale effects substantially surpassed tidal forcing in oceanic mixing in the coastal margin off Fukushima.

Keywords: ROMS, radionuclide dispersion model

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Transport processes around the Izu-chain islands investigated with a Lagrangian particle tracking model

*Waku Kimura[1], Eiji Masunaga[1], Taichi Kosako[2], Yusuke Uchiyama[3]

1. Ibaraki University, 2. Port and Airport Research Institute, 3. Kobe University

This study investigated mass transport and dispersion around Izu-chain islands off the Japan mainland using with 3-D Lagrangian particle tracking simulations modeled in a high-resolution reginal ocean modeling system (ROMS). The Kuroshio and eddies, tides largely influence physical processes in the study area. Details of transport processes involving the Kuroshio, eddies and tides have not been understood well. However, these processes are important for understanding oceanic environments and ecosystems in the North Pacific Ocean. Particles were released from three regions: around the Izu-chain islands (north of the Kuroshio), in the Kuroshio, south of the Kuroshio. Model results show that the particle trajectory is different depends on the initial location of particles. Approximately 60% particles released from the Izu-chain islands were transported outside the model domain in 30 days. On the other hands, more than 90% particles released from the Kuroshio and south of the Kuroshio flew out from the domain in 30 days. The vorticity is enhanced by the tidal forcing in the whole study area. The tidal forcing enhances the horizontal diffusion of particles within 2 days scale. By contrast, in the longer time scale longer than 5 days, the dispersion of particles is suppressed by the tidal forcing, because large scale motions are suppressed by tides. The frequency spectrum of the particle velocity shows semi-diurnal peaks and high frequency (low frequency) is enhanced (decreased) by the tidal forcing.

Keywords: Tide, Lagrangian particle tracking model, Kuroshio

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Fates and dynamical roles of pinch-off mesoscale eddies originated from the Kuroshio Extension Jet

*Yusuke Uchiyama[1], Nobue Okada[1], Changming Dong[2]

1. Graduate School of Engineering, Kobe University, 2. Nanjing University of Information Science & Technology

Mesoscale eddies are ubiquitous in the world ocean that frequently collide with currents, leading to substantial alteration of the associated dynamics. For instance, the Kuroshio plays a major role in preconditioning the coastal environment around Japan through poleward heat and material transport from the subtropics, while its path is known to meander occasionally by eddy collisions. Pinch-off mesoscale eddies that detach intermittently from the Kuroshio tend to travel westward as Rossby waves and have been found to collide with the Kuroshio again to alter oceanic and coastal environment through alteration of the Kuroshio path.

For realization of such processes, we applied the eddy detection algorithm used in Liu et al. (2012) to ARMOR3D. The ARMOR3D dataset is a 3D global currents and density data set that is reconstructed from a combination of extensive satellite data and in situ observations based on the geostrophic thermal wind relation and statistical methods as described in Guinehut et al. (2012). By conducting several sensitivity tests, we introduced constraints on vorticity magnitude of detected mesoscale eddies and their relative positions to the Kuroshio path to determine pinch-off eddies near the Kuroshio Extension (KE) region. It was found that the constraint on vorticity magnitude of the detected individual eddies greater than $0.15f$, where f is the local Coriolis frequency, throughout eddy lifetime is significant to successfully isolate pinch-off eddies.

With this constraint, we discovered that most of the detected pinch-off eddies are cyclonic on the south side of the KE region, while anticyclonic eddies are predominant on the north side. The former occurred 2.5–3 times as often as the latter, although in the entire North Pacific, cyclonic eddies occurred only 12.1% more frequently than anticyclonic eddies. Hence, it is considered that this cyclone dominance in the pinch-off eddies from the Kuroshio is a unique feature. We also succeeded to determine pinch-off eddies that collide again with the Kuroshio by introducing another constraint, which is the threshold distance between the Kuroshio path and terminal positions of pinch-off eddies traveled westward. In several selected cases with these constraints, comparisons of the surface temperature and salinity before and after the eddy collisions clearly exhibit that the alteration of the Kuroshio path due to eddy collisions is quite influential in modifying the oceanic structures. It was also found that the pinch-off eddies occasionally interact with other mesoscale eddies to modify the upper-ocean structure pronouncedly.

The Kuroshio path in the KE region is known to vary on annual to decadal time scales, where it was rather stable for 1993-1995 and 2002-2005, whereas largely meandered unstably for 1996–2001 and 2006–2009. During the first unstable periods, the number of cyclonic pinch-off eddies were significantly increased in the area between 144 °E and 150 °E for 1996–2001. However, no significant increase was observed during the other unstable period for 2006–2009. More than 70% of the pinch-off eddies that collided with the Kuroshio appeared during the unstable periods, suggesting that the stability of the Kuroshio path in the KE region is a key influencer on vigorous generation of such colliding pinch-off eddies.

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Keywords: pinch-off mesoscale eddy, Kuroshio, eddy tracking algorithm, ARMOR3D

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CC Cryospheric Sciences & Cold District Environment

Wed. May 29, 2019 9:00 AM - 10:30 AM JST | Wed. May 29, 2019 12:00 AM - 1:30 AM UTC | 303 3F

[A-CC27] Glaciology

convener:Takayuki Nuimura(Tokyo Denki University), Ishikawa Mamoru(Hokkaido University), Kzutaka Tateyama(National University Corporation Kitami Institute of Technology), Hiroto Nagai(Waseda Univ., School of Education), Chairperson:Hiroto Nagai(Japan Aerospace Exploration Agency)

The cryosphere is a fundamental component of the earth system. It is a region where snow and ice exist in the form of glacier/ice sheet, snow cover and snowfall, frozen ground, sea ice and fresh water ice, and they play a critical role in the global environment under the interactions with atmosphere, ocean, ecosystem and others. In this session, research results on physical and chemical characteristics of snow and ice, variations and dynamics of cryospheric environment, roles of the cryosphere on the earth and other planets will be discussed broadly, regardless of the research method.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[ACC27-01] The early validation results of the GCOM-C/SGLI cryosphere standard product

★Invited Papers

*Rigen Shimada[1], Masahiro Hori[1], Teruo Aoki[2,3], Tomonori Tanikawa[2], Sumito Matoba[4], Masashi Niwano[2], Knut Stamnes[5], Wei Li[5], Nan Chen[5] (1.Japan Aerospace Exploration Agency, 2.Meteorological Research Institute, 3.Okayama University, 4.Institute of Low Temperature Science, Hokkaido University, 5.Stevens Institute of Technology)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[ACC27-02] Overview of the cryospheric variables derived from GCOM-C/SGLI observations: The first-year results

★Invited Papers

*Masahiro Hori[1], Teruo Aoki[2,4], Knut Stamnes[3], Wei Li[3], Nan Chen[3], Rigen Shimada[1], Tomonori Tanikawa[4], Masashi Niwano[4] (1.Earth Observation Reseacrh Center, Japan Aerospace Exploration Agency, 2.Okayama University, 3.Stevens Institute of Technology, 4.Meteorological Research Institute)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[ACC27-03] Relationships between PASAR-2 backscatter amplitude changes and snow depths

*Hiroto Nagai[1], Satoru Yamaguchi[2], Katsuya Yamashita[2], Mayumi Kashima[3] (1.Waseda University, School of Education, 2. National Research Institute for Earth Science and Disaster Resilience, 3.Esri Japan Corporation)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[ACC27-04] Breaking-off of hanging glaciers at Mt. Langtang-Lirung in Nepal

Honami Watanabe[2], *Chiyuki Narama[1], Yoshitaka Mori[2], Katsuhisa Kawashima[3] (1.Niigata University, Program of Field Research in the Environmental Sciences, 2.Graduate School of Science and Technology, Niigata University, 3.Research Institute for Natural Hazards & Disaster Recovery, Niigata University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[ACC27-05] Spatial distribution of ice cliff in the Trakarding glacier, Nepal Himalaya

*Yota Sato[1], Koji Fujita[1], Hiroshi Inoue[2], Sojiro Sunako[1], Akiko Sakai[1], Akane Tsushima[1], Evgeny Podolskiy[3,4], Etienne Berthier[5], Rijan Kayastha[6] (1.Graduate School of Environmental Studies, Nagoya University, 2.National Research Institute for Earth Science and Disaster Resilience, 3.Arctic Research Center, Hokkaido University, 4.Global Station for Arctic Research, Global Institution for Collaborative Research and Education, Hokkaido University, 5.Centre National de la Recherche Scientifique, 6.School of Science, Kathmandu University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[ACC27-06] Quantify the range of projections of future changes in glacier mass caused by differences among observed past climate datasets

*Megumi Watanabe[1], Aki Yanagawa[2], Yukiko Hirabayashi[3], Satoshi Watanabe[4], Shinjiro Kanae[1] (1.Tokyo Institute of Technology, 2.Meisei University, 3.Shibaura Institute of Technology, 4.The University of Tokyo)

The early validation results of the GCOM-C/SGLI cryosphere standard product

*Rigen Shimada[1], Masahiro Hori[1], Teruo Aoki[2,3], Tomonori Tanikawa[2], Sumito Matoba[4], Masashi Niwano[2], Knut Stamnes[5], Wei Li[5], Nan Chen[5]

1. Japan Aerospace Exploration Agency, 2. Meteorological Research Institute, 3. Okayama University, 4. Institute of Low Temperature Science, Hokkaido University, 5. Stevens Institute of Technology

Japan Aerospace Exploration Agency (JAXA) polar-orbit satellite, Global Change Observation Mission for Climate (GCOM-C) has been launched on 23 December 2017. The Second-generation Global Imager (SGLI) which is carried on GCOM-C observes various geophysical variables in the Atmosphere, Ocean, Land and Cryosphere for long-term monitoring of earth environment using multi wavelength, high resolution and multi angles. When focusing on the cryosphere: snow, sea-ice, glacier and ice sheet, their high albedo affect the cooling mechanism of the radiative balance. The GCOM-C/SGLI regularly creates cryosphere standard products including C1: snow, ice and cloud classification product and C2: snow grain size and snow surface temperature product. We validated these products by comparison with other satellite products and in-situ observation data. C1 product was validated by comparing other similar satellite product (e.g. Terra/MODIS) focusing on the snow and ice extent. C2 product was validated by match-up comparison with in-situ data and satellite retrieval results. Snow grain size of shallow layer was measured at the in-situ observation carried out at the East GRIP site on the North-eastern Greenland Ice Sheet in July 2018. Snow and ice surface temperature was derived from automatic weather station (AWS). From these validation results, all standard product was achieved the release threshold and JAXA decided to release the GCOM-C/SGLI product. In the presentation, some examples and case study of the GCOM-C/SGLI observation results will be shown.

Keywords: GCOM-C/SGLI, remote sensing, snow grain size

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Overview of the cryospheric variables derived from GCOM-C/SGLI observations: The first-year results

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1. Earth Observation Reseacrh Center, Japan Aerospace Exploration Agency, 2. Okayama University, 3. Stevens Institute of Technology, 4. Meteorological Research Institute

The “Global Change Observation Mission-Climate” (GCOM-C) is an Earth observing satellite of Japan Aerospace Exploration Agency (JAXA) for the global observation of the Earth environment. GCOM-C carries a multi-spectral optical radiometer named Second Generation Global Imager (SGLI), which has special features of wide spectral coverage from 380 nm to 12 μm, a high spatial resolution of 250 m, a field of view exceeding 1000 km, two-direction simultaneous observation, and polarization observation. The GCOM-C satellite was successfully launched from the Tanegashima Space Center in Japan on December 23, 2017 and SGLI started the Earth observations on January 1st, 2018. From the SGLI observations snow-related variables such as snow and ice cover extent, snow grain size, and snow surface temperature are being retrieved and the products of those variables have been released to the public from the JAXA’s satellite data providing service “G-Portal” (https://gportal.jaxa.jp/gpr/index/index) since December 20th 2018. These snow physical variables are important for determining spectral albedo and radiation budget at the snow surface. In this presentation, the first-year results of SGLI snow observations are presented as well as the introduction of the SGLI products with the special attention to the thermal infrared observations at 250-m spatial resolution.

Keywords: GCOM-C, SGLI, Snow Cover, Snow Grain Size, Surface Temperature, Remote Sensing

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Relationships between PASAR-2 backscatter amplitude changes and snow depths

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For local governments heavy snowfall gives a very big economic burden. A large amount of tax will be put into operation of the snow removal vehicle, for example. The snow removal expenses of Niigata prefecture approaches 10 billion yen annually, but the operation plan (route selection and operation count) of the snow removal vehicle is not based on objective awareness of snow depth which can vary year by year.
In order to solve this problem, it is important to grasp the snow depth deep space distribution. The estimation of snow accumulation by the conventional satellite-mounted synthetic aperture radar (SAR) was mostly based on the C-band, and adaptation to the snow layer including liquid moisture have difficulty due to the short wavelength (Bernier et al., 1999; Li et al., 2017; Rignot et al., 2001; Shi et al., 1993; Shi and Dozier, 1995). However, in the L-band SAR, the correlation between the snow depth and the backscattering intensity was confirmed to be wet snow, which was a negative correlation (the snow is deeper the reflected intensity decreases) in the night observation assumed to be dry snow It was shown that positive correlation was obtained by day observation (Nagai et al., 2018a, 2018b).
In this research, we examined the image processing algorithm suitable for snow depth estimation for PALSAR-2 which is the L-band SAR equipped with "Daichi-2". First of all, the night observation data was used to minimize the influence of liquid moisture. Obtain data of the observation as 2015/11/22, 2016/11/20 as the no-snow period and 2018/01/28 as the snowy season, convert the backscattering intensity (dB). A series of moving average filter of 0, 5, 10, 15...55 pixels were carried out for each. Then statistical comparison of the ground measurement value compiled by Niigata University (Iyobe and Kawashima, 2016) and the SAR-derived backscatter amplitude changes was carried out.
As a result, the moving average filter with 10 pixels or more shows a negative correlation of $r < -0.3$, $p < 0.1\%$ in all cases, and the correlation coefficient decreased as the number of pixels of the filter increased. There was no significant difference between the November average image and the single scene image. For the linear approximation between the intensity difference and the measured value, the slope was almost constant with the moving average filter of 10 pixels or more.
By using data at night during the winter season, we can estimate snow depth from SAR with high negative correlation. In order to create a snow depth map with a better correlation coefficient, it is necessary to apply a stronger moving average filter, but since it becomes a coarse and smooth snow depth map according to it, it is necessary to consider a filter according to the application.
In addition to this, statistical analysis is also presented in this presentation on other seasons as the standard as well as for snow melting daytime observations presumed to contain a large amount of snow in the snow, and a snow depth estimation method using SAR deepens in the discussion.

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Keywords: SAR, snowpack, backscatter amplitude

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Breaking-off of hanging glaciers at Mt. Langtang-Lirung in Nepal

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On 25 April 2015, an earthquake (M7.8) occurred at Gurkha region located northwest of Kathmandu, the capital of Nepal. On 12 May, an earthquake of M 7.3 occurred at 80 km northeast from Kathmandu. Due to this series of large earthquakes, slope failure events (ice avalanche, snow avalanche, snow-rock avalanche, rock avalanche) occurred frequently in snow mountain area of the Himalaya. In Langtang valley, a huge snow-rock avalanche caused more than 100 victims in Langtang village. We investigated the characteristics of bereaking-off from hunging glaciers around Mt. Langtang-Lirung using satellite data and digital aerial images in 2015 and 2018.

Keywords: hanging glacier, breaking-off, Mt. Langtang-Lirung, Gurkha earthquake

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Spatial distribution of ice cliff in the Trakarding glacier, Nepal Himalaya

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Glaciers in High Mountain Asia are valuable indicator of climate change, and its melt water have an important role for the regional water resources (e.g. Immerzeel et al., 2010). We thus need to estimate Himalayan glacier melting amount. However, the lower part of large Himalayan glaciers is generally covered with debris mantle, which makes the melting process complicated. Several previous works pointed out a role of ice cliffs that promote local enhancement of the ice melting (e.g. Brun et al., 2018). In previous studies, digital elevation models (DEMs) based on satellite imageries have been analyzed to estimate glacier mass change. However, it is difficult to extract ice cliffs due to their low resolution. Recently, Structure from Motion (SfM), image analysis technology, has been dramatically developed. This method enables to obtain high resolution glacial terrain data and identify the small features on glacier surface such as ice cliffs.
In this study, we generated high resolution DEMs and orthomosaic images from aerial photographs taken at three different times at the Trakarding glacier, Rolwaling region, Nepal Himalaya in order to evaluate area and aspect of ice cliffs, and analyzed the relation between cliff distribution and glacier surface elevation change. We carried out field observations and conducted aerial photogrammetry by fixed wing UAV in 2017 and helicopter in 2018 at the entire debris-covered area (3.1 km^2). We also analyzed photographs taken in 2007, and then created high resolution (0.2~2.0 m/pix) DEMs and orthomosaic images, from which about 500 ice cliffs were extracted.
DEMs shows that the surface elevation of the Trakarding Glacier declined between 2007 and 2017 by -1.65 m w.e. yr^{-1} while it lifted up between 2017 and 2018 by +1.25 m w.e. yr^{-1}. We find that the surface elevation changes are spatially heterogeneous. The more significant surface lowering happens, the higher cliff density is observed, suggesting that the ice cliff locally enhances glacier melting. In addition, the ice cliff length density was 7.9×10^{-3} m m^{-2} in 2017, which remarks the highest density comparing to a previous study in the Khumbu region (Watson et al., 2017). Further, we find significant correlation between ice cliff length and its slope area, which means that it is possible to estimate the slope area of cliff from the cliff length, which can be obtained from satellite images.

Reference

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Keywords: Glacier, Himalaya, UAV, SfM, Remote Sensing

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Quantify the range of projections of future changes in glacier mass caused by differences among observed past climate datasets

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1. Tokyo Institute of Technology, 2. Meisei University, 3. Shibaura Institute of Technology, 4. The University of Tokyo

Observed climate data used as input in glacier models are expected to differ among datasets particularly at high elevations. Differences among datasets have not yet been described as a cause of uncertainty in projections of future changes in glacier mass, although uncertainty caused by varying future climate projections among general circulation models (GCMs) has often been discussed. Differences among climate datasets are expected to propagate as uncertainty in future changes in glacier mass due to bias correction of GCMs and calibration of glacier models. We project ensemble future changes in the mass of glaciers in Asia through the year 2100 using a glacier model. A set of 18 combinations of inputs, including two observed past air temperature datasets, three observed past precipitation datasets, and future air temperature and precipitation projections from three GCMs were used. The uncertainty in projected changes in glacier mass was partitioned into three distinct sources: GCM uncertainty, observed past air temperature uncertainty, and observed past precipitation uncertainty. Our findings indicate that, in addition to the differences in climate projections among GCMs, differences among climate datasets can propagate uncertainty into projected changes in glacier mass. Significant differences in observed precipitation did not cause major uncertainty in projected changes in glacier mass.

Keywords: propagation of uncertainty, glacier model, bias correction, calibration, air temperature, precipitation

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CC Cryospheric Sciences & Cold District Environment

Wed. May 29, 2019 10:45 AM - 12:15 PM JST | Wed. May 29, 2019 1:45 AM - 3:15 AM UTC | 303 3F

[A-CC27] Glaciology

convener:Takayuki Nuimura(Tokyo Denki University), Ishikawa Mamoru(Hokkaido University), Kzutaka Tateyama(National University Corporation Kitami Institute of Technology), Hiroto Nagai(Waseda Univ., School of Education), Chairperson:Takayuki Nuimura(Chiba Institute of Science)

The cryosphere is a fundamental component of the earth system. It is a region where snow and ice exist in the form of glacier/ice sheet, snow cover and snowfall, frozen ground, sea ice and fresh water ice, and they play a critical role in the global environment under the interactions with atmosphere, ocean, ecosystem and others. In this session, research results on physical and chemical characteristics of snow and ice, variations and dynamics of cryospheric environment, roles of the cryosphere on the earth and other planets will be discussed broadly, regardless of the research method.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[ACC27-07] Preliminary analysis result of the Handheld Integrating Sphere Snow Grain Sizer (HISSGraS)

*Teruo Aoki[1,2,3], Masashi Niwano[2], Satoru Yamaguchi[4], Sumito Matoba[5], Tomonori Tanikawa[2], Masahiro Hori[6], Rigen Shimada[6], Akihiro Hachikubo[7] (1.The Graduate School of Natural Science and Technology, Okayama University, 2.Meteorological Research Institute, Japan Meteorological Agency, 3.National Institute of Polar Research, 4.National Research Institute for Earth Science and Disaster Resilience, 5.Institute of Low Temperature Sciences, Hokkaido University, 6.Earth Observation Research Center, Japan Aerospace Exploration Agency, 7.Kitami Institute of Technology)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[ACC27-08] Experimental study on compaction process of highly porous ice: Implications for density change of icy regolith layer on icy bodies

Minami Yabe[1], *Minami Yasui[1], Masahiko Arakawa[1] (1.Department of Planetology, Graduate School of Science, Kobe University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[ACC27-09] **Effect of snow impurities on the radiation budget and snow melting observed at Sapporo during 10 winter seasons**

*Yoichiro Hirozawa[1], Teruo Aoki[1,2], Masashi Niwano[2], Sumito Matoba[3], Yuji Kodama[4], Tomonori Tanikawa[2] (1.Okayama University, Graduate School of Natural Science and Technology, 2.Meteorological Research Institute, 3.Institute of Low Temperature Science, Hokkaido University, 4.National Institute of Polar Research)

11:30 AM - 12:15 PM JST | 2:30 AM - 3:15 AM UTC

Discussion

Preliminary analysis result of the Handheld Integrating Sphere Snow Grain Sizer (HISSGraS)

*Teruo Aoki[1,2,3], Masashi Niwano[2], Satoru Yamaguchi[4], Sumito Matoba[5], Tomonori Tanikawa[2], Masahiro Hori[6], Rigen Shimada[6], Akihiro Hachikubo[7]

1. The Graduate School of Natural Science and Technology, Okayama University, 2. Meteorological Research Institute, Japan Meteorological Agency, 3. National Institute of Polar Research, 4. National Research Institute for Earth Science and Disaster Resilience, 5. Institute of Low Temperature Sciences, Hokkaido University, 6. Earth Observation Research Center, Japan Aerospace Exploration Agency, 7. Kitami Institute of Technology

Snow grain size is one of the most important factors as a snow physical parameter expressing the snow metamorphism as well as controlling the albedo. As snow grains are generally non-spherical and complicated shapes, the optically-equivalent grain size is not a common glaciological grain size[1)]. Thus, various techniques to measure the specific surface area (SSA) as an optically-equivalent grain size have been developed[2-5)]. It is known from intercomparisons of those techniques so far that one of the most accurate field instruments is IceCube (A2 Photonics Sensor, France)[2)]. The IceCube measures a reflectance of snow sample at the wavelength of 1,310 nm using an integrating sphere and a laser light source. The value of SSA is transformed from the reflectance. A weight of the IceCube is as much as about 20 kg and the snow sampling into a sampling case is needed. These impose not only a workload to the observer but also a certain observation time. We therefore developed a small and light-weight (1/10) instrument, the Handheld Integrating Sphere Snow Grain Sizer (HISSGraS), which operates on the same principle as the IceCube and can measure snow pit face or snow surface directly. This direct measurement enables us to measure the SSA of snow of natural condition in a short time. We measured the SSAs with HISSGraS and IceCube for several snow samples in a cold laboratory and for natural snow pit face in Japan and Greenland. When the SSAs were measured for the same snow samples with both HISSGraS and IceCube, the those SSAs agreed well with each other. When HISSGraS measured snow pit face directly and IceCube measured snow samples collected from the same snow pit, the SSAs by HISSGraS were somewhat larger than those by IceCube. This is because the snow crystals in a sampling case would be compressed at the sampling and the snow grain size could differ from that under natural snow condition.

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Keywords: snow grain size, specific surface area, albedo, snow metamorphism

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Experimental study on compaction process of highly porous ice: Implications for density change of icy regolith layer on icy bodies

Minami Yabe[1], *Minami Yasui[1], Masahiko Arakawa[1]

1. Department of Planetology, Graduate School of Science, Kobe University

Ice sheets are found on the polar regions of Earth and Mars. Ice sheets were formed as snow was piled up and compacted into ice. Icy satellites are covered with ice regolith layer which is generated from impact craters by collisions of small bodies. It is supposed that this regolith layer is compacted by self-gravity, but the gravity of small icy satellites is very small and also the surface temperature is quite low, compared with that on the surfaces of Earth and Mars, so the compaction rate of ice regolith layer could be very low, then the deep icy regolith layer might be kept at high porosity on their surfaces. This icy regolith layer could be attributed to the evolution of the surface geology on icy satellites such as topographic relaxation and impact cratering. In this study, we focused on the compaction process of icy regolith layer on icy satellites and conducted compression experiments for highly porous ice under low stresses to examine the relationship between the compaction rate and the porosity.

Snow samples were prepared by filling ice particles with the diameter of ~20 μm into the cylinder mold and by compressing them by a piston into the cylinder with the diameter of 20 mm and the height of 40 mm. The initial porosity was 0.5-0.65. In order to examine the effect of sintering among ice particles on the compression rate, the sintering duration was changed from 0 to 200 hours. We conducted creep tests under constant stresses from 21 to 42 kPa. The displacement of the sample height was measured by a laser or a contact-typed displacement sensors while the diameter change was measured by using images take by a time lapse camera. The temperature was set to be -9and -11 ˚C.

First, we examined the relationship between the strain in a height direction, dh/h, and that in a horizontal direction (diameter change), dr/r, and found to be (dr/r)=-0.11(dh/h). Thus, the compaction rate, $(1/\rho \cdot d\rho/dt)$, was found to be obtained to be -0.78 times the strain rate in a height direction (we call this rate as “compression rate” hereafter), $1/h \cdot dh/h$.

Next, we examined the effect of sintering duration on the compression rate. Under same stress condition, the compression rate was smaller as the sintering duration was longer. However, when the sintering duration passed the critical period, the compression rate was nearly constant even if the sintering duration passed longer. This critical period became shorter as the initial porosity was larger. In this study, to exclude the effect of sintering duration on the compression rate, we examined the effects of porosity, stress, and temperature on the compression rate that was expected for the sample sintering at the period loger than the critical period.

We examined the relationship between the compression rate and the porosity, ϕ, and found that the compression rate could be fitted by the following power equation under a constant stress, irrespective of the initial porosity, $1/h \cdot dh/dt = B\exp(C\phi)$, where B and C are constants. The constant increased exponentially with the increase of the stress, σ, that is, $B \propto \sigma^n$, where n is constant. The constants, C, and n, did not depend on the stress and obtained to be C=24, and n=1.8.

Finally, we evaluated the compaction processes due to self-gravity on the Antarctica and a saturnian icy satellite, Enceladus, by using our obtained empirical equation. We calculated the density and the elevation change of the snow layer on the Antarctica and the icy regolith layer on Enceladus. In this calculation, we assumed that the initial density was homogeneous, 180 kg/m^3, in the whole layer and the stress on the ground surface was 100 kPa. In the case of the Antarctica (a layer thickness of 10 m), the density just above the ground surface increased about three times and the thickness was changed to be a half after 100 years. In the case of Enceladus (a layer thickness of 5 km), the thickness was changed to be

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a half after 100 years, as same as the case of the Antarctica, but the density just above the ground surface increased about only twice and the density in the layer on Enceladus was smaller than that on the Antarctica on the whole.

Keywords: highly porous ice, compaction, creep experiment, sintering duration, icy regolith layer

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Effect of snow impurities on the radiation budget and snow melting observed at Sapporo during 10 winter seasons

*Yoichiro Hirozawa[1], Teruo Aoki[1,2], Masashi Niwano[2], Sumito Matoba[3], Yuji Kodama[4], Tomonori Tanikawa[2]

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Snow impurities originated from light-absorbing aerosols in the atmosphere have an effect to accelerate the cryospheric warming by reducing the albedo. According to IPCC AR5, black carbon (BC) on snow and ice was assessed to have a global and annual mean radiative forcing (RF) of +0.04 Wm^{-2}. However, the larger effect on the radiation budget and snow melting could be expected in urban area where the snow impurity concentrations are high. In this study, we investigated the effect of snow impurity (BC and mineral dust) concentration on albedo and snow melting from snow and meteorological data observed at Sapporo using physical based snow albedo model (PBSAM) (Aoki et al., 2011). The observation site is the meteorological observation field (43° 04' 56"N, 141° 20' 30"E, 15 m a.s.l) of the Institute of Low Temperature Science of Hokkaido University and the observation period analyzed is 10 winter seasons from 2007 to 2017. The observed broadband albedos were compared with the theoretical values calculated with the PBSAM to which the observed data of snow grain size, impurity concentrations, and downward radiation were input. In addition, we conducted numerical sensitivity experiments on the albedo change due to snow impurities and calculated their RFs. We also estimated a contribution of snow impurities to snow melting from the energy balance analysis.
Comparing the time series of the observed broadband albedos with the theoretically calculated values, the calculated albedo variations due to the change in snow grain size and impurity concentration agreed well with the observations in each year of the analysis period. The determination coefficient (R^2) and the root mean square error (RMSE) for the whole period obtained from the albedo comparison in the shortwave (SW) spectral region were 0.847 and 0.046, respectively, confirming the high accuracy of PBSAM. Next, sensitivity experiments were conducted on the albedo changes in the visible (VIS), near-infrared (NIR), and SW regions depending on the presence and absence of snow impurities. The albedo change and RF due to snow impurities (BC + mineral dust) in the whole period were -0.053 and +6.7 Wm^{-2}, respectively for the SW region. In addition, we estimated total snowmelt amount from the surface energy balance calculation and measured energy flux between the bottom of the snowpack and the underlying ground. The total estimated amount of snow melt for the whole period was 398 mm w. e..The contributions from surface melting and melting at the ground were 76% and 24%, respectively. The melting energy due to snow impurity-induced albedo reduction is equivalent to 28% of total amount of snow melting, which is larger than the melting at the ground and is not negligible. Furthermore, the contributions from BC and dust to this value are 21% and 7%, respectively.

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Wed. May 29, 2019 10:45 AM - 12:15 PM JST | Wed. May 29, 2019 1:45 AM - 3:15 AM UTC | 102 1F

[A-CG42] Biogeochemical linkages between the surface ocean and atmosphere

convener:Yuzo Miyazaki(Institute of Low Temperature Science, Hokkaido University), Jun Nishioka(Hokkaido University, Institute of low temperature sciences), Koji Suzuki(Hokkaido University), Yoko Iwamoto(Graduate School of Biosphere Science, Hiroshima University), Chairperson:Yuzo Miyazaki(Institute of low temperature science, Hokkaido University), Jun Nishioka(Institute of low temperature science, Hokkaido University)

Multi-scale vertical and horizontal ocean mixing processes can strongly influence the distribution of dissolved and suspended substances including macro- and micro-nutrients, and may impact on phytoplankton bloom formation. The changes in nutrient dynamics generally affect the abundance, composition and metabolic activity of marine organisms such as phytoplankton and bacteria during the bloom. Marine phytoplankton can produce volatile organic compounds (VOCs) and marine atmospheric aerosols, which strongly influence on atmospheric chemistry. Primary and secondary organic and inorganic components produced via marine phytoplankton activity can contribute to the Earth's radiative forcing, and in turn marine ecosystems including biogeochemical processes directly or indirectly. Therefore, the biogeochemical cycles have a tight linkage between the ocean and the atmosphere. In order to understand physical, chemical and biological processes relevant to phytoplankton bloom formation in the ocean, dynamics of VOCs and marine aerosols in the atmosphere, and the biogeochemical linkage between the ocean and the atmosphere, we welcome new interdisciplinary presentations and active discussions on physical, chemical, and biological sciences both from ocean and atmospheric fields in this session. Studies linked to the Surface Ocean-Lower Atmosphere Study (SOLAS) project are good examples, but other related studies are also invited.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[ACG42-01] Production of bromoform in sea ice and emission to the atmosphere

*Daiki Nomura[1], Atsushi Ooki[1], Ellen Damm[2], Gerhard Dieckmann[2], Bruno Delille[3], Markus Frey[4], Mats Granskog[5], Klaus Meiners[6,7], Anna Silyakova[8], Takeshi Tamura[9], Jean-Louis Tison[10], Youhei Yamashita[11] (1.Faculty of Fisheries Sciences, Hokkaido University, 2.Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany, 3.Université de Liège, Liège, Belgium., 4.British Antarctic Survey, Cambridge, United Kingdom., 5.Norwegian Polar Institute, Tromsø, Norway., 6.Antarctic Climate andEcosystems Cooperative Research Centre, University of Tasmania, Hobart, Australia., 7.Australian Antarctic Division, Kingston, Australia., 8.Centre for Arctic Gas Hydrate, Environment and Climate, Tromsø, Norway., 9.National Institute of Polar Research, Tokyo, Japan., 10.Université Libre de Bruxelles, Bruxelles, Belgium., 11.Graduate School of Environmental Sceince, Hokkaido University, Sapporo, Japan.)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[ACG42-02] Accumulation processes of trace metals into arctic sea ice: distribution of Fe, Mn and Cd associated with ice structure

*La Kenya Evans[1], Jun Nishioka[1] (1.Institute of Low Temperature Sciences, Hokkaido University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[ACG42-03] Is halogen chemistry responsible for low ozone levels observed over western Pacific equatorial region? - From observations on R/V Mirai

*Yugo Kanaya[1], Kazuyuki Miyazaki[1], Fumikazu Taketani[1], Takuma Miyakawa[1], Hisahiro Takashima[1,2], Yuichi Komazaki[1], Xiaole PAN[3,1], Saki Kato[2], Kengo Sudo[4,1] (1.Research and Development Center for Global Change, Japan Agency for Marine-Earth Science and Technology, 2.Fukuoka University, 3.Institute of Atmospheric Physics, Chinese Academy of Sciences, China, 4.Nagoya University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[ACG42-04] Very low $\delta^{15}N$ of atmospheric nitrate found in the earstern equatorial Pacific and its implication to dynamic nitrogen recycle between ocean and lower atmosphere

*Shohei Hattori[1], Kazuki Kamezaki[1], Yoko Iwamoto[2], Sakiko Ishino[1], Mitsuo Uematsu[3], Kazuhiko Miura[4], Naohiro Yoshida[1] (1.Department of Chemical Science and Engineering, School of Materials and Chemical Technology, Tokyo Institute of Technology, 2.Hiroshima University, 3.University of Tokyo, 4.Tokyo University of Science)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[ACG42-05] **Origin of water-soluble organic nitrogen in marine atmospheric aerosols in the subtropical North Pacific**

*Tsukasa Dobashi[1,2], Yuzo Miyazaki[1], Eri Tachibana[1], Yoko Iwamoto[3], Kazutaka Takahashi[4], Sachiko Horii[4], Shu-Kuan Wong[5], Koji Hamasaki[5] (1.Institute of Low Temperature Science, Hokkaido Univ., 2.Graduate School of Env. Sci., Hokkaido Univ., 3.Graduate School of Biosphere Science, Hiroshima Univ., 4.Graduate School of Agricultural and Life Sciences, Univ. of Tokyo, 5.Atmosphere and Ocean Research Institute, Univ. of Tokyo)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[ACG42-06] Impacts of ammonia on gas-particle partition and AWC during the 2016 APHH-Beijing campaign: inducing effects of nitrate ammonium

*baozhu Ge[1], Xiaobin Xu[2], Zhiqiang Ma[3], Xiaole PAN[1], Zhe WANG[1,4], Weili Lin[5], Bin Ouyang[6], Danhui Xu[1], James Lee[7], Mei Zheng[8], Dongsheng Ji[1], Yele Sun[1], Huabin Dong[8], Freya Anne Squires[7], Pingqing Fu[1], Zifa Wang[1] (1.State Key Laboratory of Atmospheric Boundary Layer Physics and Atmospheric Chemistry, Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing 100029, China, 2.State Key Laboratory of Severe Weather & Key Laboratory for Atmospheric Chemistry of China Meteorological Administration, Chinese Academy of Meteorological Sciences, Beijing 100081, China, 3.Institute of Urban Meteorology, China Meteorological Administration, Beijing, China, 4.Research Institute for Applied Mechanics (RIAM), Kyushu University, Fukuoka, Japan, 5.College of Life and Environmental Sciences, Minzu University of China, Beijing 100081, China, 6.Lancaster Environment Centre, Lancaster University, Lancaster, LA1 4YQ, UK, 7.National Centre for Atmospheric Science Department of Chemistry, University of York, York, YO10 5DD, UK, 8.State Key Joint Laboratory of Environmental Simulation and Pollution Control, College of Environmental Sciences and Engineering, Peking University, Beijing, 100871, China)

Production of bromoform in sea ice and emission to the atmosphere

*Daiki Nomura[1], Atsushi Ooki[1], Ellen Damm[2], Gerhard Dieckmann[2], Bruno Delille[3], Markus Frey[4], Mats Granskog[5], Klaus Meiners[6,7], Anna Silyakova[8], Takeshi Tamura[9], Jean-Louis Tison[10], Youhei Yamashita[11]

1. Faculty of Fisheries Sciences, Hokkaido University, 2. Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany, 3. Université de Liège, Liège, Belgium., 4. British Antarctic Survey, Cambridge, United Kingdom., 5. Norwegian Polar Institute, Tromsø, Norway., 6. Antarctic Climate andEcosystems Cooperative Research Centre, University of Tasmania, Hobart, Australia., 7. Australian Antarctic Division, Kingston, Australia., 8. Centre for Arctic Gas Hydrate, Environment and Climate, Tromsø, Norway., 9. National Institute of Polar Research, Tokyo, Japan., 10. Université Libre de Bruxelles, Bruxelles, Belgium., 11. Graduate School of Environmental Sceince, Hokkaido University, Sapporo, Japan.

Bromoform ($CHBr_3$) is one of the important bromine containing volatile halocarbons that are involved in ozone depletion in the atmosphere. Although the possible source of reactive bromine species from snow and sea ice has been discussed, mechanisms that control $CHBr_3$ production within sea ice and emission to the atmosphere remain unclear. Here, we show evidence of massive $CHBr_3$ production at sea ice surface-snow interfaces and its strong emission to the atmosphere from five field-campaigns to the Arctic Ocean, the Southern Ocean, and the Sea of Okhotsk in the winter and spring, in addition to supporting laboratory experiments. We found that the ice-related strong $CHBr_3$ emission was linked to the production of the $CHBr_3$ at the snow-sea ice interface through the haloform reaction. Our results suggest that sea ice acts as a strong $CHBr_3$ source for the atmosphere, indicating a significant contribution to the atmospheric bromine cycle.

Keywords: sea ice, bromoform, polar ocean

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Accumulation processes of trace metals into arctic sea ice: distribution of Fe, Mn and Cd associated with ice structure

*La Kenya Evans[1], Jun Nishioka[1]

1. Institute of Low Temperature Sciences, Hokkaido University

Increased loss of Arctic summer sea ice can influence the cycling of biogeochemical materials (trace metals, nutrients, etc.), affecting seawater’ s biology and chemistry. Sea ice is important for the supply of biogeochemical materials, especially trace metals, to the surface waters of the polar oceans; but its role is not clear. Understanding the accumulation and release mechanisms into Arctic sea ice will clarify the geochemical behaviour of trace metals. This study compared dissolved (D) and labile particulate (LP) Fe, Mn, and Cd to the observed sea ice structure from a single Arctic sea ice core. The structure of sea ice reflects the process of ice formation, which may aid in the determination of accumulation processes. Using photographic analysis for the percentage of pore microstructure and $\delta^{18}O$ analysis, sea ice structure was observed as: snow, granular (frazil), mixed (granular and columnar) and columnar ice. Salinity and nutrients were low, indicating brine drainage and multi-year ice. High trace metal concentrations in snow ice indicated meteoric snow as a source and accumulation during snow ice formation. High concentrations of LPFe in granular ice indicated accumulation via suspension freezing by frazil ice followed by entrainment. Dissolved Mn and Cd accumulated in snow and granular ice through chemical transformation processes. Elevated DMn and DCd in granular ice resulted from the reduction and release from accumulated Fe and Mn oxides. Elevated DMn and DCd in snow ice may have been due to the photochemical reduction of LPFe and LPMn. Low trace metal concentrations in mixed and columnar ice indicated trace metal release due to brine drainage. Our study clearly indicated that the differences observed in trace metals, within sea ice structure, showed that sea ice formation, chemical reduction and brine release were the processes behind trace metal accumulation and release in this Arctic sea ice.

Keywords: Trace Metals, Dissolved , Labile Particulate , Sea Ice Structure

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Is halogen chemistry responsible for low ozone levels observed over western Pacific equatorial region? - From observations on R/V Mirai

*Yugo Kanaya[1], Kazuyuki Miyazaki[1], Fumikazu Taketani[1], Takuma Miyakawa[1], Hisahiro Takashima[1,2], Yuichi Komazaki[1], Xiaole PAN[3,1], Saki Kato[2], Kengo Sudo[4,1]

1. Research and Development Center for Global Change, Japan Agency for Marine-Earth Science and Technology, 2. Fukuoka University, 3. Institute of Atmospheric Physics, Chinese Academy of Sciences, China, 4. Nagoya University

Constraints from ozone (O_3) observations over oceans are needed in addition to those from terrestrial regions to fully understand global tropospheric chemistry and its impact on the climate. Here, we provide a large data set of ozone and carbon monoxide (CO) levels observed (for 11666 and 10681 h, respectively) over oceans. The data set is derived from observations made during 24 research cruise legs of R/V *Mirai* during 2012 to 2017, in the Southern, Indian, Pacific, and Arctic Oceans, covering the region from 67˚S to 75˚N. The data are suitable for critical evaluation of the over-ocean distribution of ozone derived from chemical transport models. We first give an overview of the statistics in the data set and highlight key features in terms of geographical distribution and air mass type. We then use the data set to evaluate ozone concentration fields from Tropospheric Chemistry Reanalysis version 2 (TCR-2), produced by assimilating a suite of satellite observations of multiple species into a chemical transport model, namely CHASER. Over the western Pacific equatorial region (125-165˚E, 10˚S to 25˚N), the observed O_3 level frequently decreased to less than 10 ppb in comparison to that obtained with TCR-2, and also those obtained in most of the Atmospheric Chemistry Climate Model Intercomparison Project (ACCMIP) model runs for the decade from 2000. These results imply loss processes that are unaccounted for in the models. We found that the model's positive bias positively correlated with the daytime residence times of air masses over a particular grid, namely 165-180˚E and 15-30˚N; an additional loss rate of 0.25 ppb h^{-1} in the grid best explained the gap. Halogen chemistry, which is commonly omitted from currently used models, might be active in this region and could have contributed to additional losses. Our open data set covering wide ocean regions is complementary to the Tropospheric Ozone Assessment Report data set, which basically comprises ground-based observations, and enables a fully global study of the behavior of O_3.

Keywords: Over-ocean atmospheric composition observations, Missing sink of ozone, Halogens, Western Pacific equatorial region

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Very low $\delta^{15}N$ of atmospheric nitrate found in the earstern equatorial Pacific and its implication to dynamic nitrogen recycle between ocean and lower atmosphere

*Shohei Hattori[1], Kazuki Kamezaki[1], Yoko Iwamoto[2], Sakiko Ishino[1], Mitsuo Uematsu[3], Kazuhiko Miura[4], Naohiro Yoshida[1]

1. Department of Chemical Science and Engineering, School of Materials and Chemical Technology, Tokyo Institute of Technology, 2. Hiroshima University, 3. University of Tokyo, 4. Tokyo University of Science

Atmospheric nitrogen sources in the marine boundary layer of the remote ocean have been known to include long-range transport (LRT) of anthropogenic pollutants, and the LRT of anthropogenic atmospheric particulate nitrate ($p\text{-}NO_3^-$) within the free troposphere has been observed in regions influenced by westerlies from the Asian continent over Pacific Ocean. This traditional paradigm that the ocean is considered a passive recipient of anthropogenic N deposition can be applied western north Pacific regions. However, for the equatorial Pacific under the influence of pristine air, the sources of such $p\text{-}NO_3^-$ remain unresolved. To address this, we present $\delta^{15}N$ of $p\text{-}NO_3^-$ collected over the Pacific Ocean between 40˚S and 68˚N on two cruises, carried out by the Research Vessel *Hakuho Maru*, and estimated $\delta^{15}N$ of source NO_x of each sample. We categorized six marine regions within the Pacific Ocean, based on backward trajectory analysis to determine their source regions and various ion concentrations to assess whether anthropogenic or non-anthropogenic sources were dominant.

We found remarkably low $\delta^{15}N(NO_x)$ values for the equatorial Pacific regions compared to those in other regions over Pacific Ocean. These low source $\delta^{15}N(NO_x)$ values cannot be explained using conventional NO_x apportionment. Given that the eastern equatorial Pacific is one of the biologically active ocean regions resulted from upwelling water, here we postulate the alternative biogenic nitrogen source (NH_3 or alkyl nitrate) in this region. In the presentation, we will discuss important feature of self-recycle process of nitrogen between ocean and lower atmosphere in the eastern equatorial Pacific. We will also discuss its implication to nitrogen deposition for this region, which may contribute to new marine biological production and/or nitrous oxide emissions.

Keywords: Nitrate, Stable Isotopes, Pacific Ocean, Equatorial Pacific

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Origin of water-soluble organic nitrogen in marine atmospheric aerosols in the subtropical North Pacific

*Tsukasa Dobashi[1,2], Yuzo Miyazaki[1], Eri Tachibana[1], Yoko Iwamoto[3], Kazutaka Takahashi[4], Sachiko Horii[4], Shu-Kuan Wong[5], Koji Hamasaki[5]

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Marine atmospheric aerosol is one of the most important factors that determine the climate change, because it absorbs and reflects the sunlight which affects radiative balance of the atmosphere. In particular, water-soluble organic nitrogen (WSON) in aerosol affect physicochemical properties of aerosol such as water-solubility characteristics, acidity, light-absorption properties of the particles. However, little is known about the origin of WSON in marine atmospheric aerosols. The purpose of this study is to elucidate the origin of WSON by cruise observation in subtropical North Pacific where very limited data are available.

Size-segregated aerosol samples were collected on board the R/V *Hakuho Maru* (KH-17-4) over the subtropical North Pacific, mainly along 23ºN, during August–October in 2017. Water-soluble organic carbon (WSOC) and water-soluble total nitrogen (WSTN) were measured by a total organic carbon analyzer with a TN unit. The concentrations of inorganic nitrogen (IN) were measured by ion chromatograph. The WSON concentration was derived from the difference between WSTN and IN. The stable carbon isotope ratio ($\delta^{13}C$) was measured by elemental analyzer-isotope ratio mass spectrometer (EA-IRMS). Longitudinal distributions of WSON at 23ºN showed that the submicrometer WSON concentration (av. 5.9 ±6.0 ng N m^{-3}) to the east of 160ºW was significantly larger than that to the west (av. 2.2 ±2.0 ng N m^{-3}). Additionally, the mass fraction of WSON to WSTN in the eastern oceanic region reached as large as 40% with an average of 14.1%, suggesting the importance of WSON in this oceanic region. Backward trajectory, the chlorophyll *a* concentration in seawater, and the $\delta^{13}C$ value suggested that the majority of the observed WSON was derived from microbial activity in the sea surface. WSON did not show any significant correlation with a tracer of primary emission (i.e., Na^{+}), indicating that the majority of WSON were not directly emitted as aerosol particles from the ocean surface, but were produced from N-containing gas species released into the atmosphere. Furthermore, a significant correlation between the concentrations of WSON and the nitrogen fixation rate in the sea surface indicates that reactive nitrogen, produced by nitrogen fixing organisms (e.g., cyanobacteria), are emitted from sea surface to the atmosphere, which significantly contributed to the formation of aerosol WSON.

Keywords: Organic nitrogen, Marine atmospheric aerosol, Biogeochemical linkage between atmosphere and ocean, Nitrogen fixation

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Impacts of ammonia on gas-particle partition and AWC during the 2016 APHH-Beijing campaign: inducing effects of nitrate ammonium

*baozhu Ge[1], Xiaobin Xu[2], Zhiqiang Ma[3], Xiaole PAN[1], Zhe WANG[1,4], Weili Lin[5], Bin Ouyang[6], Danhui Xu[1], James Lee[7], Mei Zheng[8], Dongsheng Ji[1], Yele Sun[1], Huabin Dong[8], Freya Anne Squires[7], Pingqing Fu[1], Zifa Wang[1]

1. State Key Laboratory of Atmospheric Boundary Layer Physics and Atmospheric Chemistry, Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing 100029, China, 2. State Key Laboratory of Severe Weather & Key Laboratory for Atmospheric Chemistry of China Meteorological Administration, Chinese Academy of Meteorological Sciences, Beijing 100081, China, 3. Institute of Urban Meteorology, China Meteorological Administration, Beijing, China, 4. Research Institute for Applied Mechanics (RIAM), Kyushu University, Fukuoka, Japan, 5. College of Life and Environmental Sciences, Minzu University of China, Beijing 100081, China, 6. Lancaster Environment Centre, Lancaster University, Lancaster, LA1 4YQ, UK, 7. National Centre for Atmospheric Science Department of Chemistry, University of York, York, YO10 5DD, UK, 8. State Key Joint Laboratory of Environmental Simulation and Pollution Control, College of Environmental Sciences and Engineering, Peking University, Beijing, 100871, China

Atmospheric NH_3 plays a vital role not only in the environmental ecosystem but also in atmosphere chemistry. To fully understand the effects of NH_3 on the formation of haze pollution in Beijing, ambient NH_3 and related species were measured at high resolutions during the wintertime Air Pollution and Human Health-Beijing (APHH-Beijing) campaign in 2016. Simulations were made to gain insights into impacts of NH_3 on the formation of secondary inorganic aerosols (SIAs) and regional fine particle pollution. We found that the total NH_x (gaseous NH_3+particle NH_4^+) was mostly in excess of the SO_4^{2-}-NO_3^--NH_4^+-water equilibrium system during our campaign. This NH_x excess made medium aerosol acidity, with the median pH value being 3.6 and 4.5 for polluted and non-polluted conditions, respectively, and enhanced the formation of particle phase nitrate. During polluted periods, SIAs contributed most to $PM_{2.5}$ and were highly correlated with aerosol water content (AWC), indicating the importance of heterogeneous reactions in haze formation. Our analysis suggests that NH_4NO_3 is the most important factor driving the formation of AWC, with NO_3^- controlling the prior pollution stage and NH_4^+ the most polluted stage. Increased formation of NH_4NO_3 under excess NH_x, especially during the nighttime, may trigger the decreasing of aerosol DRH and hence lead to hygroscopic growth even under lower RH conditions and the wet aerosol particles become better medium for rapid heterogeneous reactions. A further increase of RH promotes the positive feedback "AWC-heterogeneous reactions" and ultimately leads to the formation of severe haze. Both our observational and modelling results suggest that the control of NH_3 may be more effective in reducing $PM_{2.5}$ under current emissions conditions in the North China Plain (NCP).

Keywords: Ammonia, partition, aerosol acidity, APHH-Beijing, PM2.5, NCP

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[J] Oral | H (Human Geosciences)：H-GM Geomorphology

Wed. May 29, 2019 9:00 AM - 10:30 AM JST | Wed. May 29, 2019 12:00 AM - 1:30 AM UTC | 101 1F

[H-GM04] Geomorphology

convener:Tsuyoshi Hattanji(Faculty of Life and Environmental Sciences, University of Tsukuba), Masayuki Seto(Fukushima Future Center for Regional Revitalization, Fukushima University), Chairperson:Tsuyoshi Hattanji

The main subject of this session is the whole range of themes relating to geomorphology, especially geomorphic processes, landform development and its relation to environmental changes, geomorphological hazards and their mitigation and reports of recent events of disaster occurred in Japan, various kind of hazard maps, relationships among geomorphic processes, other natural phenomena and human activities, and various techniques of geomorphological measurements and automatic landform classification. Japanese can be used in this session.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[HGM04-01] Salt weathering in humidity-change environments: a laboratory experiment

*Masato Sato[1], Tsuyoshi Hattanji[2] (1.Graduate School of Life and environmental Sciences, University of Tsukuba, 2.Faculty of Life and Environmental Sciences, University of Tsukuba)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[HGM04-02] Verification a new control device of blown sand transport rate by wind tunnel experiments

*Yoshinori Kodama[1], Riko Saikusa[2] (1.Faculty of Agriculture, 2.Faculty of Regional Sciences)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[HGM04-03] Bedrock landslides, river blockage, and barrier-lake outburst as general geomorphic processes in high-relief mountainous landscape: an example from the Marshyangdi River, central Nepal

*Yuki Matsushi[1], Hiroshi YAGI[2], Hiroyuki Matsuzaki[3] (1.Disaster Prevention Research Institute, Kyoto University, 2.Department of Education, Art and Science, Yamagata University, 3.icro Analysis Laboratory, Tandem Accelerator, The University of Tokyo)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[HGM04-04] Influence of lithology on production and transport of soils on hillslopes underlain by granite and hornfels

*Takuma Watakabe[1], Yuki Matsushi[2], Hiroyuki Matsuzaki[3] (1.Graduate School of Science, Kyoto University, 2.Disaster Prevention Research Institute, Kyoto University, 3.The University Museum, The University of Tokyo)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[HGM04-05] Characterization of the vertical unsaturated flow for an integrated prediction of the storm runoff response and landslide initiation on a hillslope

*Makoto Tani[1], Yuki Matsushi[2], Takahiro Sayama[2], Nagahiro Kojima[3] (1.University of Human Environments, 2.Disaster Prevention Research Institute, Kyoto University, 3.Lake Biwa Environmental Research Institute)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

Discussion

Salt weathering in humidity-change environments: a laboratory experiment

*Masato Sato[1], Tsuyoshi Hattanji[2]

1. Graduate School of Life and environmental Sciences, University of Tsukuba, 2. Faculty of Life and Environmental Sciences, University of Tsukuba

A laboratory weathering experiment simulating under changing humidity conditions were carried out using five types of rocks (porous tuff, porous sandstone, dense sandstone, and two porous mudstones) with three types of salts (sodium chloride, sodium sulfate, or magnesium sulfate). The rock specimens were subjected to humidity oscillations in a climatic cabinet where air humidity ranged from 20%RH to 98%RH during 6-hour periods 20˚C. Prior to the weathering experiment, the specimens were oven-dried, and the water supply was restricted only from air humidity during the experiment.
Humidity oscillation induced cycles of repeated of salt deliquescence-recrystallization and hydration-dehydration. Salts on rock surface deliquesced and hydrated in a high-humidity period, while they crystallized in a low-humidity period. The degrees of damage were correlated with moisture amounts absorbed to the rock specimens in the high-humidity period.
Sodium chloride which deliquesces at humidity of more than 80%RH caused the most intensive weathering. Porous sandstone with sodium chloride was completely broken down after 100 cycles of humidity changes. Dense sandstone and porous tuff showed flaking or swelling on their surfaces. Equotip surface hardness of dense sandstone with sodium chloride decreased with increasing number of humidity cycles. Sodium chloride can easily induce salt weathering by salt deliquesce and recrystallize in environment where air humidity fluctuates in a short time interval, such as the surfaces of rock cliff in coastal spray zones.
Magnesium sulfate induced a weight loss in porous sandstone, through flaking from the surface of porous tuff, and through swelling and cracking on the surface of dense sandstone. Sodium sulfate was not effective in the humidity-change experiment, although salt efflorescence was extensively produced. Slow hydration rate of sodium sulfate can cause the ineffectiveness of sodium sulfate. In addition, volumetric expansion with hydration of sodium sulfate may result in pore clogging, and hinder infiltration of moisture into the rock specimens. The restricted activity of sodium sulfate suggests that sodium sulfate rarely induces salt weathering by daily humidity fluctuation. Magnesium sulfate might influence rock decay more than sodium sulfate when air humidity fluctuates in a short period.

Keywords: salt weathering, humidity, sodium chloride, sodium sulfate, magnesium sulfate, surface hardness

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Verification a new control device of blown sand transport rate by wind tunnel experiments

*Yoshinori Kodama[1], Riko Saikusa[2]

1. Faculty of Agriculture, 2. Faculty of Regional Sciences

A new water-pool device for reducing blown sand transport rate was proposed from a view point of saltating particle motion. Wind duct experiments were conducted to check sediment trap efficiencies of a proposed device. In our experimental conditions, maximum wind velocity: 12.9 m/s, it worked well: reducing blown sand transport rate less than 6 % within 4.55 m distance. We estimated that the least length of the device is 11.3 m at 18.0 m/s wind condition, which is almost maximum in Tottori Sand Dunes.

Keywords: a water-pool method for reducing blown sand transport rate, wind tunnel experiment, saltation particle, Tottori Sand Dunes

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Bedrock landslides, river blockage, and barrier-lake outburst as general geomorphic processes in high-relief mountainous landscape: an example from the Marshyangdi River, central Nepal

*Yuki Matsushi[1], Hiroshi YAGI[2], Hiroyuki Matsuzaki[3]

1. Disaster Prevention Research Institute, Kyoto University, 2. Department of Education, Art and Science, Yamagata University, 3. icro Analysis Laboratory, Tandem Accelerator, The University of Tokyo

This study demonstrates generality of large-scale bedrock landslides, river blockage by the slid mass, and debris flow by the barrier-lake outburst in landscape evolution of high-relief mountainous watersheds. We focused on the Marshyangdi River, south-eastern range of the Annapurna massif, central Nepal, to conduct ground-based surveys and geo-spatial analyses. Geology along the river consists mainly of Paleozoic and Mesozoic sedimentary rocks, gneiss, phyllite, schist, and shale from the upper to lower reach. Deeply-incised gorge develops in the area of massive gneiss, while fill terraces occupy the wide area of valley floor downstream from the Main Central Thrust. The lower- to mid-level terraces exhibit characteristic morphology with hummocky mounds with gneiss boulders settled on the surface, indicating their origin that may be relevant to large scale debris flow events by deep-seated bedrock landslide and subsequent barrier lake breach. Exposure ages of the boulders ranges from 2 to 4 ka, indicating repeated occurrence of such events under the Holocene climate. On the upstream area, several sets of lacustrine deposits remain along the main channel. The sequence and distribution indicate that the paleo landslide-dammed lakes expanded few-kilometers in length and few hundreds meters in depth before breaching. The debris flow ran through the river for tens of kilometers, spreading out over the downstream valley. Results of evidence mapping and topographic analysis indicate that these kind of large-scale sequential phenomena play a general function in landscape evolution of a high-relief steep mountainous watershed in tectonically-active settings. Disaster mitigation for such possible event requires enhancement of preparedness through prediction and risk assessment for conceivable hillslope and/or fluvial processes.

Keywords: Mountain geography, Disaster mitigation, Landslide-dammed lake, Debris flow, Climate change

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Influence of lithology on production and transport of soils on hillslopes underlain by granite and hornfels

*Takuma Watakabe[1], Yuki Matsushi[2], Hiroyuki Matsuzaki[3]

1. Graduate School of Science, Kyoto University, 2. Disaster Prevention Research Institute, Kyoto University, 3. The University Museum, The University of Tokyo

We measured rates of soil production and transport using cosmogenic ^{10}Be and measured characteristics of soil properties in hillslopes underlain by granite and hornfels in Shirakawa watershed, eastern Kyoto City. Rates of soil production and transport of the granite hillslope were faster than those of the hornfels hillslope. Soil on the granite hillslope was incohesive sand with large saturated hydraulic conductivity and low water retention ability. In contrast, soil on the hornfels hillslope was cohesive sand with low saturated hydraulic conductivity and high water retention ability. Characteristics of the granite soil promote wet–dry weathering effect in the shallow subsurface materials of the granite hillslope. Thus, physical, mechanical, and hydrological properties of soils on each bedrock control the rates of soil production and transport.

Keywords: Soil production rate, Soil transport coefficient, Cosmogenic nuclides, Geotechnical properties

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Characterization of the vertical unsaturated flow for an integrated prediction of the storm runoff response and landslide initiation on a hillslope

*Makoto Tani[1], Yuki Matsushi[2], Takahiro Sayama[2], Nagahiro Kojima[3]

1. University of Human Environments, 2. Disaster Prevention Research Institute, Kyoto University, 3. Lake Biwa Environmental Research Institute

Studies on hillslope hydrology have demonstrated storm runoff responses are generated mainly through subsurface flow instead of overland flow, and studies on erosion control have empirically revealed landslides usually occur at the time of intense rainfall after a large cumulative rainfall. based on these findings, we have to explain with consistency that the flow generation mechanism for large magnitude storms on hillslope can produce both hydrograph responses below a threshold condition of rainfall and a landslide initiation above the threshold. Recent observational studies have shown vertical unsaturated flow within a hillslope soil layer may dominantly control the responses of ephemeral groundwater table to storm rainfall through the pressure-head propagation and that the responses are rather transmitted to the stream runoff with little modification. The present study discusses the reason why the vertical unsaturated flow can produce the runoff responses during large magnitude storms and provides a perspective on an integrative prediction of the storm runoff response and landslide initiation

Keywords: Integrated prediction of storm runoff and landslide initiation , Hillslope hydrology, Vertical unsaturated flow, Soil-layer evolution

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[J] Oral | H (Human Geosciences)：H-GM Geomorphology

Wed. May 29, 2019 10:45 AM - 12:15 PM JST | Wed. May 29, 2019 1:45 AM - 3:15 AM UTC | 101 1F

[H-GM04] Geomorphology

convener:Tsuyoshi Hattanji(Faculty of Life and Environmental Sciences, University of Tsukuba), Masayuki Seto(Fukushima Future Center for Regional Revitalization, Fukushima University), Chairperson:Masayuki Seto, Hiroshi Shimazu

The main subject of this session is the whole range of themes relating to geomorphology, especially geomorphic processes, landform development and its relation to environmental changes, geomorphological hazards and their mitigation and reports of recent events of disaster occurred in Japan, various kind of hazard maps, relationships among geomorphic processes, other natural phenomena and human activities, and various techniques of geomorphological measurements and automatic landform classification. Japanese can be used in this session.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[HGM04-06] The landform and flood characteristics of the Iron Gate on the ancient road from Samarkand to Bamian, south Uzbekistan

*Hiroshi Shimazu[1] (1.Department of Geography, Faculty of Geo-Environmental Science, Rissho University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[HGM04-07] OSL dating of sediment core in Olgoi lake, Mongolia

*Yudai Igarashi[1], Noriko Hasebe[1], Nagayoshi Katsuta[2], Hitoshi Hasegawa[3], Davaadorj Davaasuren[4], Yukiya Tanaka[5], Uyangaa Udaanjargal[1], Keisuke Fukushi[1], Ichinnorov Niiden[6] (1.Kanazawa University, 2.Gihu University, 3.Kochi University, 4.National University of Mongolia, 5.Kyunghee University, 6.Mongolian Academy of Science)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[HGM04-08] Paleo Lake level change in southern part of Mongolia

*Noriko Hasebe[1], Makoto Sambo[2], Uyangaa Udaanjargal[2,3], Shuukaaz Ganbat[3], Keisuke Fukushi[1], Yukiya Tanaka[4], Davaadorj Davaasuren[3] (1.Institute of Nature and Environmental Technology, Kanazawa University, 2.Department of Earth Sciences, Kanazawa University, 3.National University of Mongolia, 4.Kyunghee University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[HGM04-09] Numerical modeling of wave propagation on the coral reef based on high resolution 3D topography

*Kenta Minamidate[1], Kazuhisa Goto[2], Masashi Watanabe[3,4], Volker Roeber[5,6], Ken Toguchi[7], Masami Sannoh[8], Yosuke Nakashima[9], Hironobu Kan[10] (1.Graduate School of Science, Tohoku University, 2.International Research Institute of Disaster Science (IRIDeS), Tohoku University, 3.Graduate School of Engineering, Tohoku University, 4.Graduate School of Science and Engineering, Chuo University, 5.Hawaii University, 6.Université de Pau et des Pays de l'Adour, 7.Ryukyu University, 8.Mikuniya Corporation, 9.NIT, Ariake College, 10.Graduate School of Integrated Sciences for Global Society, Kyushu University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[HGM04-10] Coastal Seafloor Geomorphology: launching of a new field and perspectives

*Hironobu Kan[1], Nobuyuki Hori[2], Tatsuro Nakai[3], Yusuke Yokoyama[4], Kazuhiko Fujita[5], Hitoshi Hasegawa[3], Yosuke Nakashima[6], Kensaku Urata[1], Atsushi Suzuki[7], Masayuki Nagao[7], Kazuhisa Goto[8] (1.Graduate School of Integrated Sciences for Global Society, Kyushu University, 2.Emeritus Professor, Department of Geography, Tokyo Metropolitan University, 3.Department of Geography and Environmental Studies, Kokushikan University, 4.AORI, University of Tokyo, 5.Department of Physics and Earth Sciences, Faculty of Science, University of the Ryukyus, 6.National Institute of Technology, Ariake College, 7.Research Institute of Geology and Geoinformation, AIST, 8.IRIDeS, Tohoku University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

Discussion

The landform and flood characteristics of the Iron Gate on the ancient road from Samarkand to Bamian, south Uzbekistan

*Hiroshi Shimazu[1]

1. Department of Geography, Faculty of Geo-Environmental Science, Rissho University

“The Iron Gate” is located on the ancient road from Samarkand, which has been one of the largest cities in the central Asia from ancient times, via Termes, where is the crossing point of the Amudarya, to Bamian, which has been one of the important cities as Buddhism. The Iron Gate is a narrow gorge located several kilometers east of the main mountain ridge of the Hissar Mountains. Its length is 2 kilometers and its width of the narrowest part is 10 meters. Both valley side slopes are very steep and their relative height is about 200 meters. Genjo, who is one of the most famous Buddhism priest of 7th century walked through the gorge on the way to India.

Debris flow deposits, whose maximum diameter in b-axis is over 50cm, and sorted and clear laminated flood sediments, which are more rounded and smaller sandy gravels are distributed in the canyon. The relative height between these surface top and valley bottom is several meters. Present valley floor is buried valley bottom, whose surface is flat or covered with lobate large gravel deposits. Although there is poor vegetation on the both valley side slopes and surface of the sediments, only sporadic shrubs are on the valley bottom and both side of the eroded cliff of the sediments Heavy flood event frequent occurred in this region and debris flow and sediment flow buried the Iron Gate canyon section. After the event the buried valley bottom was dissected by water flow. Sediment transport events repeated more than once in a year and heavy flood event repeated once in several years. Samarkand and Termes have precipitation between October and April. The temperature in cold season of the city is below zero and this region has some snow. Snow melt is accelerated by rain in March and April and flood events are caused in this region.

The reason why this important road was constructed in the area of such higher risk of flood is that this place was the important checkpoint of this road. The forts of this region, located the ridge of hill, were favorable to watch passers pass through the canyon road, where sometimes closed by flood.

Keywords: Iron Gate, gorge, flooding, fluvial sediments, Surkhandarya, Uzbekistan

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OSL dating of sediment core in Olgoi lake, Mongolia

*Yudai Igarashi[1], Noriko Hasebe[1], Nagayoshi Katsuta[2], Hitoshi Hasegawa[3], Davaadorj Davaasuren[4], Yukiya Tanaka[5], Uyangaa Udaanjargal[1], Keisuke Fukushi[1], Ichinnorov Niiden[6]

1. Kanazawa University, 2. Gihu University, 3. Kochi University, 4. National University of Mongolia, 5. Kyunghee University, 6. Mongolian Academy of Science

In the southern part of Mongolia, there are many lakes in the basin between mountain ranges, which is called “Valley of the Lakes”. These lakes experienced lake level fluctuations during the Quaternary period. This lake level variation is considered important information to understand climate change. The influx from the Khangai Mountains is a major source of water for the Valley of the Gobi lakes, a large southern basin. Olgoi lake is the research target of this study and locates closer to the summit of the Khangai mountain range than other lakes of Valley of the Gobi lakes, so it is highly likely that it reflects influx sensitively. A sediment core was collected from Olgoi lake to investigate the environmental change of the region. In this study, OSL dating of quartz was carried out to date core samples from Olgoi lake. This Core sample showed the age value of 0.7 to 10 ka covering the Holocene. In addition, it is suggested that the sedimentation of gravels, which is the most characteristic feature of the lower part of the Olgoi lake core sample, was related to the Holocene rapid temperature change events. There is a large gap in age values in this core sample at 7.5-9.0m. There is a high possibility that it reflects past sedimentary environment and even the climate, but I could not reach the final argument by the ages obtained in this research. To understand the complex transition of sedimentary environment of Olgoi lake, high resolution analyses of sediment characteristics and precise age control would be necessary.

Keywords: Mongolia, Lake sediment, OSL dating

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Paleo Lake level change in southern part of Mongolia

*Noriko Hasebe[1], Makoto Sambo[2], Uyangaa Udaanjargal[2,3], Shuukaaz Ganbat[3], Keisuke Fukushi[1], Yukiya Tanaka[4], Davaadorj Davaasuren[3]

1. Institute of Nature and Environmental Technology, Kanazawa University, 2. Department of Earth Sciences, Kanazawa University, 3. National University of Mongolia, 4. Kyunghee University

Lake Boontsagaan, Orog and Olgoy are located in the Valley of the Lakes, Gobi-Altai transition zone, which stretches from central to western Mongolia. This area suffers desertification probably due to the ongoing global worming and dried up lake sediments are worried as a source of contaminated sand storm. The flat surface in Valley of Lakes is covered with Quaternary lake sediments. Paleoshorelines are identified near the lakes. This study observed the sedimentary structures of the outcrops on the paleoshoreline and samples were collected to estimate the time when lake level was high by Quartz OSL dating method. The outcrop near the Ology, Boontsagaan, and Orog lakes are higher than the present lake level by 8 m, 15 m and 3 m, respectively.
The history of lake level change is proposed based on the age, altitude of the localities, and sedimentary structure of the outcrops. Data from Boontsagaan lake, for which coarse grains were analysed, scatter, therefore the youngest age component is extracted by plotting the data on the radial plot (Galbraith, 1988, Vermeesch, 2009). Ages from Boontsagaan Lake are around ~4-9 ka, while ages from Olgoy and Orog lakes are around ~1-2 ka. Because Boontsagaan Lake is larger and deeper than other lakes, its lake level change would be less active. Besides, relative height of the locality to the current lake level is higher then other two lakes. Therefore, the lake level was very high before ~5 ka, and relatively high at ~1-2 ka. The obtained results are consistent with previously reported data from the nearby sites (Lehmkuhl et al., 2018).

Keywords: Lake level change, OSL dating, Mongolia, Holocene

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Numerical modeling of wave propagation on the coral reef based on high resolution 3D topography

*Kenta Minamidate[1], Kazuhisa Goto[2], Masashi Watanabe[3,4], Volker Roeber[5,6], Ken Toguchi[7], Masami Sannoh[8], Yosuke Nakashima[9], Hironobu Kan[10]

1. Graduate School of Science, Tohoku University, 2. International Research Institute of Disaster Science (IRIDeS), Tohoku University, 3. Graduate School of Engineering, Tohoku University, 4. Graduate School of Science and Engineering, Chuo University, 5. Hawaii University, 6. Université de Pau et des Pays de l'Adour, 7. Ryukyu University, 8. Mikuniya Corporation, 9. NIT, Ariake College, 10. Graduate School of Integrated Sciences for Global Society, Kyushu University

Coral reefs commonly act as natural barrier against swell wave impact. Conventionally, reefs efficiently attenuate storm waves. However, recent studies have indicated that during energetic typhoon swells, generation of infragravity waves can lead to hazardous conditions where the reef does not act like a protecting barrier anymore. In order to know the wave behavior near and over the reef, high-resolution 3D topographic data is required for the numerical calculation. However, most of the previous studies result from one- or two-dimensional numerical calculations based on low-resolution topographic data. This is mainly due to the challenging environment for conducting bathymetry/topography surveys in the vicinity of the reef. Hence, it was difficult to discuss the wave processes under the influence of the microtopography. In this study, we developed high resolution and complete set of the 3D topographic data (girid size: 1 m) from land to about 95 m water depth at the east coast of Kudaka Island, Okinawa Prefecture (an area of approximately 3 ×5 km) by UAV topographic and multibeam bathymetric surveys. Based on the terrain data with 5 m mesh size, we conducted two-dimensional wave-by-wave calculations with the Boussinesq-type wave model, BOSZ. The results show that the deformation and propagation mechanisms of the waves near the reef are highly controlled by microtopography features such as the differences in slope angles and the presence of spurs and grooves.

Keywords: Wave, Storm wave, Coral reef, Multi-beam survey, UAV, Numerical simulation

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Coastal Seafloor Geomorphology: launching of a new field and perspectives

*Hironobu Kan[1], Nobuyuki Hori[2], Tatsuro Nakai[3], Yusuke Yokoyama[4], Kazuhiko Fujita[5], Hitoshi Hasegawa[3], Yosuke Nakashima[6], Kensaku Urata[1], Atsushi Suzuki[7], Masayuki Nagao[7], Kazuhisa Goto[8]

1. Graduate School of Integrated Sciences for Global Society, Kyushu University, 2. Emeritus Professor, Department of Geography, Tokyo Metropolitan University, 3. Department of Geography and Environmental Studies, Kokushikan University, 4. AORI, University of Tokyo, 5. Department of Physics and Earth Sciences, Faculty of Science, University of the Ryukyus, 6. National Institute of Technology, Ariake College, 7. Research Institute of Geology and Geoinformation, AIST, 8. IRIDeS, Tohoku University

The coastal seafloor at depths shallower than ~130 m was subjected to alternating subaerial erosion and sedimentation during Quaternary sea-level change. However, the coastal seafloor is rarely discussed in conventional geomorphology. Recently, the development of exploration technology such as multibeam echo sounder survey enables us to observe the accurate and detailed coastal seafloor geomorphology. In this presentation, we discuss the novelty and possibilities of coastal seafloor geomorphology based on case studies from around the world and research materials of our group.

Keywords: multibeam bathymetry, echo sounder, sea level change, shelf

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[J] Oral | H (Human Geosciences)：H-SC Social Earth Sciences & Civil/Urban System Sciences

Wed. May 29, 2019 9:00 AM - 10:30 AM JST | Wed. May 29, 2019 12:00 AM - 1:30 AM UTC | 301B 3F

[H-SC07] CCUS (Carbon Dioxide Capture, Utilization, and Storage) for Climate Mitigation

convener:Masao Sorai(Institute for Geo-Resources and Environment, National Institute of Advanced Industrial Science and Technology), Ziqiu Xue(Research Institute of Innovative Tech for the Earth), Masaatsu Aichi(Graduate School of Frontier Sciences, University of Tokyo), Chairperson:Masao Sorai(National Institute of Advanced Industrial Science and Technology)

The prevention of the global warming, which is the urgent challenge facing the world, requires the full-out efforts of science and technology. This session focuses on the CCUS (Carbon Dioxide Capture, Utilization, and Storage) as one of the useful countermeasures for the CO2 emission reduction. It not only targets various scientific phenomenon caused by the capture and storage of CO2, CO2 utilization, and CO2-EOR/EGR, but also discusses the latest R&D developments of each method for the environmental impact assessment, safety assessment, the measuring, monitoring and verification (MMV), and public acceptance. The main theme is the recognition of key issues toward the practical use of CCUS, in addition to the deepening of our knowledge about the CO2 behavior on the underground.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[HSC07-01] Numerical simulation of variational pore pressure response to ocean tidal loading during CO2 injection

*Toshifumi Akaki[1], Hajime Yamamoto[1] (1.Taisei Corporation)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[HSC07-02] Relationship between rock deformation and permeability evolution during fracturing in rocks for CCUS technology

*Takashi Fujii[1], Xinglin Lei[1], Masao Sorai[1] (1.National Institute of Advanced Industrial Science and Technology)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[HSC07-03] Comparison of Optical Fiber Sensing Technique and Strain Gauge in a Measurement of Rock Deformation Caused by Chemical Osmosis

*Shogo Hirota[1], Tomochika Tokunaga[1], Ziqiu Xue[2], Hyuck Park[2] (1.Department of Environmental Systems, Graduate School of Frontier Science, the University of Tokyo, 2.Research Institute of Innovative Technology for the Earth)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[HSC07-04] Experiment of precipitation of salt for dry-out condition caused by CO_2 storage in saline aquifer

*Hayato Morigaki[1,2], Masaatsu Aichi[1] (1.University of Tokyo, 2.Toshiba Energy Systems & Solution Corporation)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[HSC07-05] Thermodynamic Approach to Wettability of CO_2/Brine/Mineral System by Augmented Young Laplace Equation

*Masashige Shiga[1,2], Masao Sorai[1], Masaatsu Aichi[2], Hiromi Honda[2] (1.AIST, 2.The University of Tokyo)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[HSC07-06] A proposal of CO2 underground storage using hydrate

*Takaomi Tobase[1] (1.Electric Power Development Co., Ltd.)

Numerical simulation of variational pore pressure response to ocean tidal loading during CO2 injection

*Toshifumi Akaki[1], Hajime Yamamoto[1]

1. Taisei Corporation

As a promising measure against global warming, CCS (Carbon dioxide capture and storage) has been extensively studied over recent decades and some large-scale projects are currently in operation worldwide. Carbon dioxide is captured from flue gases emitted from large sources such as coal-fired power plant, and injected and kept stored in a deep geologic formation for long-term. In the geologic CO2 storage, reliable and cost-effective monitoring techniques of the injected CO2 need to be established. It is well known that the pore-pressure of groundwater is affected by the earth and ocean tides. Recently, at a geologic CO2 storage project, it has been reported that the pore-pressure fluctuation at a monitoring well is explained by diurnal earth tides, and the amplitude of the pressure fluctuation significantly attenuated when the carbon dioxide arrived at the well due to the changes in compressibility of pore fluid around the well (i.e. the compressibility of CO2 is much smaller than that of water). This suggests a potential low-cost CO2 monitoring technique through monitoring and analyzing tidal responses of pore pressure during geologic CO2 storage. The tidal response of pressure is understood as a hydro-geomechanical coupled phenomena in deformable porous media containing water and CO2. Previous studies indicated that the changes in amplitude of pore-pressure before and after CO2 arrival at a monitoring well can be simply explained by poroelasticity theory. However, numerical simulations are required to further quantitatively investigate the tidal effects on pressure fluctuation at monitoring wells during CO2 injection. For example, the pressure response is possibly affected by many geometrical and geological settings in three-dimensional space, such as distance between the monitoring wells and CO2 plume, geometry of CO2 plume, and pressure dissipation induced by fluid flow. In this study, we developed a numerical simulator in the framework of poromechanics to simulate three-dimensional deformations and stress changes of geological formations under two-phase flow conditions of water-CO2, which was enhanced to be adoptive to cyclic loading by diurnal and semi-diurnal tide. Using this simulator, we investigate variation of responses of pore water pressure to the ocean tide loading during CO2 injection. Amplitude of the response at injection well decrease during CO2 injection, and somewhat recovered due to upward movement of CO2 plume after injection. The final amplitude in this simulation is smaller than initial amplitude under water saturated condition due to an effect of CO2 plume staying top of the reservoir.

Keywords: Ocean tide, Carbon dioxide geologic storage, Numerical simulation

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Relationship between rock deformation and permeability evolution during fracturing in rocks for CCUS technology

*Takashi Fujii[1], Xinglin Lei[1], Masao Sorai[1]

1. National Institute of Advanced Industrial Science and Technology

An understanding of relationship between fluid flow transport and geo-mechanical response within geological reservoirs is of a fundamental concept for a suitable utilization of deep underground repositories (e.g., Carbon Capture and Storage (CCS), Carbon Capture Utilization and Storage (CCUS), shale gas exploration). Particularly, fracture permeability within caprocks plays an important role in producing hydrocarbon during the trapping of buoyant gas fluids in reservoirs for CCUS projects. Wide variations of permeability value depending on rock deformation (including fracturing process) for several types of rocks has been determined using the coupled fluid flow transport (TOUGH2) and geo-mechanical response (FLAC3D) simulator (e.g., Rutqvist et al., 2002) so far. However, the evolution of permeability during fracturing in such rocks is very complex, and there now are being reported few constitute law for the linked deformation and fracture permeability. Furthermore, few laboratory studies have experimentally been conducted so as to replicate this process by simultaneously fracturing specimens and measuring permeability at in situ fracturing stress states (Carey et al., 2015; Fujii et al., 2015; Frash et al., 2016).
The purpose of this study is to investigate experimentally permeability change during fracturing in (i) caprocks (shale, mudstone, slate) and (ii) reservoir rock (sandstone, tuff), the conditions of which assumes that CO_2 is injected into geological media. We attempt to fit a model to obtained experimental data (i.e., permeability: K, volumetric strain: e_v) in order to develop suitable constitute law for the optimize use of coupled geo-mechanics and fluid flow simulator.
Our results demonstrate that there could mainly be classified into the two patterns of relationship between e_v and K of all materials tested. Particularly, it is apparent that the permeability behavior throughout fracturing and slipping processes are quite different between rock groups of (i) and (ii). Caprocks have a sharp-jumped increase of permeability during fracturing in the rock matrix, but reservoir rocks have significantly smaller permeability change, compared to the caprocks in post-failure regime. Furthermore, model fitting results suggest that the relationship between e_v and K of all materials tested could be explained fully by modification of conventional model (e.g., Cappa et al., 2009)
In light of findings of our study, it can be concluded that the propsed constitute law might be contributed to the simplification and optimization of the coupled fluid flow and geomechanical simulator.

Keywords: rock deformation, fracture permeability, Constitute law

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Comparison of Optical Fiber Sensing Technique and Strain Gauge in a Measurement of Rock Deformation Caused by Chemical Osmosis

*Shogo Hirota[1], Tomochika Tokunaga[1], Ziqiu Xue[2], Hyuck Park[2]

1. Department of Environmental Systems, Graduate School of Frontier Science, the University of Tokyo, 2. Research Institute of Innovative Technology for the Earth

Mass transport and water flow in subsurface are generally considered to be much smaller than those on surface environment. Stability of subsurface environment is useful to isolate specific substances (e.g. CO_2 or high-level radioactive wastes) from human societies for a long time. For these purposes, argillaceous formations perform as effective seal layer because of its low permeability and smaller diffusion coefficient.

It is known that some argillaceous rocks show semipermeable membrane behavior, i.e., the process called chemical osmosis. Chemical osmosis causes water flow across semipermeable membrane driven by the gradient of osmotic pressure between two solutions (Marine and Fritz, 1981). Previous research showed that the pressure change caused by chemical osmosis can reach to about 20 MPa (Neuzil, 2000). Osmosis-induced pore pressure change can cause deformation of porous medium (Greenberg et al., 1973: Noy et al., 2004), however, the detailed discussion on the osmosis-induced deformation behavior of argillaceous rocks is still premature because of the difficulty for measuring multiple strain in the sample.

Generally, normal strain gauges by measuring the changes of the electrical resistance are used for laboratory-scale rock deformation experiments. Experiments for measuring deformation caused by chemical osmosis take a long time and drifts caused by water intrusion and/or delayed heat dissipation is considered to be the issue for the accurate measurements. Distributed optical fiber sensing (DOFS) is a technique for possibly avoiding the measurement drift. In DOFS measurement, the backscattering light is used to measure strains along the fiber, and DOFS can use entire optical fiber as a sensor, thus, strain behavior at multiple points along the optical fiber can be obtained.

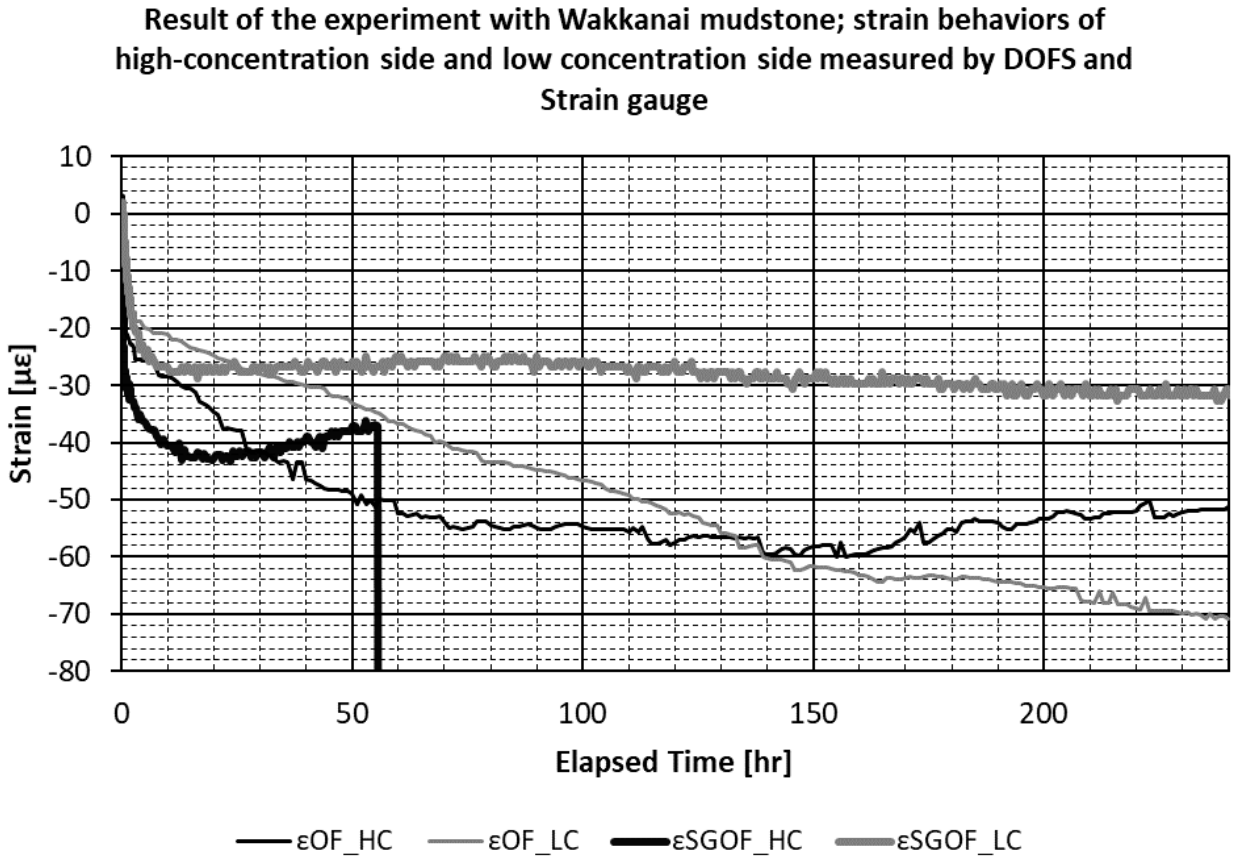
The purpose of this study is to investigate the applicability of both strain gauges and DOFS to the laboratory-scale chemical osmosis experiments through the comparison of both results, and to discuss the strain behavior of argillaceous rocks by chemical osmosis. In this experiment, core samples with the height of about 30mm and diameter of about 50mm made from mudstones collected from the Wakkanai Formation in Hokkaido prefecture and the Oganocho Formation in the Chichibu Basin, Saitama prefecture, were used. Strain gauges were attached to the sample, and axial and circumstantial strains near the both edges were measured. Optical fiber was attached helically to the sample, and the strains along the direction of the fiber were measured. The lateral and top surfaces of the specimen were sealed by silicon rubber to prevent water flow through these surfaces. In the experiment, the bottom surface of the sample was contacted to NaCl solution with 10g/L higher concentration than that of pore water, and osmotic flow was induced by the concentration gradient. The strains of the specimen caused by osmotic flow were measured by both DOFS and strain gauges. Temperature was kept almost constant throughout 240 hours by putting the apparatus into a box made with heat insulating material and the experimental room was controlled by air conditioner.

In the initial phase of the experiments, the strain behaviors measured by both strain gauges and DOFS showed a good agreement. Initial strain behavior characteristic to the poroelastic effect was found only in the measurement by strain gauges because of the much shorter sampling interval compared with that in

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DOFS. On the other hand, after 20 hours, strains measured by the strain gauges near the bottom of the sample, i.e., high-concentration side, started to increase while those measured by DOFS not. It is considered to be caused by the unstable behavior of strain gauges.

Keywords: Chemical osmosis, optical fiber sensing technique, argillaceous formation, poroelasticity



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Experiment of precipitation of salt for dry-out condition caused by CO_2 storage in saline aquifer

*Hayato Morigaki[1,2], Masaatsu Aichi[1]

1. University of Tokyo, 2. Toshiba Energy Systems & Solution Corporation

Since CO_2 is transported in dry condition to prevent corrosion of the press-in pipe, CO_2 injected into the saline aquifer may evaporate water and dry the formation. In this case, there is concern that the porosity and permeability of the reservoir will decrease due to salt precipitation and clogging. On the other hand, the influence of cap rock on the sealing ability has not been considered sufficiently.
In this study, in order to observe the state of salt precipitation while controlling the degree of drying, the experiment was carried out with humidity control to generate a suction of about 100 MPa using a thermo-hygrostat. In the experiment, the core sample with the side sealed and the brine reservoir attached at the bottom was placed in the humidity control space, and the water evaporation from the top of the core sample was measured and the precipitation of salt was observed. In addition, in the comparison between before and after this experiment, we also tried to evaluate the influence of semipermeable membrane performance of mudstone on the presence or absence of precipitation and change in salt concentration of brine in the reservoir. The salt concentration of the reservoir, which was assumed to be the saline aquifer, was set at 0.6 mol / L as seawater, and when experiments were conducted assuming that the brine saturated rock was exposed to dryness, it was confirmed that the flux of moisture did not change remarkably before and after salt precipitation on the muddy sandstone of the Otadai Formation, the mudstone of the Otadai Formation and the mudstone of Wakkanai Formation. Also, the salt transport inhibition due to the semipermeable membrane effect was not noticeable. This suggests it is not necessarily expected that the precipitation of salt by drying improves CO_2 shielding performance of cap rock.

Keywords: saline aquifer, salt precipitation, reflection coefficient

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Thermodynamic Approach to Wettability of CO_2/Brine/Mineral System by Augmented Young Laplace Equation

*Masashige Shiga[1,2], Masao Sorai[1], Masaatsu Aichi[2], Hiromi Honda[2]

1. AIST, 2. The University of Tokyo

CO_2 Geo-Sequestration (CGS)has been regarded as one of the most significant technologies to reduce the amount of CO_2 emissions into the atmosphere.

Sealing performance of the caprock in the geological formation is largely influenced by wettability which is evaluated by the contact angle of the CO_2/Brine/Mineral system.

A lot of researchers have measured the angles in various conditions (e.g. pressure, temperature, salinity, or types of minerals) by various methods.

However, the value and the trend of the contact angle have not been confirmed yet.

This is mainly because there are a lot of inconsistencies in the experimental data due to the difficulties of controlling the surface roughness or impurities.

In order to tackle this problem,we calculated the contact angle and studied the key factor to affect its value by using augmented Young Laplace equation in which a thickness of the film on the mineral substrate is considered as a thermodynamic variable.

Parameters of the interfacial properties were calculated by PhreeqC, which is a simulator performing a wide variety of aqueous geochemical calculations.

Keywords: CO2 Geo-Sequestration, Wettability, Contact Angle

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A proposal of CO2 underground storage using hydrate

*Takaomi Tobase[1]

1. Electric Power Development Co., Ltd.

There is a fact that methane exists naturally and stably in the form of hydrate (solid).
As natural analog with methane hydrate, form CO2 hydrate using gas hydrate mechanism based on temperature and pressure, propose that could also be applied to underground storage of CO2. The concepts of the CO2 hydrate storage are as follows.
(1) Injection liquid or supercritical CO2 in the storage layer.
(2) Injected CO2 moves above by a density difference, when temperature and pressure condition reached the domain that formed hydrate, make clogging in a pore (come to have seal function).
(3) CO2 becomes able to storage under layer of CO2 hydrate having seal function. (not need the cap rock as geological structure)
As a result of investigating the temperature in the surrounding sea area of Japan, we confirm that temperature and pressure condition to form CO2 hydrate in the underground of sea bottom. It is thought that very likely to be the CO2 hydrate storage.
Aquifer storage (including CO2-EOR) to have the cap rock as a method of the CO2 storage is popular. But if CO2 hydrate storage is realized, we can hope that contribute to right lot expansion of the CO2 storage.

Keywords: carbon storage, gas hydrate, seal function

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[J] Oral | H (Human Geosciences)：H-SC Social Earth Sciences & Civil/Urban System Sciences

Wed. May 29, 2019 10:45 AM - 12:15 PM JST | Wed. May 29, 2019 1:45 AM - 3:15 AM UTC | 301B 3F

[H-SC07] CCUS (Carbon Dioxide Capture, Utilization, and Storage) for Climate Mitigation

convener:Masao Sorai(Institute for Geo-Resources and Environment, National Institute of Advanced Industrial Science and Technology), Ziqiu Xue(Research Institute of Innovative Tech for the Earth), Masaatsu Aichi(Graduate School of Frontier Sciences, University of Tokyo), Chairperson:Ziqiu Xue(Research Institute of Innovative Technology for the Earth)

The prevention of the global warming, which is the urgent challenge facing the world, requires the full-out efforts of science and technology. This session focuses on the CCUS (Carbon Dioxide Capture, Utilization, and Storage) as one of the useful countermeasures for the CO2 emission reduction. It not only targets various scientific phenomenon caused by the capture and storage of CO2, CO2 utilization, and CO2-EOR/EGR, but also discusses the latest R&D developments of each method for the environmental impact assessment, safety assessment, the measuring, monitoring and verification (MMV), and public acceptance. The main theme is the recognition of key issues toward the practical use of CCUS, in addition to the deepening of our knowledge about the CO2 behavior on the underground.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[HSC07-07] CO_2 behavior simulation using large scale geological model

*Yuuki Shigeoka[1], Haruki Nishiyama[1], Hiroshi Kinoto[1], Takaomi Tobase[2], Takahiro Nakajima[3], Ziqiu Xue[3] (1.JP Business Survice Corporation, 2.Electric Power Development Co., Ltd., 3.Research Institute of Innovative Technology for the Earth)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[HSC07-08] **Monitoring hydromechanical responses in aquifer by distributed fiber-optic strain sensing: From lab to field**

*Yi Zhang[1,2], Ziqiu Xue[1,2], Tsutomu Hashimoto[1,2], Hyuck Park[1,2] (1.Geological Carbon dioxide Storage Technology Research Association, 2.Research Institute of Innovative Tech for the Earth)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[HSC07-09] **Field Testing of Hybrid Brillouin-Rayleigh Distributed Sensing System for Subsurface Water Injection Monitoring**

*Yankun Sun[1,2], Ziqiu Xue[1,2], Tsutomu Hashimoto[1,2], Xinglin Lei[3], Yi Zhang[1,2] (1.Geological Carbon Dioxide Storage Technology Research Association, 2.Research Institute of Innovative Technology for the Earth, 3.National Institute of Advanced Industrial Science and Technology)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[HSC07-10] Gravity monitoring using superconducting gravimeters near the seashore at the Tomakomai CCS demonstration site

*Hiroki Goto[1,2], Mituhiko Sugihara[1,2], Hiroshi Ikeda[3], Yuji Nishi[1,2], Tsuneo Ishido[1,2], Masao Sorai[1,2] (1.Geological Carbon Dioxide Storage Technology Research Association, 2.National Institute of Advanced Industrial Science and Technology, 3.University of Tsukuba)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[HSC07-11] Pilot test for microbubble CO_2 injection to reservoir in oil field - Test planning and preparation -

*Kazunori Nakagawa[1], Ryo Ueda[1], Masanori Nakano[1], Ziqiu Xue[2] (1.Japan Petroleum Exploration Co., Ltd., 2.Research Institute of Innovative Technology for the Earth)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[HSC07-12] Mechanisms inducing anomalously high pCO_2 without CO_2 leakage in coastal environment

*Yuji Watanabe[1,2], Keisuke Uchimoto[1,2], Makoto Nishimura[1,2], Saeko Mito[1,2], Ziqiu Xue[1,2] (1.Geological CO2 Storage Technology Research Association, 2.RITE)

CO_2 behavior simulation using large scale geological model

*Yuuki Shigeoka[1], Haruki Nishiyama[1], Hiroshi Kinoto[1], Takaomi Tobase[2], Takahiro Nakajima[3], Ziqiu Xue[3]

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Carbon Capture and Storage (CCS) is expected as a mitigation measure of climate change and global warming causing by the rise in atmospheric carbon dioxide (CO_2) concentration. CCS is a technology that can reduce the amount of CO_2 emissions from large point sources, such as electricity power plant, by separating and recovering CO_2 from atmosphere-releasing gas and storing it in the basement. Main items of reservoir evaluation are (1) evaluation of injection performance and (2) evaluation of storage capacity. In this research, the above two evaluation items were investigated by numerical analysis. Analysis module, TOUGH2-ECO2N which deals with multicomponent and multiphase fluid was used.

(1) Evaluation of injection performance
The influence of basic physical parameter (permeability and porosity) on the CO_2 injection performance of the reservoir layer was investigated. As a result, it has been found that permeability affects whole pressure level of the reservoir layer and porosity affects the slope of pressure rise. Furthermore, their influence on the long-term distribution range of pressure and CO_2 plume has been revealed clearly.

(2) Evaluation of storage capacity
The basic physical parameter of analysis model for the evaluation of the storage capacity was determined with history matching based on the monitoring and the prediction simulation of the pressure, which was conducted in the CCS project in Canada Quest. In order to reveal the factors affecting the storage capacity evaluation were carried out, case studies such as changing placement of injection wells, etc. It is expected that the findings from this study can contribute to the evaluation of the storage capacity, such as predicting pressure rise in the reservoir layer and distribution of CO_2 plume, and the helpful for enabling "reservoir management", such as arrangement of injection wells, number of wells, injection rate and time, and installation of a pressure relief well.

Keywords: Carbon dioxide Capture and Storage, TOUGH2, Large scale Reservoir Simulation

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Monitoring hydromechanical responses in aquifer by distributed fiber-optic strain sensing: From lab to field

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Pore fluids control deformation of porous media by the fluid-to-solid hydromechanical (HM) coupling in which a change in fluid pressure can modify the effective stress and deform the porous medium (Wang, 2000). The HM coupling mechanism provides a possibility that to understand aquifer characteristics and fluid activities during fluid extraction and/or injection operations, e.g., in geological CO_2 storage (GCS), by monitoring rock strain changes. We successfully measured such HM deformations using a high-resolution distributed fiber optic strain sensing (DFOSS) tool in both laboratory and field scale studies. From the DFOSS-obtained HM information, we are able to track the pressure impact zone, understand the permeability structure of the aquifer formation and identify the preferential flow layers. Moreover, we can track the fluid migration front during CO_2 displacing water and the mechanical response of CO_2 breaking through to a low-permeability layer or caprock. The application of DFOSS would be beneficial to guide the aquifer pressure management for safe GCS with prior or simultaneous water extraction (Buscheck et al., 2012).

Keywords: Distributed fiber-optic strain sensing, Aquifer test, Hydromechanical deformation, CO2 storage

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Field Testing of Hybrid Brillouin-Rayleigh Distributed Sensing System for Subsurface Water Injection Monitoring

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Massive fluid injections into underground formations inevitably alter stress state and even induce damaging earthquakes, so robust high-resolution monitoring technologies are urgent to track geomechanical behaviors of injected fluids. Here we present one of the first case studies demonstrating the use of distributed fiber optic sensing (DFOS) technique based on hybrid Brillouin-Rayleigh backscattering for well-based monitoring of geomechanical deformations induced by field water injection. Injection tests were conducted with different injection scenarios between injection well (230 m, IW #2) and 5.5 m away from fibered monitoring well (300 m, MW #1) deployed cable behind casing in Mobara, Japan. Geomechanical responses were real- time recorded using DFOS approach; the resulting strain profiles were used to capture fluid evolution behaviors; thus evidencing that induced strains significantly depend on injection rate, injection pressure and lithological heterogeneity using this approach. Concurrent borehole logging was utilized to detect injection-induced variation of near- wellbore formations, which results agreed reasonably well with DFOS readings. This field application of hybrid DFOS technology conclusively enables speedy improvement of finely monitoring subsurface geoscience engineering activities, such as CO_2 storage.

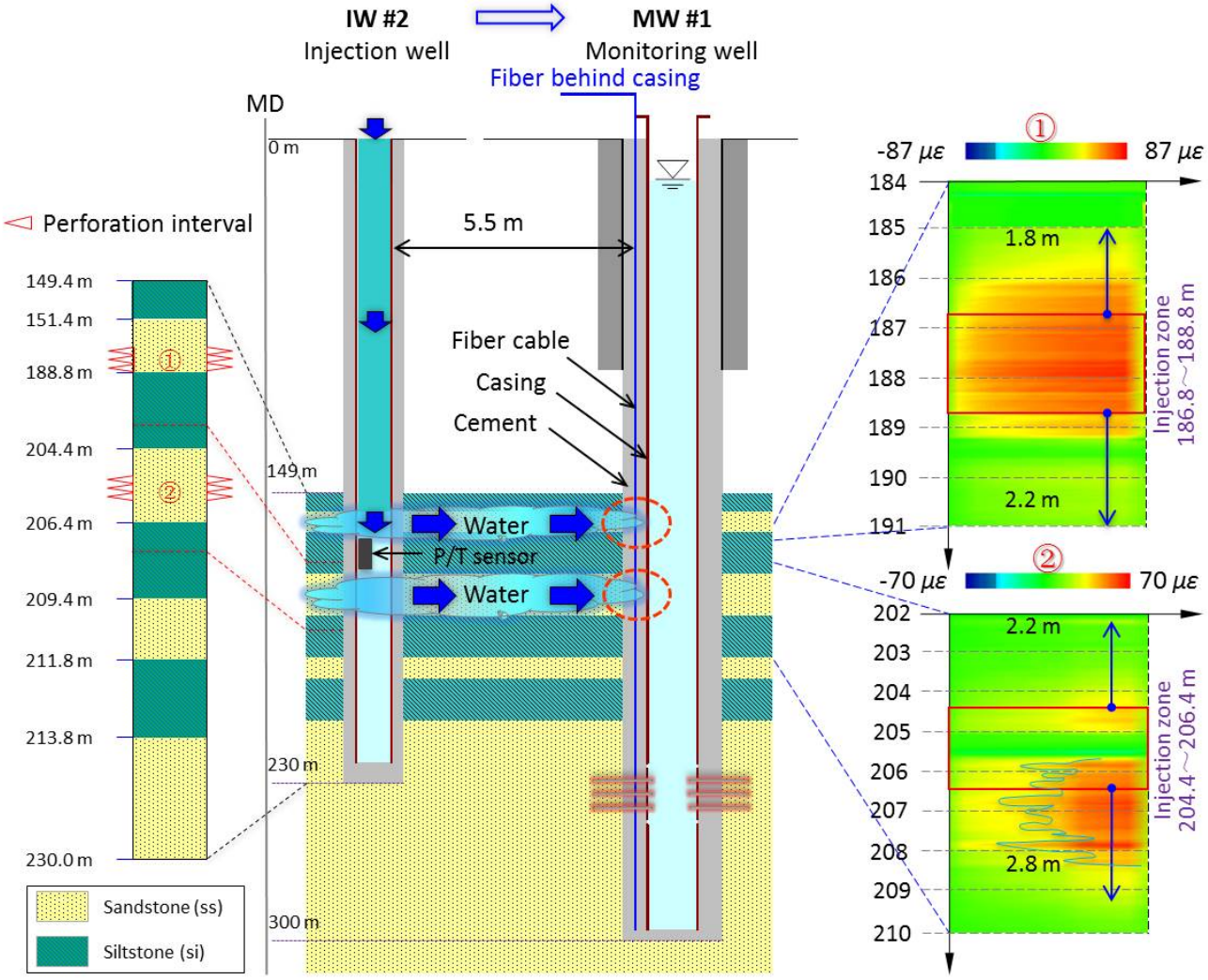
Based on this methodology, some conclusions in this study can be drawn below:
1. An advanced DFOS system based hybrid Brillouin-Rayleigh backscattering is successfully applied to real-time monitor water injection tests between two adjacent wells. Two different injection formations ① and ② are investigated.
2. Field testing demonstrates that induced geomechanical deformation (i.e., strain) is mainly dependent on injection volume rather than injection temperature, which has no significant effect on the strain changes.
3. Geomechanical deformations harmoniously emerge and eliminate with injection schemes, although the effect of packers on the strain profile results in slight emergency of strain leaps. The impacted zones expand along vertical direction beyond corresponding injection sections.
4. Formation heterogeneity results in lateral transport of injected water and its pressure propagation in the pore space. Compared with *V*sh -GR and BH, the lower *V*sh related to formation is easier for strain accumulation. In addition, although the impact acting on clay-rich formations is relatively small, the existence of shale just weakens the induced deformation intensity rather than completely stops the strain expansion.
5. According to open-hole resistively logs of IW and MW, simplified simulation result further confirms strong small-scale formation heterogeneity and discontinuities of shale-sand distribution in the injection formations.
6. Testing results also reveal that there are two main reasons accounting for vertical expansion of impacted zones during water injections. First reason is formation heterogeneity, which is quantified by open-hole resistivity logging and GR data, largely affecting fluid behaviors, including migration, evolution and diffusion in subsurface. Second reason is that due to poroelastic deformation, different injection scenarios can generate different injection pressure, which will ultimately lead to different geomechanical deformation responses and first-arrival pressure front patterns of injected water propagating to the

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fibered well.

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Sun, Y., Xue, Z., Hashimoto T., Zhang, Y., 2019. Hybrid Brillouin-Rayleigh Sensing System for Cross-well Monitoring Fluid Injection Tests—A Geomechanical Responses Perspective. *Water Resource Research.* (Under review).

Keywords: Distributed fiber optic sensing, Fluid injection and storage, Hybrid Brillouin-Rayleigh backscattering, Real-time monitoring, Strain responses, Geomechanical deformation



A schematic for fiber optic sensors deployment (left) and the mapped strain by the fiber optic cable (right).

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Gravity monitoring using superconducting gravimeters near the seashore at the Tomakomai CCS demonstration site

*Hiroki Goto[1,2], Mituhiko Sugihara[1,2], Hiroshi Ikeda[3], Yuji Nishi[1,2], Tsuneo Ishido[1,2], Masao Sorai[1,2]

1. Geological Carbon Dioxide Storage Technology Research Association, 2. National Institute of Advanced Industrial Science and Technology, 3. University of Tsukuba

Monitoring the distribution and migration of CO_2 injected into geological formations is needed for management of geological storage of CO_2. Superconducting gravimeters (SG’s) potentially enable monitoring of offshore CO_2 storage at ground-based stations because of its high precision. We conducted continuous gravity observations using SG’s near the seashore at the Tomakomai CCS (carbon dioxide capture and storage) demonstration site, Japan to study variation in the observed gravity near the seashore. The gravity data after correcting for tides, polar motion, and barometric pressure changes was strongly affected by shallow groundwater level changes but it was corrected by expressing their effects as a summation of linear functions of groundwater level changes. The standard deviation of the gravity residuals was reduced to less than 1 μGal after correcting for the groundwater effects. The small variation in the observed gravity residuals suggests that the ground-based gravity monitoring using SG's can be useful in long-term monitoring of offshore CO_2 storage.

Keywords: offshore CO2 geological storage, superconducting gravimeter, groundwater

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Pilot test for microbubble CO_2 injection to reservoir in oil field - Test planning and preparation -

*Kazunori Nakagawa[1], Ryo Ueda[1], Masanori Nakano[1], Ziqiu Xue[2]

1. Japan Petroleum Exploration Co., Ltd., 2. Research Institute of Innovative Technology for the Earth

In this study we have studied to evaluate the effect of microbubble CO_2 injection to CO_2 storage by core flooding test in laboratory and develop the tools for microbubble CO_2 injection in reservoir and we reached at the step which we plan to conduct the field pilot test in 2019.

We provide an introduction to the planning and preparation to the field pilot test for microbubble injection technology.
Summary of the pilot test
We plan to conduct this test at a part of oil field in Japan. This oil reservoir is consisted of the alternate layers of sand and mud and has high hetrogeneity which the advantage in the microbubble injection technology is expected. Huff' n Puff method will be applied in this test and pressure and flow rate at CO_2 injection and reproduction (flow back) from reservoir after CO_2 injection are measured as field test data. Two CO_2 injection tests, microbubble and normal injection are planned to estimate the effect of microbubble injection technology and behavior. Injected CO_2 volume is 100t at each test, microbubble and normal injection. Moreover, we construct the flow simulation model and estimate the microbubble CO_2 injection before and after field test.
preparation
We produced the tools for microbubble CO_2 injection in well based on prototype tools developed in this study and constructed facility which consisted of CO2 storage tank, CO2 injection pump and warming apparatus in test field.

Acknowledgements

This presentation is based on results obtained from a project commissioned by the New Energy and Industrial Technology Development Organization (NEDO) and the New Energy the Ministry of Economy, Trade and Industry (METI) and attributed to basic study for micro bubble CO_2 injection technology by Tokyo-gas Co., Ltd. and RITE. We deeply appreciate them.

Keywords: Geological CO2 Storage, microbubble, field test

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Mechanisms inducing anomalously high pCO_2 without CO_2 leakage in coastal environment

*Yuji Watanabe[1,2], Keisuke Uchimoto[1,2], Makoto Nishimura[1,2], Saeko Mito[1,2], Ziqiu Xue[1,2]

1. Geological CO2 Storage Technology Research Association, 2. RITE

When CO_2 is stored in sub-seabed geological formations in Japan, marine monitoring is mandatory to detect CO_2 leakage as soon as possible should it occur. In the Tomakomai CCS Demonstration Project, a threshold line based on a negative correlation between partial pressure of CO_2 (pCO_2) and dissolved Oxygen saturation in seawater is used to detect an anomalously high value of pCO_2, which is suspected to be a sign of CO_2 leakage. Although CO_2 leakage has never occurred in Tomakomai, pCO_2 values obtained in the monitoring have frequently exceeded the threshold line; that is, many false-positives have been produced. It is important to consider what can be causes of the false-positives. To discuss the causes, we analyzed data observed in the marine monitoring of the Tomakomai project, and meteorological data at Tomakomai. It is implied that weather conditions, such as wind speeds and precipitation, were related with false-positives. Also, we found that total alkalinity was remarkably low at a monitoring survey where many false-positives were observed. The low values of total alkalinity make pCO_2 values higher than usual, and consequently they might produce many false-positives. Based on the results, we are going to present how to avoid or reduce false-positives.

Keywords: Sub-seabed CO2 storage, Marine monitoring, CO2 leakage, pCO2, Total alkalinity

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[J] Oral | H (Human Geosciences)：H-DS Disaster geosciences

Wed. May 29, 2019 9:00 AM - 10:30 AM JST | Wed. May 29, 2019 12:00 AM - 1:30 AM UTC | Convention Hall B 2F

[H-DS13] Tsunami and Tsunami Forecast

convener:Naotaka YAMAMOTO CHIKASADA(National Research Institute for Earth Science and Disaster Resilience), Hiroaki Tsushima(Japan Meteorological Agency), Tatsuya Kubota(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Masaaki Minami(気象研究所), Naotaka Chikasada(National Res. Inst. for Earth Science and Disaster Resilience)

This session discusses issues related to improving real-time and long-term prediction accuracy of tsunami from earthquakes, landslides, and volcanoes, which include such as a better understanding of tsunami dynamics, new real-time tsunami observing systems deployed in the open ocean and coastal waters, methodologies of more rapid and accurate prediction during tsunami emergencies, more extensive and accurate inundation maps, and long-term tsunami potential forecast.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[HDS13-07] Functions of Real-time Tsunami Inundation Forecast System Using S-net Pressure Data

*Wataru Suzuki[1], Naotaka YAMAMOTO CHIKASADA[1], Takayuki Miyoshi[1], Shin Aoi[1] (1.National Research Institute for Earth Science and Disaster Resilience)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[HDS13-08] Improvement of Real-time Tsunami Forecast System for Outer-rise Earthquake

*Naotaka YAMAMOTO CHIKASADA[1], Toshitaka Baba[2] (1.NIED, 2.Tokushima University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[HDS13-09] Maximum tsunami height prediction using Ocean-Bottom Pressure Values based on Gaussian Process Regression

*Kotaro Takahashi[1], Kenjiro Kashiwabara[1], Yasuhiko Igarashi[1,2], Toshitaka Baba[3], Takane Hori[4], Masato Okada[1] (1.Graduate School of Frontier Sciences, The University of Tokyo, 2.Japan Science and Technology Agency PRESTO, 3.Institute of Technology and Science, The University of Tokushima, 4.Research and Development Center for Earthquake and Tsunami, Japan Agency for Marine-Earth Science and Technology)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[HDS13-10] Improvement for Finite-Difference Formula of Non-Linear Longwave Equations to Express Tsunami Decay

*Masaaki MINAMI[1] (1.Meteorological Research Institute)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[HDS13-11] Real time tsunami inundation forecast method developed for Central America Region

*Yuichiro Tanioka[1], Ulbert Gleb Grillo[2], Greyving Jose Argrello[2], Amilcar Cabrera[2] (1.Hokkaido University, Institute of Seismology and Volcanology, 2.Nicaraguan Institute of Territorial Studies, Nicaragua)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[HDS13-12] Near-fault observations of an offshore earthquake by DONET: Comparison of ocean bottom pressure gauges and strong-motion accelerometers

*Ayumu Mizutani[1], Kiyoshi Yomogida[1] (1.Natural History Science, Graduate School of Science, Hokkaido University, Earth and Planetary Dynamics)

Functions of Real-time Tsunami Inundation Forecast System Using S-net Pressure Data

*Wataru Suzuki[1], Naotaka YAMAMOTO CHIKASADA[1], Takayuki Miyoshi[1], Shin Aoi[1]

1. National Research Institute for Earth Science and Disaster Resilience

We have developed real-time tsunami inundation forecast system using S-net ocean bottom pressure data (Aoi et al., 2019, JDR). The forecast methodology of the system is mainly based on the multi-index method (Yamamoto et al., 2016, EPS) coupled with tsunami scenario bank (Chikasada et al., 2019, Technical Note NIED). In addition, the system has many functions to perform appropriate forecast considering a nature of the observed S-net pressure data, additional seismological data, regression targeted for specific region and alerting for tsunami without search for tsunami scenario bank. In this presentation, we introduce the developed forecast system focusing on these various functions.

The system has a redundancy and robustness in processing the observed S-net data by receiving the data from dual receiver with quality check. The pressure data are corrected for offset, band-pass filtered to extract the tsunami components. It was found that high waves due to typhoon or storm cause noises even in the ocean bottom pressure data and scenarios are selected by multi-index method. Therefore, the system does not make forecast information if no stations have larger amplitude than criterion value.

Forecast information, i.e., coastal tsunami heights and inundation depth distribution, is produced from the selected scenarios from the multi-index method by taking the maximum and average value of the selected scenarios. The scenario with the largest variance reduction between the observed and scenario data can be forecast information too. Standard deviation can be used to present the scattering of the forecast. As additional information, the system imposes the consistency with the hypocenter information on the selected scenarios by the multi-index method. This works well for the tsunamis generated at the edge or outside of S-net region. Moreover, most possible tsunami scenario for specific region can be derived from the selected scenarios in comparison with the forecast tsunami inundation depth at representative points based on neural network regression. The system also has functions to alert the tsunami by detecting the large pressure changes as well as using the tsunami warnings issued by the Japan Meteorological Agency. Detailed information based on the tsunami simulation based on 10-m mesh topography model is output for Kujukuri-Sotobo region of Chiba prefecture and rough and limited information is output from Ibaraki prefecture to Pacific coast of Hokkaido.

Acknowledgements: This work is partly supported by Council for Science, Technology and Innovation (CSTI), Cross-ministerial Strategic Innovation Promotion Program (SIP), “Enhancement of societal resiliency against natural disasters” (Funding agency: JST).

Keywords: Tsunami, Inundation, Real-time forecast, S-net

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Improvement of Real-time Tsunami Forecast System for Outer-rise Earthquake

*Naotaka YAMAMOTO CHIKASADA[1], Toshitaka Baba[2]

1. NIED, 2. Tokushima University

The outer-rise earthquakes often induce the behavior of the unusual tsunamis. For example, it induces an abnormally larger tsunami than expected from its seismic ground motion, called tsunami earthquake and/or contains short wavelength components produced by sea floor displacements caused by shallow depth fault slip. Additionally, the depressed wave usually arrives preceding the first elevated wave for the normal fault earthquake tsunamis. National Research Institute for Earth Science and Disaster Resilience (NIED) has developed real-time tsunami inundation forecasting method using real-time ocean bottom pressure data taken by the dense offshore observation network such as the Seafloor observation network for earthquakes and tsunamis (S-net) that has been constructed along the Japan Trench (Chikasada et al., 2019, Technical Report of NIED; Yamamoto et al., 2016, EPS). They calculated synthetic tsunami waveforms at the observation locations by solving nonlinear long-wave equations using a staggered leapfrog finite-difference scheme. A run-up boundary condition was applied to the coastal regions and an open boundary condition was applied to the rims of calculation region. But they did not consider about dispersive wave (Baba et al., 2017, Ocean Modeling) neither the attenuation effect of ocean bottom pressure changes (Chikasada et al., 2018, AGU).
Therefore, we reconsidered the effects of the dispersion term and the attenuation for a few thousands tsunami scenarios stored in the Tsunami Scenario Bank (TSB). As a result, we confirmed that these two effects possibly cause underestimation in real-time tsunami forecast. Therefore, we need to update waveforms calculated and registered for outer-rise earthquake into the TSB with a dispersion term. However, it is quite time-consuming task to solve non-linear long-wave equations with Boussinesq terms. In order to reduce calculation time, the linear long-wave equations with Boussinesq terms could be used to generate offshore synthetic waveforms. We considered the attenuation effect as well.
This work was partially supported by JSPS KAKENHI Grant Number JP15H05718 and JP18K04674.

Keywords: Tsunami, Outer-rise earthquake, Ocean bottom pressure observation

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Maximum tsunami height prediction using Ocean-Bottom Pressure Values based on Gaussian Process Regression

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1. Graduate School of Frontier Sciences, The University of Tokyo, 2. Japan Science and Technology Agency PRESTO, 3. Institute of Technology and Science, The University of Tokushima, 4. Research and Development Center for Earthquake and Tsunami, Japan Agency for Marine-Earth Science and Technology

Tsunami early warning systems using water pressure gauges operate around the world to cope with human damage caused by tsunami waves. The systems use a correlation between observed pressure gauges value around coast and tsunami height at prediction points near shore, based on prior insights such that tsunami height highly depends on the topography (bathymetry) during its propagation.

In predicting the tsunami height, it is important both to avoid underestimation for minimizing the damage and to increase accuracy for minimizing the evacuation cost. Takahashi et al. [2018] proposed a method making use of a database of the tsunami height and the observed pressure-gauge-values. While it is good at avoiding underestimation, it puts the prediction accuracy second; its prediction is likely to be highly overestimated. To improve the accuracy, Igarashi et al. [2016] proposed a method based on Gaussian Process regression, but it does not avoid underestimation. In this work, we extend the method by Igarashi et al. [2016], and proposed a prediction method with less underestimation and higher accuracy. We used pressure gauges data from the Dense Ocean-floor Network System for Earthquakes and Tsunamis (DONET) in the Nankai trough to investigate the prediction accuracy and the possibility of underestimation by our proposed method. Compared to the method by Takahashi et al. [2018], our method dropped the average prediction error from 4.44m to 1.61m, at the cost of an increase in the average underestimation rate of only 3.5%. Likewise, compared to the method by Igarashi et al. [2016],

our method dropped the average underestimation rate from 43.2% to 4.38%, at the cost of an increase in the average prediction error of only 0.84m. These facts prove the effectiveness of our method, which is good at making predictions with both little underestimation and high accuracy.

Keywords: Gaussian Process, Machine Learning, Disaster prevention, tsunami height prediction

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Improvement for Finite-Difference Formula of Non-Linear Longwave Equations to Express Tsunami Decay

*Masaaki MINAMI[1]

1. Meteorological Research Institute

In the current, we can not correctly express the decay process of the tsunami by numerical calculation. In the meantime, social demands for accurately expressing the tsunami decay are strengthening, for judging the timing of cancellation of the tsunami warning and information on the outlook of the tsunami. Therefore, at the Meteorological Research Institute, we are conducting research to improve the accuracy of the subsequent wave and decay process of the far-field tsunami and modeling of the decay process using observation waveforms (Hayashi et al., 2010, JSCE papers B2 (coastal engineering) etc.). We are conducting large-scale and highly accurate tsunami calculations using supercomputer using nonlinear longwave equations, which is a conventional tsunami numerical calculation method. (Minami et al., 2018, Japan Seismological Society Autumn Meeting etc.) Nevertheless, the decay process of the tsunami was not correctly expressed like the results of various calculations so far.

In this paper, we focused on bottom friction of tsunamis, which is an important factor in decay, and improved the differential formula of nonlinear longwave equations. First, in the friction term in the equation, the position difference of the total water depth (D) for calculating the friction term has been calculated as the arithmetic mean of the two adjacent meshes (central difference). If you use arithmetic averaging, there is a possibility that non-negligible errors may occur compared to when solving continuously. This is because D changes in the friction term on the order of -1/3. Therefore, the positional difference was improved to the one using the average value theorem (fig1). Furthermore, with regard to the time difference, assuming that dt is dt/n within one calculation step dt seconds and assuming that the calculation is repeated n times, it is possible to take the limit at $n \rightarrow \infty$, and the difference expression can be transformed as shown in fig 2.

Using these improved difference formula and appropriate coefficients, we calculated in the case of the 2010 Chile earthquake tsunami (Mw 8.8), and as a result its deay is larger than the conventional formula. In the example of fig3, the total energy amount of the later part, which became larger than the observation amount, decreased by about 4% and approached the observation amount. As a calculation condition of the tsunami, all areas including the entire Pacific Ocean (E100° to W90°) are assumed to be 30 seconds mesh (GEBCO 30 sec-grid), and in the area surrounding Hokkaido, Honshu, Shikoku and Kyushu, nesting is performed with a 10 second mesh, and we calculated for a long time (72 hours) in order to see the decay process. For the calculation we use JAGURS (Baba et al., 2015) , considering the elastic loading of the crust and the density effect of seawater, and using the result of the fault parameter (Fujii & Satake, 2013).

By using this formula, the decay of the tsunami becomes larger than the conventional formula by about 5%, and it is 10% or more in large case when the total depth D is small (generally less than 1 m) such as run-up and exposure. Also, by improving the time difference, it is possible to take longer time steps and it is possible to shorten the calculation time.

Although the decay process of the tsunami was not correctly expressed by the previous numerical calculation, it became possible to express the decay process more correctly by this method. In the future,

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we will continue to study this method and apply this method to various cases to improve the accuracy of the tsunami decay process.

Keywords: Far-field tsunami, Numerical simulation, Supercomputer

$$gn^2\left(\frac{D_{i,j}^k+D_{i+1,j}^k}{2}\right)^{-7/3}\frac{M_{i+1/2,j}^{k+1/2}+M_{i+1/2,j}^{k-1/2}}{2}\sqrt{(M_{i+1/2,j}^{k-1/2})^2+(N_{i+1/2,j}^{k-1/2})^2}$$

$$\downarrow$$

$$gn^2\frac{3}{2}\frac{(D_{i+1,j}^k)^{\frac{2}{3}}-(D_{i,j}^k)^{\frac{2}{3}}}{D_{i+1,j}^k-D_{i,j}^k}\left(\frac{D_{i,j}^k+D_{i+1,j}^k}{2}\right)^{-2}\frac{M_{i+1/2,j}^{k+1/2}+M_{i+1/2,j}^{k-1/2}}{2}\sqrt{(M_{i+1/2,j}^{k-1/2})^2+(N_{i+1/2,j}^{k-1/2})^2}$$

fig1. Bottom Friction Term Using Mean Value Theorem

Conventional difference formula is

$$\mathrm{M_new(i,j)}=(\mathrm{M'\ (i,j)}-\frac{1}{2}\mathrm{fric}*\mathrm{M_old(i,j)})\ /\ (1+\frac{1}{2}\mathrm{fric})$$

$$\mathrm{M'\ (i,j)=M_old(i,j)-(gravity\ term)-(advection\ term)}$$

$$\mathrm{fric=dt\cdot g\cdot n\hat{}2\cdot D\hat{}-7/3\cdot \bar{M}}$$

solving n times

$$\begin{cases}\mathrm{M_{1/n}(i,j)}=\mathrm{M'(i,j)}-\frac{1}{n}*\mathrm{fric}*\mathrm{M_old(i,j)}\\ \mathrm{M_{2/n}(i,j)}=\mathrm{M_{1/n}(i,j)}-\frac{1}{n}*\mathrm{fric}*\mathrm{M_{1/n}(i,j)}\\ \vdots\\ \mathrm{M_{n/n}(i,j)}=\mathrm{M_{n-1/n}(i,j)}-\frac{1}{n}*\mathrm{fric}*\mathrm{M_{n-1/n}(i,j)}\end{cases}$$

$$\mathrm{M_new(i,j)}=(\mathrm{M'(i,j)}-\tfrac{1}{n}*\mathrm{fric}*\mathrm{M_old(i,j)})\cdot(1-\tfrac{\mathrm{fric}}{n})^{n-1}$$

$$n\to\infty,\ (1\text{-}a/n)\hat{}n=\exp(-a)$$

$$\mathrm{M_new(i,j)}=\mathrm{M'(i,j)}\cdot\exp(-\mathrm{fric})$$

fig2. Bottom Friction Term Using Limit of a function

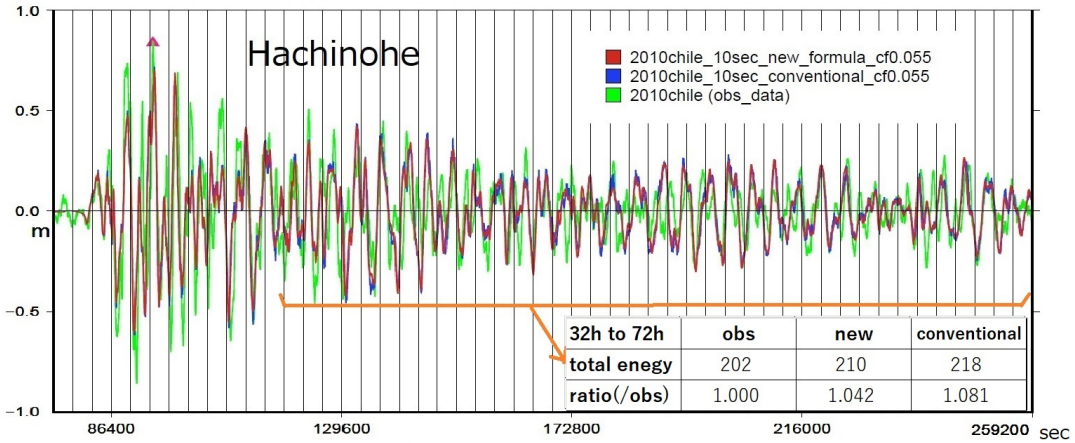


fig3. Time Series of Comparisons between New and Conventional Formula

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Real time tsunami inundation forecast method developed for Central America Region

*Yuichiro Tanioka[1], Ulbert Gleb Grillo[2], Greyving Jose Argrello[2], Amilcar Cabrera[2]

1. Hokkaido University, Institute of Seismology and Volcanology, 2. Nicaraguan Institute of Territorial Studies, Nicaragua

In 1992, the Nicaragua tsunami earthquake generated a large tsunami which caused a significant disaster along the coast. In Central America, it has been an issue to develop a tsunami warning system which can manage a tsunami earthquake such as the 1992 Nicaragua earthquake. Recently, the Intergovernmental Oceanographic Commission of UNESCO (IOC/USESCO) decided to make the Central America Tsunami Advisory Center (CATAC) in Nicaragua. Therefore, Japan International Cooperation Agency (JICA) with Japan Meteorological Agency (JMA) run a technical program to support the establishment of CATAC. In this paper, we develop a tsunami inundation forecast method for CATAC which can manage a tsunami earthquake.

First, we previously developed the method to appropriately estimate the source model (Tanioka et al., 2017). The technique was tested for four large earthquakes, the 1992 Nicaragua tsunami earthquake (Mw7.7), the 2001 El Salvador earthquake (Mw7.7), the 2004 El Astillero earthquake (Mw7.0), and the 2012 El Salvador-Nicaragua earthquake (Mw7.3), which occurred off Central America. At first, fault parameters were estimated from the W-phase inversion. Then the fault length and width were determined from scaling relationships. To estimate a slip amount, we constructed a depth dependent rigidity curve, similar to that suggested by Bilek and Lay (1999). The curve with a central depth estimated by the W-phase inversion was used to calculate the slip amount of the fault model. Using that slip amount, the tsunami numerical simulation with inundations was carried out. The result indicated that the observed tsunami heights, run-up heights, and inundation areas for the 1992 Nicaragua tsunami earthquake were well explained by the computed one. The other tsunamis from the other large earthquakes were also reasonably well explained by the computed ones.

In this paper, we applied the near-field tsunami forecast method (NearTIF) using a data base (Gusman et al., 2014) by computing a tsunami from the appropriate fault model which estimated in the above. First, we built a data-base which contained tsunami waveforms at several reference points for each region and inundation results at 6 regions, Gulf of Fonseca, Corinto, Puerto Sandino, El Transito, Masachapa,El Astillero, along the Pacific coast of the Central America. We put source models of Mw7.0, 7.2, 7.4, 7.6, 7.8, 8.0, 8.2 along the subduction interface. Totally, 135 source models are in the data base. The best tsunami inundation distribution for the forecast will be chosen by comparing the tsunami waveforms at the reference points computed in a real time with the tsunami waveforms at those points in the data base. Nest, the method is applied for the 1992 Nicaragua tsunami earthquake case. The source model for the 1992 Nicaragua earthquake was previously estimated from the W-phase inversion with the scaling relationship. The slip amount is estimated using the depth dependent rigidity curve. The tsunami forecast result shows that the observed tsunami heights, run-up heights, and inundation areas are reasonably well explained by the tsunami forecasted inundation map. The method developed in this paper should be useful for the tsunami early warning system at CATAC.

Keywords: Real time tsunami inundation forecast, Nicaragua, CATAC

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Near-fault observations of an offshore earthquake by DONET: Comparison of ocean bottom pressure gauges and strong-motion accelerometers

*Ayumu Mizutani[1], Kiyoshi Yomogida[1]

1. Natural History Science, Graduate School of Science, Hokkaido University, Earth and Planetary Dynamics

New ocean-bottom networks for earthquakes and tsunami such as S-net and DONET have been recently deployed in the offshore Japan. One important feature of these networks is that seismometers and ocean bottom pressure (OBP) gauges are installed at the same sites. Tsunamis are designed to be recorded in terms of water pressure changes. During an earthquake, the water pressure near its fault area changes not only by tsunamis (i.e., sea surface heights) but also by water depth change of instruments themselves, vertical accelerations of a seafloor itself (i.e., reaction force from water column), and the seismic waves radiated (including ocean acoustic waves) (e.g. Saito and Tsushima, 2016).

In this study, we analyzed the OBP and strong-motion accelerogram records provided by DONET1 that associated with the 2016 Off-Mie earthquake (Mw 6). First, we compared the pressure records in the forms of acceleration, velocity and displacement recorded in strong-motion accelerograms. Velocity and displacement records were calculated by integrations of accelerometer seismograms. Because a simple integration leads to unreasonable results, we conducted the baseline correction by the method based on Iwan et al. (1985). Second, we estimated tsunami heights at stations near the fault in near real-time basis, using the records of OBPs and accelerograms combined.

We obtained the following results by these comparisons: (1) the pressure change proportional to ocean-bottom velocity especially for each first motion, (2) in contrast, at around 0.1Hz, the pressure proportional to ocean-bottom acceleration at some stations, and (3) during the coseismic period, the effect of displacement not contributing to the pressure change at the same site. (1) and (2) are consistent with the numerical simulations by Saito (2017).

Next, we removed the effect of accelerations using 0.05-0.1Hz band-pass filter from the OBP records that were processed by 0.1Hz low-pass filtering, enabling us to extract tsunami and displacement signals at 10s intervals. The resulted waveforms are matched well with 0.01Hz low-pass filtered OBP records, suggesting that this method would be useful for tsunami early warning with near-fault combined records of OBP and accelerograms.

Keywords: DONET, tsunami

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[J] Oral | H (Human Geosciences)：H-DS Disaster geosciences

Wed. May 29, 2019 10:45 AM - 12:15 PM JST | Wed. May 29, 2019 1:45 AM - 3:15 AM UTC | Convention Hall B 2F

[H-DS13] Tsunami and Tsunami Forecast

convener:Naotaka YAMAMOTO CHIKASADA(National Research Institute for Earth Science and Disaster Resilience), Hiroaki Tsushima(Japan Meteorological Agency), Tatsuya Kubota(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Kentaro Imai, Toshitaka Baba(Graduate School of Science and Technology, Tokushima University)

This session discusses issues related to improving real-time and long-term prediction accuracy of tsunami from earthquakes, landslides, and volcanoes, which include such as a better understanding of tsunami dynamics, new real-time tsunami observing systems deployed in the open ocean and coastal waters, methodologies of more rapid and accurate prediction during tsunami emergencies, more extensive and accurate inundation maps, and long-term tsunami potential forecast.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[HDS13-13] Investigation of variation in multiple tsunami inundation modelling

*Yoshinori Shigihara[1], Kentaro Imai[2], Hiroyuki Iwase[3], Koji Kawasaki[4], Makoto Nemoto[5], Toshitaka Baba[6], Naotaka YAMAMOTO CHIKASADA[7], Yu Chida[8], Taro Arikawa[9] (1.Department of Civil and Environmental Engineering, National Dedense Academy, 2.Japan Agency for Marine-Earth Science and Technology, 3.Ecoh Corporation, 4.Hydro Technology Institute, Co., Ltd., 5.OYO Corporation, 6.Graduate School of Science and Technology, Tokushima University, 7.National Research Institute for Earth Science and Disaster Resilience, 8.Port and Airport Research Institute, 9.Civil and Environmental Engineering, Faculty of Science and Engineering, Chuo University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[HDS13-14] Numerical Modeling of Tsunami Inundation in Urban Area using Sub-Grid Scale Drag Force Model

*Nobuki Fukui[1], Nobuhito Mori[2] (1.Graduate School of Engineering, Kyoto University, 2.Disaster Prevention Research Institute, Kyoto University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[HDS13-15] Numerical experiment of tsunami deposits related to fault parameters by sediment transport model

*Ako YAMAMOTO[1], Tomoyuki Takahashi[2], Kenji Harada[3] (1.Forest of Research and Management Organization Forestry and Forest Products Research Institute, 2.Kansai University, 3.Shizuoka University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[HDS13-16] Evaluation of potential impact of tsunami-induced sediment transport in Kochi Prefecture during the Nankai Trough megathrust earthquake and tsunami

*Kei Yamashita[1], Daisuke Sugawara[2], Shuji Seto[1], Taro Arikawa[3], Tomoyuki Takahashi[4], Fumihiko Imamura[1] (1.International Research Institute of Disaster Science, Tohoku University, 2.Museum of Natural and Environmental History, Shizuoka, 3.Faculty of Science and Engineering , Chuo University, 4.Faculty of Societal Safety Sciences, Kansai University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[HDS13-17] Tsunami damage of the Keicho Earthquake of February 3rd, 1605 on the coasts of Tokai, Shikoku, and Kyushu Districts

*Yoshinobu Tsuji[1], Kentaro Imai[2], Yuuichi Ebina[3], Hiroyuki Iwase[4], Ryoko Oobayashi[2] (1.Shimanto City, 2.JAMSTEC, 3.IRIDeS, 4.Ecoh co. LTD)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[HDS13-18] Re-examination of tsunami heights distribution during the 1854 Ansei Tokai Earthquake

*Kentaro Imai[1], ebina yuichi[2], Yoshinobu Tsuji[3], Hiroyuki Iwase[4], Takane Hori[1], Narumi Takahashi[1,5], Takashi Furumura[6] (1.Japan Agency for Marine-Earth Science and Technology, 2.International Research Institute of Disaster Science, 3.Shimanto City, 4.ECOH CORPORATION, 5.National Research Institute for Earth Science and Disaster Resilience, 6.Earthquake Research Institute The University of Tokyo)

Investigation of variation in multiple tsunami inundation modelling

*Yoshinori Shigihara[1], Kentaro Imai[2], Hiroyuki Iwase[3], Koji Kawasaki[4], Makoto Nemoto[5], Toshitaka Baba[6], Naotaka YAMAMOTO CHIKASADA[7], Yu Chida[8], Taro Arikawa[9]

1. Department of Civil and Environmental Engineering, National Dedense Academy, 2. Japan Agency for Marine-Earth Science and Technology, 3. Ecoh Corporation, 4. Hydro Technology Institute, Co., Ltd., 5. OYO Corporation, 6. Graduate School of Science and Technology, Tokushima University, 7. National Research Institute for Earth Science and Disaster Resilience, 8. Port and Airport Research Institute, 9. Civil and Environmental Engineering, Faculty of Science and Engineering, Chuo University

Many researchers have developed numerical models based on the nonlinear shallow water equations to estimate the propagation and inundation of tsunamis. Several models have been distributed as the software packages including source code, thus tsunami inundation simulation can be performed easily with bathymetric and topographic data available free. However, the tsunami modelling researchers also empirically understand that no tsunami simulation results agree perfectly with that of other research institutes even if the same numerical model is used. The maximum inundation depth, flow velocity and inundated area are different to a certain extent. To clarify the variation in tsunami simulation is very important to establish the standard method that confirm the reliability of tsunami inundation models and it will be useful for the tsunami countermeasure/mitigation planning.

The present study aims to evaluate magnitude of the variation in tsunami inundation simulation quantitatively. We conducted tsunami simulations under the same input data: the initial source model of tsunami, bathymetry, topography and land-use model provided by Cabinet Office, Government of Japan are adopted. A total of eight research institutes participated this project using four kinds of numerical models that are widely employed for the tsunami hazard/risk assessment. Comparison of the time history of water surface elevation and flow velocity at the specific points indicated that a significant difference was confirmed among the model results to the maximum value of physical quantities. The spatial distribution maps of the maximum inundation depth also showed that large variation occurs around the front of tsunami run-up. In order to explain the variation in tsunami inundation model quantitatively, the total flooded volume and the total momentum flux were newly defined. By statistical procedures using these variables, we were able to show the mean value, confidence interval and coefficient of variation of the tsunami inundation models.

Keywords: tsunami, numerical model, variation

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Numerical Modeling of Tsunami Inundation in Urban Area using Sub-Grid Scale Drag Force Model

*Nobuki Fukui[1], Nobuhito Mori[2]

1. Graduate School of Engineering, Kyoto University, 2. Disaster Prevention Research Institute, Kyoto University

Numerical simulation of tsunami inundation using high-resolution topography (resolution is less than 1m) needs to consider the effect of structures on wave run-up. However, numerical simulation with medium resolution (resolution over 50m to 100m) is still important for practical use due to computational cost. This study developed Drag Force Model (DFM) and individual Drag Force Model (iDFM) as an urban roughness parameterization to obtain acceptable accuracy in medium resolution tsunami inundation model based on physical modeling. The model treats the effect of structures as grid-averaged drag force and projected area in x and y-direction in Cartesian coordinate and characteristic structure height are used as parameters representing the sub-grid scale structure. Furthermore, iDFM considers the number of structures and structure height in the area of interests individually. The edge detection technology for image processing tool is used to count the number of structures. Moreover, various mesh size 10cm to 40cm (25m to 100m in real scale) are used to check mesh size dependency. The validation DFM and iDFM is conducted using numerical simulation and physical modeling of tsunami inundation targeting available tsunami inundation experiments.

Keywords: tsunami, bottom roughness, drag force

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Numerical experiment of tsunami deposits related to fault parameters by sediment transport model

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1. Forest of Research and Management Organization Forestry and Forest Products Research Institute, 2. Kansai University, 3. Shizuoka University

Large tsunamis cause extensive damage to coastal areas. Underestimation of the tsunami risk can increase the extent of damage and delay reconstruction. To improve tsunami estimation requires review of many records of tsunami cycles and sources (i.e., geologic faults). Sand deposits from tsunamis provide many paleo tsunami records; however, the relationship between tsunami sand deposits and the magnitude of tsunamis is not understood. Takahashi et al. (1999) proposed a sediment transport model for tsunamis. This model was adapted using data from the 1960 Chilean tsunami in Kesennuma Bay, although the amount of sand transportation was underestimated due to the local topography. Takahashi et al. (2011) improved the model based on a hydraulic experiment using three types of sand grains, although verification using other grain sizes and mixed sand compositions has not been conducted. Furthermore, numerical analysis focusing on tsunami sand deposits in inundation areas has fewer verification examples. Yamamoto et al. (2017, 2018) carried out a hydraulic experiment to validate the sediment transport model. This experiment used three types of sand grains, which had sizes different from those used by Takahashi et al. (2011). The model of Takahashi et al. (2011) was confirmed to be very accurate for medium sand. However, the relationship between the tsunami sand deposits and fault parameters has not been verified.

To clarify the relation between tsunami sand deposits and fault parameters, we carried out numerical experiments of sediment transport in a simple topography. The numerical experiments consisted of two steps. The first step investigated the influence of fault conditions on the tsunami waveform. The fault condition was changed according to fault width, length, slip, and position. The waveform observed in this experiment was used as the boundary condition for the second step of the experiment. The second step investigated the effect of the tsunami waveform on the sand deposits in the land area. The topography conditions were changed by changing the slope of the sea area and land area. Furthermore, we investigated the effect of setting a structure in the land area on the sand deposits. Numerical experiments confirmed the points at which the nature of sediment deposits changes according to fault and topography conditions.

Keywords: Tsunami deposit, Numerical experiment, Fault parameter

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Evaluation of potential impact of tsunami-induced sediment transport in Kochi Prefecture during the Nankai Trough megathrust earthquake and tsunami

*Kei Yamashita[1], Daisuke Sugawara[2], Shuji Seto[1], Taro Arikawa[3], Tomoyuki Takahashi[4], Fumihiko Imamura[1]

1. International Research Institute of Disaster Science, Tohoku University, 2. Museum of Natural and Environmental History, Shizuoka, 3. Faculty of Science and Engineering , Chuo University, 4. Faculty of Societal Safety Sciences, Kansai University

Introduction

Strong flows due to giant tsunamis may cause large-scale sediment erosion, deposition and resulting morphological changes in coastal areas, in which sometimes alter the nature and size of tsunami hazards (e.g., Sugawara, 2017). The tsunamis flow loaded with a large amount of sediments possesses an increased hydrodynamic force, which causes not only loss of lives and properties but also incidental injuries to human healths, such as “Tsunami lung”. Flush-out of coastal sediments into deeper sea often cause irreversible changes in sandy beaches, on which post-tsunami natural coastal processes may form an altered beach morphology. Sediment deposition on lands and shallow waters hampers not only emergent rescue and support, but also post-disaster recovery and reconstruction. Environmental pollutions due to chemical elements in sludge deposits are additional consequences of the tsunami-induced sediment transport.

In 2012, the Cabinet Office of Japan updated the tsunami risk assessment of the Nankai Trough earthquake and tsunami. However, influences of the sediment transport have not been included quantitatively in the tsunami scenarios. In this study, numerical simulations of tsunami sediment transport caused by the Nankai Trough earthquake have been performed to investigate the potential impacts of sediment erosion, deposition and morphological change in Tosa Bay, Kochi Prefecture, where severest damages are presumed by the Case 4 of the assessment of the Nankai Trough earthquake.

Numerical Calculation Methods

The tsunami sediment transport model (STM) proposed by Takahashi et al. (1999) was used. The STM takes into account exchange of bed- and suspended loads, in which parameters of the transport formula depend on the grain size of the sediment. Computational region covers a wide area of Tosa Bay including Kure Bay in Takaoka-gun to Hane Cape in Muroto City. To assess the uncertainties due to the grain size, three types of median size d_{50} were assumed, i.e., d_{50} = 0.127, 0.267 and 0.394 mm.

Results and Discussion

The numerical simulations demonstrated that in the mouths of class A (Niyodo and Mononobe) and B

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(Shinjo, Aki, Ioki and Nahari) rivers, strong flows caused severe erosion greater than 10 m in depth, regardless of the choice of the grain size. A large amount of the sediments were flushed out to the offshore zone deeper than the wave base. In addition, extensive sediment deposition occurred on the lands neighborhood of the class A rivers. For example, deposit thickness near Niyodo River was as large as 1 m. Note that thickness of known paleotsunami deposits in this area is much smaller than the simulations. Further comparison of the field data and modeling results is needed to examine the assumptions of the size of the Nankai Trough earthquake. Based on the findings from the 2011 Tohoku tsunami, averaged deposit thickness is estimated at 4-5 cm. Choice of the grain size caused variations of the averaged deposit thickness ranging from 4.2 to 11.3 cm.

Sediment erosion and deposition were significant around harbors and bays along the coast. Bottom sediments of the mouth and inner part of Susaki Bay were eroded and that the sediments were deposited over a wide area of Susaki City. However, the simulated thickness of the deposit on Ikenouchi area including Tadasu-ike was quite thin compared to the paleotsunami deposits (Okamura and Matsuoka, 2012). Coastal defenses and changes in the land use might have affected to the difference between the deposits. In the mouth of Usa and Urado Bays, the simulations showed that part of the sediments were transported to the land near the source meanwhile most sediments were deposited on the seaward the bay mouth and the head of the bay.

The simulated morphological changes became larger with decreasing grain size. Increase in the maximum inundation heights was 2 and 1 m for d_{50} = 0.127 and 0.394 mm, respectively. In some of the investigated areas (i.e., Geisei-mura), effect of the morphological change to the inundation height was totally different. These results imply importance of sediment transport modeling for regional tsunami hazard assessments.

Conclusions

In Kochi Prefecture, tsunami-induced sediment transport may cause not only large-scale morphological changes of the coasts but also increase in tsunami hazards. Note that the influences of the sediment transport depend significantly on uncertainties in bed materials. Acquisition of detailed sedimentary data will benefit improved assessment of impacts from tsunamis. Further discussions are needed regarding countermeasures to tsunami hazards considering the regional characteristics of tsunami-induced sediment transport.

Keywords: tsunami-induced sediment transport, Nankai Trough earthquake and tsunami, Kochi Prefecture, Numerical simulation

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Tsunami damage of the Keicho Earthquake of February 3rd, 1605 on the coasts of Tokai, Shikoku, and Kyushu Districts

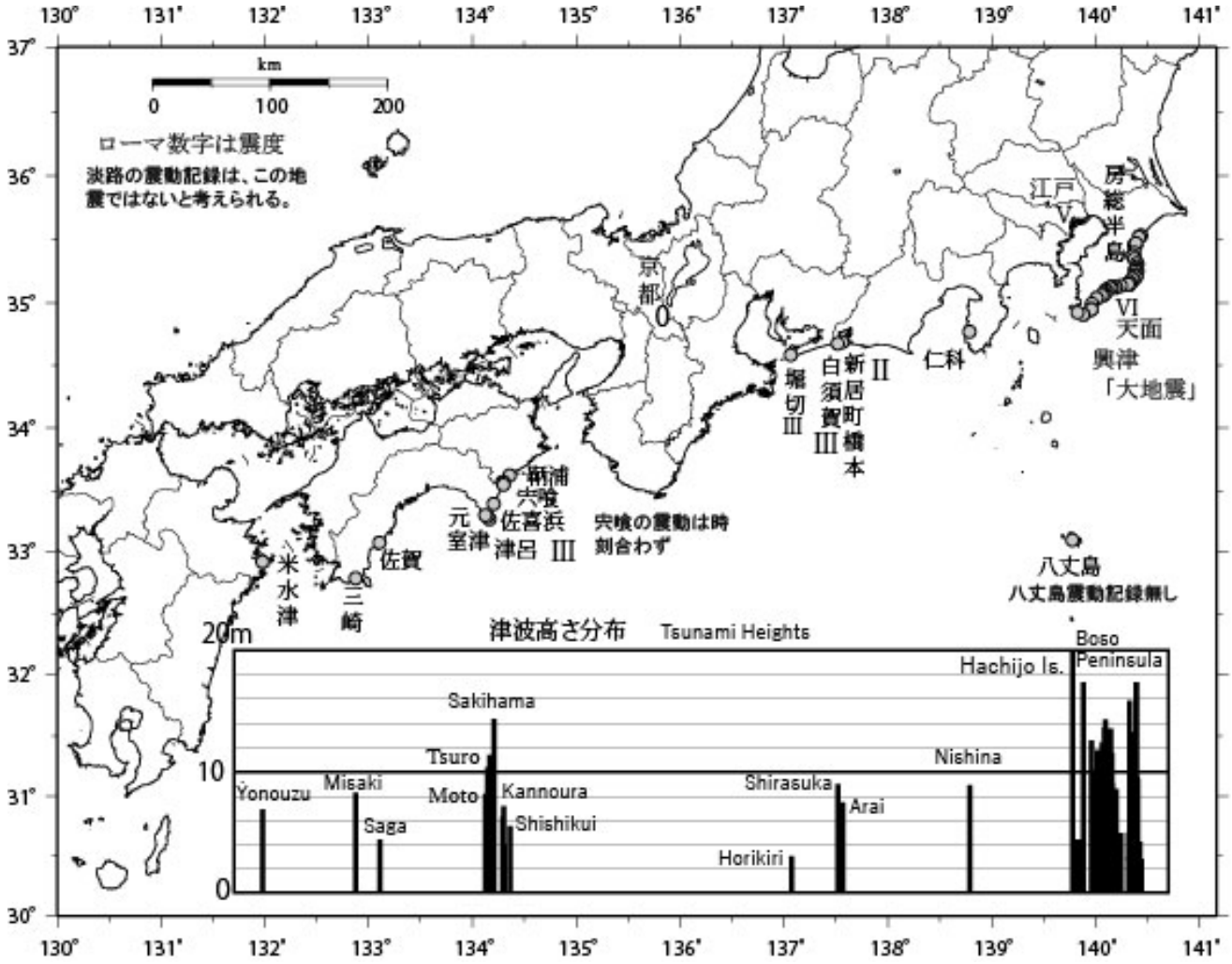
*Yoshinobu Tsuji[1], Kentaro Imai[2], Yuuichi Ebina[3], Hiroyuki Iwase[4], Ryoko Oobayashi[2]

1. Shimanto City, 2. JAMSTEC, 3. IRIDeS, 4. Ecoh co. LTD

We conducted field survey of the tsunami damaged coast of the Keicho 9 earthquake of February 3rd, 1605 on the coasts of Tokai, Shikoku And Kyushu and tsunami inundation or run-up heights were measured newly at 17 points by using GPS. Tsunami height distribution along Boso Peninsula had been clarified by Tsuji et al(2018). At Nishina, Nishiizu Town, Shizuoka prefecture, sea water went upstream along Nishina River about 1.4 km from the river mouth and run up height was estimated at 8.9 meters above mean sea level. At Hashimoto in Arai Town, Kosai City, Shizuoka prefecture, 80 houses out of 100 houses were swept away, and tsunami height was 8.2 meters. At Shirasuka, a post town of Tokaido houses were swept away and severel people, horses, and cows were killed, and tsunami height was 9.4 meters. At Horikiri village, Tahara city, near the to of Atsumi Peninsula, Aichi preffecture, all fishing ships were wrecked but no house and human damage took place, and height was estimeted at 3 meters. At Sakihama, Muroto city, Kochi prefecture, sea water rose up to the entrance step stone of the main building of Dainichiji temple, and tsunami height was 14.4 meters. Coastal villages near cape Muroto, about 400 people were killed due to the tsunami. At Saga, Kuroshio Town, documents given by Lord Motochika Chosokabe was lost in Sakamoto's house, where tsunami height was estimated at 6.2 meters. At Misaki, in Tosashimizu city, 153 peoples were killed due to the tsunami, and tsunami height was estimated at 8.1 meters. Tsunami height distribution is illustrated in the figure.
This research was supported by MEXT (“Research project for compound disaster mitigation on the great earthquakes and tsunamis around the Nankai Trough region”).

Keywords: the tsunami of the 1605 Keicho earthquake, historical earthquake, historical tsunami

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Re-examination of tsunami heights distribution during the 1854 Ansei Tokai Earthquake

*Kentaro Imai[1], ebina yuichi[2], Yoshinobu Tsuji[3], Hiroyuki Iwase[4], Takane Hori[1], Narumi Takahashi[1,5], Takashi Furumura[6]

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The great Nankai Trough earthquake has been accepted for the recurrence on the characteristic earthquake based on the plate tectonic interpretation. On the other hand, Seno (2012) pointed out the possibility that overlapping regions are few and complementary in the seismic zone of the Ansei Tokai Earthquake and the Showa Tonankai Earthquake. It is necessary to similar reinterpretation of the tsunami source. In this research, we reexamined the historical documents related to the Ansei Tokai earthquake Tsunami, along the coast of the Izu Peninsula from the coast of the Kii Peninsula, close to the source area of the Ansei Tokai earthquake. Furthermore, field survey for tsunami trace height based on historical documents conducted to clarify the characteristics of the tsunami height distributions.

We extracted historical materials on the 1854 Ansei Tokai Earthquake published in the Japan Earthquake reference material as “Zotei Dai Nippon Jishin shiryo”, “Shinshu Nihon Jishin Shiryo” and so on. 801 documents stored in these collections were selected and checked for newly found documents that have not been used in previous research. We conducted a field survey on tsunami trace height information obtained through historical document. We reviewed carefully these selected historical documents, and evaluation for tsunami trace height on the field was carried out by GNSS and laser range finder measurement. For the comprehensive tsunami trace height distribution, the data evaluated by previous research [Hatori (1977); Tsuji et al. (1991); Namegaya & Tsuji (2005); Tsuji et al. (2013); Tsuji & Saito (2014); Imai et al. (2017)] were partially used.
There are two peaks of the tsunami height during the tsunami trace height distributions on the Ansei Tokai earthquake tsunami, the one as the tsunami trace height was reached 22 m at Kuzaki the east of the Shima Peninsula. the other one as the tsunami trace height was exceeding 15 m at Iruma the south east of Izu Peninsula. This information are extremely important clues to re-examine for the tsunami source of the Ansei Tokai earthquake. We examine the tsunami source that explains such tsunami trace height distribution in this presentation.

Acknowledgments: This research was supported by MEXT (“Research project for compound disaster mitigation on the great earthquakes and tsunamis around the Nankai Trough region”).

Keywords: The great Nankai Trough earthquak, the 1854 Ansei Tokai Earthquake, tsunami trace heights distribution

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[J] Oral | H (Human Geosciences)：H-RE Resource and Engineering Geology

Wed. May 29, 2019 10:45 AM - 12:15 PM JST | Wed. May 29, 2019 1:45 AM - 3:15 AM UTC | 106 1F

[H-RE16] Resource Geology

convener:Tsubasa Otake(Division of Sustainable Resources Engineering, Faculty of Engineering, Hokkaido University), Daisuke Araoka(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Ryohei Takahashi(Graduate School of International Resource Sciences, Akita University), Tatsuo Nozaki(Research and Development Center for Submarine Resources, Japan Agency for Marine-Earth Science and Technology), Chairperson:Tsubasa Otake(Faculty of Engineering, Hokkaido University), Daisuke Araoka

Ore deposits containing valuable elements and minerals at high concentrations in supracrustal rocks are formed by the Earth's dynamics including magmatism, hydrothermal activity, metamorphism, and weathering. The formation of ore deposits is also closely associated with global environmental changes and biological evolution in the Earth's history. Involvement of difference academic fields in earth sciences including geology, petrology, geochemistry, mineralogy, and microbiology is required to understand the genesis of ore deposits. The field of resource geology is essential not only for efficient exploration and development of ore deposits but also for better understanding and assessment of hazardous elements that may be caused by the resource development. This session widely covers various topics of field investigation and observation, laboratory experiments, theoretical calculation, development of analytical methods and others related to the supracrustal migration and concentration of elements.

10:45 AM - 11:15 AM JST | 1:45 AM - 2:15 AM UTC

[HRE16-01] The role of water in the concentration of Cr

★Invited Papers

*Shoji Arai[1] (1.Department of Earth Sciences, Faculty of Science, Kanazawa University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[HRE16-02] Mineralogical Features of Silver-Bearing Minerals in Chimney Ore from Myojinsho Caldera, Myojin Knoll and Bayonnaise Knoll Seafloor Hydrothermal Area, Izu-Bonin Arc

Shinji Kawaguchi[1], *Kotaro Yonezu[1], Thomas Tindell[1], Jun-ichiro Ishibashi[2], Tatsuo Nozaki[3], Yoko Ohtomo[4], Koichiro Watanabe[1] (1.Deaprtment of Earth Resources Engineering, Faculty of Engineering, Kyushu University, 2.Department of Earth and Planetary Sciences, Faculty of Sciences, Kyushu University, 3.Research and Development Center for Submarine Resources, Japan Agency for Marine-Earth Science and Technology, 4.Faculty of Engineering, Hokkaido University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[HRE16-03] Organic matters and acid-sulfate alteration in Itomuka Mine, Hokkaido, Japan: implications for the transportation and deposition mechanisms of mercury

*Takuya Echigo[1], Mitsuyoshi Kimata[2], Masahiro Shimizu[2] (1.Graduate School of International Resource Sciences, Akita University, 2.Graduate School of Life and Environmental Sciences, University of Tsukuba)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[HRE16-04] Significances of 12 Ma manganese ores in the Hokuroku district, Akita: unique Mn accumulation and interaction with organic matter during submarine hydrothermal activities

*Yuya Tsukamoto[1], Takeshi Kakegawa[1] (1.Tohoku Univ.)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[HRE16-05] Microbial communities around ca. 2.7 Ga submarine hydrothermal fields at the Potterdoal deposit in Abitibi Greenstone Belt, Canada

*Takeru Osato[1], Akizumi Ishida[1], Takeshi Kakegawa[1] (1.Tohoku University)

The role of water in the concentration of Cr

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The role of water in the formation of chromitites, which have been designated as a typical orthomagmatic ores, has been long controversial. Johan et al. (1983, 2017), for example, concluded that chromites are precipitated from water-rich fluids at relatively low temperatures (< 1000 ºC) to form podiform chromitites in the mantle. Those arguments are mainly based on two observations; (1) podiform chromitites and surrounding peridotites have been preferentially hydrated, which may mean the initial water enrichment, and (2) chromite grains contain fluid and hydrous mineral inclusions of apparently primary origin. I criticize the related interpretations based on those observations. The selective hydration in and around chromitite pods is due to the Mg-rich character of olivines, which has been obtained during a subsolidus cooling stage (Arai, 1978), and does not definitely show the involvement of water-rich fluid in chromitite formation. The origin of the chromite-hosted hydrous mineral inclusions has not been left unclear. Many authors a priori interpreted the inclusions as being representative of the trapped melts or fluids that precipitated the host chromites. This is, however, highly questionable. The inclusions are most probably formed during a stage of peridotite-melt reaction within a complicated igneous stage of podiform chromitite generation in the mantle. Hydrothermal fluids can transport Cr and precipitate chromite, but may not form most of the podifrom chromitites.

Keywords: Chromium, Chromitite, Water

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Mineralogical Features of Silver-Bearing Minerals in Chimney Ore from Myojinsho Caldera, Myojin Knoll and Bayonnaise Knoll Seafloor Hydrothermal Area, Izu-Bonin Arc

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Submarine hydrothermal deposits in western Pacific is characterized as volcanic massive sulfide deposits mainly consisting of Cu-Pb-Zn (± Au ±Ag). Recent explorations have resulted in discoveries of submarine mineral resources in the exclusive economic zones around Japan. The previous study reported chimney ores collected from Izu-Bonin arc are of high grade (Au; 24.1 ppm, Ag; 1275 ppm, Cu: 1.14%, Pb: 5.57%, Zn: 35.03%), (Tanahashi et al, 2004). According to this study, chimney ores were characterized by porous constituents and concentric ring structures, white colored barite layer and sulfide mineral layer mainly composed of sphalerite and galena are recognized from the outer surface to the center part. This concentric ring structures may be attributed to order of precipitations during formation of the chimney ores, however only few studies have discussed mineralization of the chimney along the growth axis (e.g., Watanabe & Hayashi, 2014). Purpose of our research is to clarify mineralogical features of silver minerals in chimney ore by identifying the precipitation conditions of hydrothermal fluids in the Izu-Bonin arc. We studied chimney ores collected during the NT13-09 scientific cruise and NT14-06 scientific cruise.The chimney ores collected from Izu-Bonin arc have quite similar mineralogical features. They have a tubular structure and can be divided into three groups along growth axis from outside to inside of chimney; G1: composed of barite; G2: mainly composed of barite and the principal sulfide minerals of submarine hydrothermal ore deposit (sphalerite, pyrite, chalcopyrite and galena); and G3: composed of main sulfides. According to EPMA analysis, barite is observed in G1 and G2 in addition to pore filling barite in G3. These barite formations are considered to mixing of the hydrothermal fluid with ambient seawater and formation temperature estimated for the initial barite mineralization recognized in G1 and G2 as 190-215℃, and for the second barite mineralization in G3 is as 150-195℃, suggesting temperature decrease of the hydrothermal fluid during the formation of chimney ores (Iizasa, et al. 1997). Based on these results, we propose following formation stages. First, G1 are formed by mixing of the hydrothermal fluid with seawater. Subsequently, porous G2 is formed by a change in the mixing ratio of seawater and hydrothermal fluid. Finally, the hydrothermal contribution becomes greater, so that exclusively sulfide mineral can be precipitated in G3. In addition, as shown in barite observed in G3, after the hydrothermal activity stopped, the second barite is precipitated in the void of the porous chimney ore by mixing ambient seawater and hydrothermal fluid. We noticed that the silver-bearing minerals can be observed in G2 and G3 as tetrahedrite-tennantite series minerals (Ave (wt.%): Ag; 2.9, Cu: 11.1, Zn: 7.0, Pb: 46.6, Sb: 4.0, As: 3.0 and S: 10.9) of 1-20 μm. Silver bearing minerals are associated with sphalerite and galena. According to Ag vs. Sb/(Sb+As) diagram, relatively silver-rich hydrothermal fluids contributed to form the chimney ore in Izu-Bonin arc as compared to that of typical with Kuroko type deposits. Especially from the chimney ore of the Bayonaissea knoll, 1-10 μm of tetrahedrite-tennantite series containing a high content of silver (Ave (wt.%): Ag: 52.9, Cu: 9.6, Zn: 1.6, Pb: 37.5 and S: 13.8) are observed at the rims of galena in the boundary between G1 and G2. Silver mineralization may be explained as follows. Firstly, silver present in galena formed during the principal sulfide mineralization moves by equilibrium equation,

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$2Pb^{2+} = Ag^{+} + Sb^{3+}$ (Karup-Moller, 1971 and Foord, 1989) towards the right side by decreasing in temperature. As a result, tetrahedrite-tennantite series minerals are precipitated at G2 and G3. After hydrothermal active vent stopped, further temperature drop was introduced and furutobeite is formed from tetrahedrite-tennantite series minerals.

Keywords: Submarine hydrothermal ore deposit, Chimney ore, Izu-Bonin arc

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Organic matters and acid-sulfate alteration in Itomuka Mine, Hokkaido, Japan: implications for the transportation and deposition mechanisms of mercury

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We investigated the ore and hydrothermal alteration minerals and solid organic matters from Itomuka mercury mine which is located in the eastern part of central Hokkaido to examine the transportation and deposition mechanisms of mercury. In addition to the ore minerals, native mercury and cinnabar, powder X-ray diffraction (XRD) analysis showed that the mercury ore consist of quartz, marcasite, alunite, kaolinite and minor amounts of pyrite and smectite. This mineral assemblage suggests that mercury deposition occurred with the advanced argillic alteration under low temperature and low pH condition. Two types of solid organic matter were recognized in quartz vein by yellow-green fluorescence under the ultraviolet radiation: (1) film-shaped organic matter occurring on the surface of quartz vein and (2) globule-shaped organic matter filling pores of quartz vein. Both of these organic matters occur with mercury minerals, cinnabar, native mercury and calomel (Hg_2Cl_2). These organic matters were analyzed with SEM-EDS, micro-X-ray diffraction and micro-FTIR. SEM-EDS analysis showed that film-shaped organic matter is closely associated with mercury and silica minerals though globule-shaped organic matter is not associated with such minerals. Micro-FTIR spectra of both organic matters are similar and suggested that these contain aromatic rings, carboxyl group (-COOH) and adamantine ($C_{16}H_{10}$). Micro-XRD showed that film-shaped organic matter consists quartz, opal- and adamantine crystals and globule-shaped organic matter consists of quartz and amorphous organic matter, respectively. The occurrence of these organic matters suggests that hydrothermal fluid which transported mercury was highly reduced. Because the solubility of Hg in acidic fluid is low, neutral to alkaline fluid seems to have leached mercury from the basement sedimentary rocks of Hidaka formation. The mercury-bearing fluid ascended along the faults in Itomuka formation and oxidized at near the surface. Reduced sulfur (HS^-) in the fluid oxidized into sulfate (SO_4^{2-}) and reduced pH, which resulted in mercury deposition and advanced argillic alteration. Probably, rapid oxidation of ore-forming fluid promoted the precipitation of marcasite, a metastable phase of iron sulfide. The dominance of native mercury over cinnabar indicates that mercury was transported by biphase (liquid+vapor) hydrothermal fluid.

Keywords: Mercury, Organic matter, Advanced argillic alteration

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Significances of 12 Ma manganese ores in the Hokuroku district, Akita: unique Mn accumulation and interaction with organic matter during submarine hydrothermal activities

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Various Mn ores are found in the Hokuroku district in Akita through the course of the present study. Stratified and veined Mn ores, which lengths are up to 10 cm, are formed during volcanic recession periods (less than 1 Ma) with associated with carbonaceous sediments and local hydrothermal systems. Such short-term precipitation of “pure” Mn ores is unusual, compared to normal Fe-Mn nodules or crusts. In order to understand detailed mechanisms, in particular, role of organic matter, of Mn ore formations, we performed standard mineralogical characterization, magnetic field analyses and oxygen isotope analyses on Mn ores. The first type of Mn ores appear on mudstone and veins in hydrothermally altered hyaloclastite of rhyolite lavas. Detailed geological and geochemical studies revealed that local submarine hydrothermal processes mobilized Mn and Fe in host rocks, Fe-oxides were precipitated first and then discharged Mn were precipitated as oxides (rhodonite and todorokite) on mudstone. $\delta^{18}O_{SMOW}$ value of Mn oxide is + 7.7‰ showing the precipitation temperature less than 112 C. Mn carbonate (rhodochlosite and kutnohorite) also appears in the same region. $\delta^{13}C_{PDB}$values of Mn carbonate were -21‰ (PDB), suggesting interaction with organic matters during intrusive activities of later rhyolite. The second type of Mn ores appear as veins in rhyolitic tuff or stratified lenticular forms with mud/tuffs. Ca. 30 μm colloform structures consisted of organic matter and Mn oxides can be observed. Major Mn mineral in these second type is todorokite. $\delta^{18}O_{SMOW}$value of second types of Mn ores is + 8.5‰ indicating low temperature precipitation of Mn oxides less than 101 C. Magnetic field was detected on Mn oxides in colloform structure by magnetic field microscopy (MFM). Such magnetic fields indicate high cation vacancies and abundance of Mn^{4+}, which are common in biogenic Mn oxides. Formational processes of both Mn ores provide new insight of the unique formational process of Mn ores, especially geological separation from $Fe^{2+}$and interaction with organic matter, in hydrothermal systems at the subseafloor on felsic volcanic setting. Further, this study indicates that low temperature (<100 C) hydrothermal activities can form the Mn ores with high precipitation rates.

Keywords: Manganese, Hokuroku district, Hydrothermal system

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Microbial communities around ca. 2.7 Ga submarine hydrothermal fields at the Potterdoal deposit in Abitibi Greenstone Belt, Canada

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1. Tohoku University

The Archean submarine hydrothermal environment is often considered as a cradle of early life. Large uncertainties still exist as to which microorganisms were active around Archean submarine hydrothermal systems and if hydrothermal communities could be the primary producers for the global biosphere. To approach this problem, we studied ca. 2.7 Ga volcanogenic massive sulfides (VMSs) and associated sedimentary rocks at the Potterdoal deposit in Abitibi Greenstone Belt, Canada. Purposes of the present study are (1) to evaluate which type of microorganisms were active in 2.7 Ga submarine hydrothermal environments, and (2) to find new biosignature in nanoscale analysis of organic matter (OM).
VMS ores were mainly composed of chalcopyrite, sphalerite, pyrrhotite and pyrite, mostly showing layered and sorting textures. They often contained brecciated shale or actinolite or chlorite. Chert and sandstone appeared in the distal area from the VMSs. Most examined VMSs did not have OM, but some samples had up to 0.5 wt.% of carbon concentration. Those OM were found together with actinolite or chlorite or shale fragments trapped in VMSs. Carbon concentration in sedimentary rocks were moderate in general, ranging from 0.0 to 0.9 wt.%C. The thermal alteration temperature was estimated as below 300 ˚C based on the full widths of half maximum of the D1 band in the Raman spectra of kerogen, indicating that less altered features. Overall carbon isotope compositions of kerogen were ranging from -44.6 to -23.6 ‰ (PDB). These values suggest that the presence of contrast microbial ecosystems at this region, utilizing either hydrothermal CH_4 or atmospheric CO_2. Transmitted electron microscope analysis revealed that examined kerogen were mainly composed of immature OM with minor graphene layers. Novel nanostructures of Mo-sulfides stacked with graphene or Fe-sulfides were newly found in immature kerogen structures.These nano-sulfides associated with kerogen may suggest incorporation of biological sulfides in OM during the early diagenesis, possibly giving new evidence of sulfur metabolisms for the early life.

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[J] Oral | H (Human Geosciences)：H-RE Resource and Engineering Geology

Wed. May 29, 2019 1:45 PM - 3:15 PM JST | Wed. May 29, 2019 4:45 AM - 6:15 AM UTC | 106 1F

[H-RE16] Resource Geology

convener:Tsubasa Otake(Division of Sustainable Resources Engineering, Faculty of Engineering, Hokkaido University), Daisuke Araoka(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Ryohei Takahashi(Graduate School of International Resource Sciences, Akita University), Tatsuo Nozaki(Research and Development Center for Submarine Resources, Japan Agency for Marine-Earth Science and Technology), Chairperson:Tatsuo Nozaki(JAMSTEC), Ryohei Takahashi(Faculty of International Resource Sciences, Akita University)

Ore deposits containing valuable elements and minerals at high concentrations in supracrustal rocks are formed by the Earth's dynamics including magmatism, hydrothermal activity, metamorphism, and weathering. The formation of ore deposits is also closely associated with global environmental changes and biological evolution in the Earth's history. Involvement of difference academic fields in earth sciences including geology, petrology, geochemistry, mineralogy, and microbiology is required to understand the genesis of ore deposits. The field of resource geology is essential not only for efficient exploration and development of ore deposits but also for better understanding and assessment of hazardous elements that may be caused by the resource development. This session widely covers various topics of field investigation and observation, laboratory experiments, theoretical calculation, development of analytical methods and others related to the supracrustal migration and concentration of elements.

1:45 PM - 2:15 PM JST | 4:45 AM - 5:15 AM UTC

[HRE16-06] Development of nano-fabrication and high-resolution electron microscopy techniques: their possible applications to resource geology

★Invited Papers

*Naotaka Tomioka[1], Satoko Motai[1], Yu Kodama[2], Motoo Ito[1] (1.Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology, 2.Marine Works Japan)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[HRE16-07] Microscopic study on rare earth elements in ion-adsorption type ore of China

*Hiroki Mukai[1], Yoshiaki Kon[1], Kenzo Sanematsu[1], Yoshio Takahashi[2], Motoo Ito[3] (1.National Institute of Advanced Industrial Science and Technology, 2.Graduate School of Science, the University of Tokyo, 3.Kochi Institute for Core Sample Research JAMSTEC)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[HRE16-08] Geochemical features of “invisible gold” in pyrites from the Akeshi and Kasuga deposits, Kagoshima, Japan

*Mizuki Ishida[1], Rurik Romeo[2,3], Mathieu Leisen[2,3], Junji Torimoto[4], Tatsuo Nozaki[4,5,6,7], Kazutaka Yasukawa[1,6], Koichiro Fujinaga[6,1], Kentaro Nakamura[1], Martin Reich[2,3], Yasuhiro Kato[1,6,5] (1.Department of Systems Innovation, School of Engineering, The University of Tokyo, 2.Department of Geology and Andean Geothermal Center of Excellence (CEGA), FCFM, 3.Millennium Nucleus for Metal Tracing Along Subduction, FCFM, Universidad de Chile, FCFM, 4.Japan Agency for Marine-Earth Science and Technology (JAMSTEC), 5.Frontier Research Center for Energy and Resources, School of Engineering, The University of Tokyo, 6.Ocean Resources Research Center for Next Generation, Chiba Institute of Technology, 7.Department of Planetology, Graduate School of Science, Kobe University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[HRE16-09] Hydrothermal Mineral Assemblage of the Southwest Prospect, in the Vicinity Sto. Tomas II (Philex) Porphyry Cu-Au Deposit, Baguio District, Philippines

*Avriel Venis Literal Cirineo[1], Akira Imai[2], Ryohei Takahashi[1], Noel C. Oliveros[3], Redempta P. Baluda[3], Victor B. Maglambayan[3], Roy Ronald C. Luis[3], Maria Lourdes M. Faustino[3] (1.Graduate School of International Resource Sciences, Akita University, 2.Faculty of Engineering, Kyushu University, 3.Philex Mining Corporation)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[HRE16-10] Characteristics and genesis of weathering REE deposits

★Invited Papers

*Kenzo Sanematsu[1] (1.Mineral Resource Research Group, Institute for Geo-Resources and Environment, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology)

Development of nano-fabrication and high-resolution electron microscopy techniques: their possible applications to resource geology

*Naotaka Tomioka[1], Satoko Motai[1], Yu Kodama[2], Motoo Ito[1]

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In order to explore accessible and profitable natural resources, scientific elucidation of their origin and evolution are an essential issue. The natural resources often have fine-grained textures and minute mineral/fluid inclusions in the host minerals. Therefore, microanalysis is required to clarify their mineralogical and geochemical characteristics in detail. Focused-ion beam (FIB) microfabrication and transmission electron microscopy (TEM) are potentially effective techniques for this purpose. FIB allows to precisely extract portions of interest in sub-micron scale from various types of samples. Using TEM, microtextural, chemical, and crystallographic information can be obtained in nano-scale spatial resolution from ultrathin-film (100–200 nm) samples. With taking these technical advantages, state-of-the-art FIB and TEM at JAMSTEC KOCHI have been applied to a variety of geosciences including clay mineralogy [1], biomineralization [2], mantle rheology [3], and meteoritics [4].

One of uniqueness of the FIB/TEM laboratory at KOCHI is a combined FIB-FESEM instrument equipped with an energy dispersive spectrometer (EDS) and a cryo-holder system [5]. We are currently developing a FIB-fabrication scheme of fluid inclusions in minerals such as olivine and halite, so that those fluids are exposed in frozen state for their in-situ chemical analysis including X-ray elemental mapping using EDS [6]. 3D tomography by micro X-ray CT is effective to visualize distribution of fluid inclusions especially in nontransparent minerals prior to nanofabrication and analysis by the FIB-FESEM system.

The nanoscale occurrence of fluid (as voids) and mineral inclusions can be further characterized by high-resolution TEM. This technique would be useful for mineralogical analysis of fine-grained resource materials such as deep-sea mud containing abundant rare-earth elements [7] and manganese deposits. As a typical example, we have mineralogically characterized several-micron-sized Mn-rich microparticles recently discovered in seafloor sediments, and found vernadite-like mineral therein based on their electron diffraction patterns and elemental mappings [8]. We are further developing the linkage fabrication/analysis scheme to extend toward more comprehensive sample analysis including trace elemental and isotopic analyses using NanoSIMS [9]. These microanalysis techniques would play a key role for our better understanding of environments for the formation of resource materials.

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Keywords: microanalysis, Transmission electron microscopy, Focused ion beam

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Microscopic study on rare earth elements in ion-adsorption type ore of China

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At present, China constitutes more than 80 % of the rare earth elements (REE) production in the world. Among REE ores, ion-adsorption type ones existing mainly in southern China are a major supply source of heavy REE (HREE) which are especially valuable. The ion-adsorption type ore is formed under weathering of the underlying parent granite rocks. This ore typically contains more than 50 % of ion-exchangeable REE that can be extractable with electrolyte solution such as ammonium sulfate $(NH_4)_2SO_4$ solution. It has been estimated that permanent negative charge on clay minerals, such as kaolinite, leads to surface adsorption of REE in the ore. However, the direct observations or analyses for the individual minerals have been rarely conducted due to the relatively low concentrations of REE (<2000 ppm). In the present study, we analyzed weathered granite collected from an ion-adsorption ore in Dingnan County, Jiangxi Province, China on a submicroscopic scale by using various experimental apparatuses.
XRD measurements indicated that the weathered granite is mainly composed of quartz, K-feldspar and kaolinite. The results of SEM-EDS and LA-ICP-MS measurements showed that “kaolinitic particle” is abundant with REE compared to the other minerals. These results suggest that the kaolinitic particles are major reservoir of REE in the ore. The elemental mapping for a kaolinitic particle by LA-ICP-MS showed that each element is distributed heterogeneously in the particle. The SEM-EDS analyses also suggested that the kaolinitic particle is composed of several minerals. For further micro-analyses, cross sections were processed from the kaolinitic particles by FIB. XAFS study on the cross sections suggested that REE are basically hydrated in the particle. STEM-EDS analyses revealed that the kaolinitic particle contains illite and hematite in addition to kaolinite. Considering general weathering process, it can be assumed that K-feldspar was altered into illite and further into kaolinite during chemical weathering. Elemental mapping with high spatial resolution by NanoSIMS clarified that REE are distributed in kaolinite and illite.

Keywords: Ion-adsorption type rare earth ore, LA-ICP-MS, FIB-TEM, XAFS, NanoSIMS

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Geochemical features of “invisible gold” in pyrites from the Akeshi and Kasuga deposits, Kagoshima, Japan

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The occurrence of gold in ore is one of the most important information in gold deposit research. This information allows us to optimize beneficiation and smelting processes, as well as providing valuable insights into the mineralization mechanism, which can improve exploration strategies (e.g., [1]).

In hydrothermal gold deposits, gold is not always visible as native gold, electrum, caraverite (AuTe2) or other gold minerals. In many cases, it also exists as submicrometer-size inclusions and solid solution in other minerals, which is so-called “*invisible gold*” [2]. Pyrite is the most ubiquitous and well-known host mineral for this invisible gold, and its trace element geochemistry has been increasingly recognized as a useful tool to understand the mineralization processes (e.g., [3]).

In this study, we report the geochemical features of invisible gold in pyrites collected from the Akeshi and Kasuga deposits. These deposits, located in the southern part of the Kagoshima Prefecture, Japan, are currently under operation, and are classified as high-sulfidation gold deposits. In both Akeshi and Kasuga, gold minerals are only reported from high-grade ores, and other hosts of gold in lower-grade ores remain still uncertain [4]. Pyrite is the most common sulfide mineral in these deposits. Here, we report the results of EPMA (Electron Probe Micro Analyzer) and LA-ICP-MS (Laser Ablation Inductively Coupled Plasma Mass Spectrometry) trace element analyses of pyrite, in order to determine their mineralization processes.

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Keywords: Pyrite, Trace elements, Invisible gold, High-sulfidation deposit, Nansatsu-type

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Hydrothermal Mineral Assemblage of the Southwest Prospect, in the Vicinity Sto. Tomas II (Philex) Porphyry Cu-Au Deposit, Baguio District, Philippines

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Overprinting relationship between intrusive rocks, diatreme-breccias and mineralized porphyry-type veinlets are documented in the Southwest prospect was recently discovered along the contact of the basement Pugo metavolcanics and conglomerates of the Zigzag formation, overlain by dacitic tuff termed as the Keratophyre (KTP). The prospect is located at the southwestern periphery of the Sto. Tomas II orebody, a 60-year old porphyry Cu-Au mine being operated by Philex Mining Corporation (PMC).
At least four intrusive rocks were recognized. In chronological order, they are the: (1) coarse-grained biotite quartz diorite (ODP –Old Diorite Porphyry), (2) fine-grained quartz diorite porphyry (EMD -Early Mineralization Diorite), (3) medium-grained porphyritic hornblende quartz diorite (LD –Late Diorite) and (4) hornblende andesite porphyry (DP –Diorite Porphyry). Meanwhile, at least five breccia facies were identified: (1) Phreatomagmatic Breccia facies 1 or PMBx1, (2) Phreatomagmatic facies 2a or PMBx2a, (3) Phreatomagmatic Breccia facies 2b or PMBx2b, (4) Early Mineralization Diorite Breccia or EMDBx and (5) Diorite Porphyry Breccia or DPBx. The PMBx facies are polymictic breccias with chaotic mixture of clasts set in a matrix composed of rock flour of earlier formed rocks and juvenile tuffaceous matrix. They are sub-vertical pipes that flare upwards and may represent diatreme breccias (Sillitoe, 1985, Baker et al., 1986, Lawless and White, 1990). On the other hand, EMDBx and DPBx are intrusion breccias that were formed during the emplacement of their intrusive equivalents (Sillitoe, 1985). Porphyry-type veinlets are observed overprinting ODP, EMD and PMBx1, while at the same time, quartz vein fragments are included in the latter. These veinlets are also commonly found along the contacts between LD and the PMBx1. PMBx2a and PMBx2b crosscut all the earlier intrusions and breccias. Spatial and temporal associations suggest syn-mineralization timing of the EMD, PMBx1 during porphyry-type quartz veining, while LD and some of the porphyry-type veinlets associated with the LD suggest a late-mineralization timing.
Intense potassic alteration is characterized by secondary biotite-quartz-magnetite-anhydrite-chalcopyrite-bornite. It is exhibited by EMD and andesitic clasts of Pugo Metavolcanics occurring as clasts in the diatreme breccias. It is also well-developed in the EMD at the deeper central portion of the prospect, in the matrix of the adjacent EMDBx and PMBx1. Secondary biotite is present as fine disseminations in the groundmass and as polygrain aggregates completely altering former ferromagnesian minerals, such as hornblende. It is often accompanied with quartz, anhydrite, magnetite and copper iron sulfides. Occasional K-feldspar, chlorite, illite and epidote are present in the assemblage. Associated sheeted quartz and granular quartz veinlets indicated a wide range of liquid-vapor homogenization temperature (T_h(L-V)) from 436˚C to 578˚C and 461˚C to >720˚C, respectively, and salinities from 41 to 43 wt% $NaCl_{equivalent}$ and 37 to 43 wt% $NaCl_{equiv.}$ This alteration is overprinted by illite-chlorite-carbonate-magnetite±K-feldspar alteration with abundant chalcopyrite and bornite. It pervasively overprinted the quartz stockwork zone hosted in the PMBx1 adjacent to the EMD at the central deeper portion of the prospect. Associated banded quartz veinlets indicated Th(L-V) >720˚C and salinities ranging from 55 to 70 wt% $NaCl_{equiv.}$ The shallower portions dominated by the later breccias were altered by chlorite-illite-pyrite±chalcopryite with associated quartz-gypsum cement. Lastly, propylitic

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alteration is exhibited by LD. It is characterized by chlorite-epidote-calcite±illite. Associated crystalline quartz-chlorite veinlets indicated lower Th(L-V) 246˚C and lower salinity of 40 wt% $NaCl_{equivalent.}$
K-Ar ages determined on the secondary biotite of the EMD sample that exhibited intense hydrothermal biotitization typical at the potassic core in Southwest and on the hornblende grains of LD that showed no hydrothermal alteration are both 3.5Ma. This indicates that the hydrothermal biotitization prevalent in the potassic alteration in EMD and the emplacement of the LD could have happened in a single magmatic-hydrothermal event. This may also indicate that the timing between the potassic alteration and intrusion are close in Southwest, and also constrained an older age than the mineralization at the Sto. Tomas II orebody (Imai, 2001, Waters et al., 2011).

Keywords: Baguio district, Southwest prospect, Sto. Tomas II orebody, potassic alteration, overprinting porphyry-type veinlets, diatreme breccias

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Characteristics and genesis of weathering REE deposits

*Kenzo Sanematsu[1]

1. Mineral Resource Research Group, Institute for Geo-Resources and Environment, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology

The world rare earth deposits can be classified into carbonatite, alkaline-rocks related, placer and ion-adsorption types. Rare earth elements (REE) which are present as trace elements in the mantle and crusts can be geologically condensed by either or both of the formation of alkaline magma and weathering. This talk reviews on the characteristics and genesis of weathering REE deposits consisting of weathered carbonatites, placer and ion-adsorption type deposits.

Weathered carbonatite deposits are characterized by high REE grades. Carbonatites are high in REE (>1%, approximately) and these elements are condensed by dissolution of carbonate minerals during chemical weathering. The dominant REE minerals are primary and secondary phosphate minerals including monazite. The ores are rich in LREE (light REE) and Th and poor in HREE (heavy REE), reflecting compositions of the unweathered carbonatites. REE minerals are generally fine-grained compared to unweathered carbonatites and this may influence the recovery of REE during mineral processing.

Placer deposits are formed by weathering and erosion of igneous and metamorphic rocks and deposition of heavy minerals in alluvium and beach sands. Placer ore minerals are mainly Ti minerals (ilmenite and rutile), zircon and cassiterite. REE-bearing placer deposits contain monazite and lesser amount of xenotime. Although the bulk REE grade is low, the ore consisting of sand and gravels can be mined and heavy minerals are processed easily. This deposit type was the leading world REE producer in the world until 1965. Since monazite is the dominant REE mineral, placer deposits are rich in LREE and Th and poor in HREE. Zircon is the common HREE-bearing mineral in placer deposits, however they are not economically extractable.

Contrasting to the two types of residual deposits mentioned above, ion-adsorption type deposits are characterized by REE adsorbed electrostatically on the surface of clays (not in the crystal structure of minerals) and they are extractable by ion exchange from the REE ores. The ores, called ion-adsorption ores, are formed mainly from granite by chemical weathering. Although these deposits are generally low in REE, they can be rich HREE. Parent granites contain weatherable REE bearing minerals such as fluorocarbonates (e.g., bastnaesite, synchysite) and REE-bearing silicates (e.g., allanite, titanite) and LREE/HREE ratios of these minerals constrain those of ion-adsorption ores. In contrast, parent granite rich in phosphate minerals (e.g., monazite and apatite) tends to form weathered granites with low ion-exchangeable REE because most REE are incorporated in phosphate minerals which resistant to chemical weathering. Kaolinite, halloysite, illite and vermiculite appear to have ion-exchangeable REE. Since the ores and extracted solutions are generally low in Th, ion-adsorption type deposits are poor in Th compared with the other REE deposits.

Keywords: rare earths, weathering, deposits, resources, adsorption

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Wed. May 29, 2019 3:30 PM - 5:00 PM JST | Wed. May 29, 2019 6:30 AM - 8:00 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-SS09] Earthquake prediction and forecast

convener:Masayuki Obayashi(Japan Agency for Marine-Earth Science and Technology), Toshitaka Baba(Graduate School of Science and Technology, Tokushima University), Chairperson:Sumio Yoshikawa(気象研究所), Mamoru Kato(Graduate School of Human and Environmental Studies Kyoto University)

This session provides the opportunity for contributions that fall within the scientific spectrum of earthquake prediction and forecasting. We welcome theoretical, observational or numerical papers that are either on long- or short-term predictions, and either based on deterministic or probabilistic approaches.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SSS09-01] **Objective evaluationof precursory seismic quiescence and activation phenomenon in wide area**

*Sumio Yoshikawa[1] (1.Meteorological Research Institute)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SSS09-02] Long-term Probability of a Great Earthquake along the Kurile Trench, Hokkaido Japan (2)

*Masajiro Imoto[1], Morilkawa Nobuyuki[1], Fujiwara Hiroyuki[1] (1.National Research Institute for Earth Science and Disaster Resilience)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SSS09-03] Parallel and Focused Increase Trends in Time Series (M-T Diagram) of Earthquake Occurrences

*Satoshi Hashimoto[1] (1.none)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SSS09-04] Revisiting a simple method for short-term earthquake probabilities derived from past Seismicity

*Mamoru Kato[1] (1.Graduate School of Human and Environmental Studies Kyoto University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SSS09-05] Recent anomalous groundwater temperature and water level changes at the frontier land zone of Nanki region for impending great earthquakes at the Nankai trough

*Tameshige Tsukuda[1] (1.none)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SSS09-06] What happen on the East Japan Megaquake; answer to sufferers

*Nobuaki Niitsuma[1] (1.Institute of Geosciences,Shizuoka University)

Objective evaluationof precursory seismic quiescence and activation phenomenon in wide area

*Sumio Yoshikawa[1]

1. Meteorological Research Institute

The 1995 Kobe earthquake of M7.3 is an earthquake known to have observed abnormal changes in seismic activity accompanied by various changes such as crustal deformation, groundwater and electromagnetism before the main shock. Especially Mogi (1995) pointed out the seismicity gap and the quiescent phenomenon of the seismic activity with a long-term and wide-area perspective. Yoshida (1995) pointed out the wide range of the preceding phenomena of seismic activity and showed that the area wider than the epicenter area is involved in the earthquake occurrence process. Therefore, if any prediction method is supposed, it is a problem how much accuracy it is possible to know based on such a preceding phenomenon in wide area.

eMAP is a tool to evaluate the appearance probability of seismic activity by Poisson's probability (Yoshikawa et al., 2017). In this method a region is set for each individual epicenter and the degree of abnormality is displayed in all regions. In order to consider the above problem, we examined the possibility of diagnosis of wide area seismic activity by this method.

By analysis of the quiescence and activation phenomenon in wide area during the Kobe earthquake, mainly in the Kinki, Chugoku and Shikoku districts, the following features were found. At that time, in the JMA seismic catalog before the unification, the magnitude threshold is considered to be around M 2.0 since 1988. The spatial distribution of the seismic activity has changed in a relatively short time scale and a stable pattern is not seen until 5 to 6 years before the main shock, but about 2 years before, a quiet phenomenon is confirmed in the area with the range of 50 km in the eastern part of Hyogo Prefecture. About a year before to the main shock, we can see activation in the epicenter area and a wide area surrounding it. This seems to be due to the small foreshock activity occurred along various active faults and geological lineaments. Based on this seismic sequence, it is possible to suppose a forecasting tactics as follows. First of all, by grasping the location and extent of the quiescence phenomenon, we assume the location and the scale of the main shock (Yoshikawa, 2015), and then estimate the urgency of earthquake occurrence by detecting the simultaneity of temporal changes.

Keywords: Kobe eq, Seismic quiescence and activation

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Long-term Probability of a Great Earthquake along the Kurile Trench, Hokkaido Japan (2)

*Masajiro Imoto[1], Morilkawa Nobuyuki[1], Fujiwara Hiroyuki[1]

1. National Research Institute for Earth Science and Disaster Resilience

Great earthquakes (M8 and larger) repeatedly occur along the Kurile Trench off Hokkaido. A much larger one in the 17-th century (17-th type earthquake) is indicated by studies of tsunami deposits, which is considered as representing the simultaneous of Tokachi-oki and Nemuro-oki earthquakes. The Earthquake Research Committee, the Government of Japan has reported the long-term probability of the 17-th type earthquake. We discuss the uncertainty of the long-term probability of the 17-th type earthquake, applying the method by Parsons (2008) to compare the likelihood of both the Brownian Passage Time distribution and the Poisson distribution for recurrent earthquakes. We adopted the seven probable ranges of origin times observed at Mochirippu-toh, and the five ranges at Kiritappu Marsh (Table 7 in the ERC report). Considering two probable ranges of 68% and 95% listed, two different functions of a origin time are adopted as weights; a modified Gaussian function and a step-function. The latter function is fixed so as to reserve the 68% and 95% probabilities in their ranges.
The likelihood ratios of the BPT model to the Poisson one are 0.70-0.79 for the Mochirippu-toh and 1.9-2.0 for the Kiritappu Marsh. The mean of the 17-th type earthquake probability in the next 30 years over the model parameters is about 11% for the Mochirippu-toh and around 21% for the Kiritappu Marsh. Only slight differences of both likelihood ratios and the thirty year probabilities among the three weight functions are observed.

Keywords: Great Earthquake, Kurile Trench, Probability

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Parallel and Focused Increase Trends in Time Series (M-T Diagram) of Earthquake Occurrences

*Satoshi Hashimoto[1]

1. none

Usually time sequence of earthquakes is not used as continuous variations because of special property of its occurrences. A few cases such as aftershocks and repeated earthquakes are attributed to continuous series. However, in a time series downloaded from HP of earthquake catalog continuous increase variations are seen clearly in almost all M-T diagrams, here M and T mean magnitude and occurrence time of earthquakes, respectively.

For example, since 2000 a time series of earthquake is shown under the conditions that M > 5.5, D (depth) < 50km, and main 4 islands of Japan with sea areas. In this series clear increase trend consisted from 13 earthquakes (M > 6) can be recognized on a time period from 2002 to 2005. Note that 3 points deviated largely from the straight line are excluded. Surprisingly the straight line connects roughly to the M9 of 2011/3/11 Tohoku-oki Earthquake. If we focus our attention to the increase trend, several lines with similar slope can be seen in other time durations since 2000. These lines are parallel with each other and interrupted at some value of M.

One more important character is seen in the M-T diagram since 2000. Before 2011/3/11 extrapolated more lines gather to the value M9 of Tohoku-oki Earthquake in detailed observations. These are called focused lines. Focused lines are coexisted with the parallel series. Both series are exhibited in whole time span of about 100 years of the catalog. The excluded points described above are probably included by other parallel or focused lines. In short, almost all earthquakes are included in many increase trends of earthquake time sequences.

Little work has be done to the regularity shown above. If several focused time series are found for a few and several years at present, extrapolation of the series will cross in near future. Just the crossing point is the predicted point.

In order to obtain further information about two kinds of the time series, several blocks of Japanese islands are analyzed together with sea areas. From the results two kinds of the time series can be seen in the all blocks. In a small region, increase trend of M~7 does not appear, but in a case of M~6, focused trends are also seen. This fact means that possibility of the prediction is successfully performed to M~6.

Appearance of two kinds of time series is not understood at present. Statistical rule of earthquake occurrences called G-R (Gutenberg-Richter) law is well known. This is one of the power laws, in which number of very large earthquakes are very small, and number of small earthquakes are order of magnitude greater than that of large earthquakes. Comparison of this law with the present results can give us important suggestion. This law does not include the factor of time. Present results shows linear increase trends are very simple but real time series are very complex. Time plays main role in the time series. G-R law is obtained from just after many earthquake occurrences. Present results do not show the individual earthquakes, but show continuous processes in earthquake preparation time span.

At the first stage of this study, present trends are presumably attributed to the constant rate of strain

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energy accumulation. However, this idea does not interpret the both parallel and focused trend in the time series. Namely mechanism that long time of several years are spent for accumulating the energy is not adequate in the present results. Perhaps critical state of the crust on the earth did exist hundreds of millions of years ago. At present the state can occur the earthquake both at all time and all places, crust give rise to the earthquake occurrences depending on the time durations. Trial of the prediction is now under planning, but origin of the mechanism is an important problem to be solved.

Keywords: M-T diagram, Earthhquake Time Series, Palallel Time Series, Focused Time Series

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Revisiting a simple method for short-term earthquake probabilities derived from past Seismicity

*Mamoru Kato[1]

1. Graduate School of Human and Environmental Studies Kyoto University

We revisit the method of Kato (2016, doi:10.4294/zisin.68.163) to estimate the probability that random earthquake predictions would hit using the seismicity data after 2011. When the seismicity rate is high, a random earthquake prediction without scientific evidence often becomes successful. Accidental, occasional hits will not guarantee that such methods of earthquake prediction are worthy of trust, and we should have a measure to judge whether the method is reliable. Kato (2016) proposed a method to roughly compute the probability that a random earthquake prediction accidentally hits. In this method, assuming that the rate of background seismicity is nearly constant in any period. This presentation is a follow-up to this study, and we reevaluate the method of Kato using the other seismicity data in Japan. We also revisit two probabilities of Utsu (1977) and argue how to make apparently successful earthquake predictions

Keywords: Earthquake prediction, seismicity

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Recent anomalous groundwater temperature and water level changes at the frontier land zone of Nanki region for impending great earthquakes at the Nankai trough

*Tameshige Tsukuda[1]

1. none

Earthquakes are generated by the anisotropic principal stress regime in the rock medium. In the preparing process of a large earthquake, the medium would be deformed generating regions of contraction and dilatation around the nucleus of the shearing stresses. According to a hydraulic model, pore fluid flow is driven upward to the ground surface through crack systems serving as flowing pipes by high pressure pumps at a deep spot. The change in the quantity of the upwelling hot water from deep underground causes a change of groundwater temperature(Tsukuda et al., 2005).
We have 16 groundwater observation stations for temperature, and 3 stations for water level in the Tokai and Nanki regions, central and southwest Japan, respectively, where are close to the source regions of the great Nakai-trough earthquakes. This paper reports the seismological meaning of the data from Nanki region.
At stations HA and WA in Shionomisaki, Nanki region, Wakayama Prefecture, the long-term trend of the water level is rising, corresponding to the ground subsidence found by levelling and GNSS data (Kobayashi, 2013). The trend of temperature is similarly rising, suggesting contraction of the rock medium under Shionomisaki, the southernmost end of Honshu. At KZ(Kozagawa)about 15km northeast of HA or WA in the Nanki region, the temperature is monotonously falling since the observation started in 2002. However, the decreasing temperature changed to severely increase in the middle of 2015, and changed to decrease again in 2017.
As mentioned above, the deformations of the rock medium are accelerated under the regions close to the source regions of the great erthquakes at the Nankai trough. For prediction studies for the impending great erthquakes, we should start to conduct detailed and multidisciplinary observations.

Keywords: dilatation, contraction , groundwater temperature, water level, precursor, earthquake prediction

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What happen on the East Japan Megaquake; answer to sufferers

*Nobuaki Niitsuma[1]

1. Institute of Geosciences,Shizuoka University

Significant change on stress field was appeared on Northeast Japan. The difference on stress field can be identified by Euler rotation of principal stress axes (Niitsuma, JpGU2015, s-ss27), and the stress fields rotated toward trench side in southeastern part of Northeast Japan but not in northwestern, comparing to stress field of Megaquake. The foci of Megaquake was located on the boundary of the rotation, which indicate the rotation was caused by Megaquake.

Hida area in the central Japan sits on the southwest extinction of the rotation boundary. Hida area had earthquakes from 6 February 2011, 10 days before foreshocks of Megaquake. The activity was complementary with the foreshocks, and the polarities of the stress field (Niitsuma, JpGU2017, sss05-P01) were normal, except the last of 6th March with reversed polarity, comparing with stress field of Megaquake. The maximum foreshock happened 3 days and mainshock of Megaquake 4 days later the polarity reversal, which means Hida area was a part of the constitution to block subduction of Pacific Plate along Japan Trench. The southwestern extinction of Hida area consistent of continental crust, connecting to Korean Peninsula, and the strain for Megaquake had been accumulated in the longest continental crust in Japan and Pacific Plate.

The activity of earthquakes can be converted to Plate relative motion, using area of earthquake fault S from the magnitude M based on log S =1.2M −9.9 (Matsuda,1975). The total area of earthquake faults in North East Japan from 1923/9/2 (just after Kanto Earthquake) to 2011/3/10 (just before East Japan Megaquake) is stepwise increasing on Benioff Chart and reaches to area of M9.0 as same for East Japan Megaquake. The area of relative Plate motion along the Japan Trench for the time interval is 9% less than the earthquake faults, which means the strain for East Japan Megaquake could not be accumulated after Kanto Earthquake, but before.

The area of earthquake faults in North East Japan reached to area for M9.0 before Kanto Earthquake 1923 from 1793, for which area of relative Plate motion was 1.34 of M9.0 and could accumulate strain of 0.34 for M9.0. The Plate motion is not enough for the strain of M9.0 which should be accumulated before 1793.

Because records on historical earthquakes in Northeast Japan are poor comparing with Southwest Japan, the ratio 1.65 on areas of historical earthquake faults in Northeast to Southwest Japan from 1793 to 1923 for calculation on corrected area of earthquake faults in Northeast Japan before 1793.

The corrected area of earthquake faults in Northeast Japan is 0.73 of M9.0 from 1611 to 1793, whose area of Plate motion is 2.06 in which 1.33 could be accumulated enough for the Megaquake. The history of strain accumulation indicates that the Megaquake strain could be kept after filled up with spending for usual earthquake.

Before Megaquake, the focal distribution around non seismic Megaquake foci indicates that rupture was reaching to Megaquake foci. The difference in magnitude of CMT to initial moment in CMT solutions for Hida-side were small than 0.4, which means the main moments were smaller than one forth of estimated

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moment from initial moment. Such magnitude differences were identified on the foreshock of Kumamoto Earthquake in April 2016.

Keywords: East Japan Megaquake, Area of earthquake fault, Area of relative plate Motion, Benioff Chart, Difference in Magnitude of Earthquake, Hida

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Wed. May 29, 2019 9:00 AM - 10:30 AM JST | Wed. May 29, 2019 12:00 AM - 1:30 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-SS14] Fault Rheology and Earthquake Physics

convener:Keishi Okazaki(Japan Agency for Marine-Earth Science and Technology), Hideki Mukoyoshi(Department of Geoscience Interdisciplinary Graduate School of Science and Engineering, Shimane University), Hiroyuki Noda(Kyoto University, Disaster Prevention Research Institute), Keisuke Yoshida(Tohoku University), Chairperson:Hideki Mukoyoshi, Shunya Kaneki(Osaka University)

The goal of this session is to integrate theoretical, experimental, observational, and numerical perspectives from various fields such as seismology, geodesy, geology, mineralogy, and so on, to define what is known about earthquake source processes and the physical and chemical elementary processes of faulting. This session welcomes studies that address such issues as pre-, co-, and post-seismic processes, the rheology of seismogenic faults and fault rocks, laboratory experiments on elementary processes, numerical models based on frictional laws, and estimates of the stress field in the seismogenic zones. We also welcome studies on fault-zone drilling projects and in situ stress measurements.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SSS14-07] Effect of slickenside on the crustal strength

*Jun-ichi Ando[1], Takayoshi Nagaoka[1], Naotaka Tomioka[2], Hiroyuki Kagi[3], Kaushik Das[1] (1.Department of Earth and Planetary Systems Science, Hiroshima University, 2.Kochi Institute for core sample research, Japan Agency for Marine-Earth Science and Technology, 3.Geochemical Research Center, Graduate School of Science, University of Tokyo)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SSS14-08] Dehydroxylation kinetics of clay minerals and its application to friction heating along an imbricate thrust in an accretionary prism

★Invited Papers

*Hirokazu Masumoto[1], Jun Kameda[1] (1.Faculty of Science, Hokkaido University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SSS14-09] Origin of frictional melt in the Jurassic accretionary complex of the Mino Belt on the basis of trace element and isotope analysis

*Chizuru Ozawa[1], Tsuyoshi Ishikawa[2], Kohtaro Ujiie[1] (1.University of Tsukuba, 2.JAMSTEC)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SSS14-10] Geochemical constraint on the origin of albite-bearing black fault rocks in the Kodiak accretionary complex

*Tsuyoshi Ishikawa[1], Asuka Yamaguchi[2] (1.Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology, 2.AORI, The University of Tokyo)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SSS14-11] Importance of initial maturity and reaction kinetics on maturation of carbonaceous material and its implications for thermal maturity as a proxy for temperature in estimation of coseismic slip parameters

*Shunya Kaneki[1], Ichiba Tatsuya[1], Shuhei Yamashita[1], Tetsuro Hirono[1] (1.Graduate School of Science, Osaka University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SSS14-12] Experimental investigation of cumulative effect on thermal maturation of carbonaceous material as a proxy for earthquake slip

*Tetsuro Hirono[1], Yuhtaro Shimamura[1], Shunya Kaneki[2] (1.Department of Earth and Space Science, Graduate School of Science, Osaka University, 2.Disaster Prevention Research Institute, Kyoto University)

Effect of slickenside on the crustal strength

*Jun-ichi Ando[1], Takayoshi Nagaoka[1], Naotaka Tomioka[2], Hiroyuki Kagi[3], Kaushik Das[1]

1. Department of Earth and Planetary Systems Science, Hiroshima University, 2. Kochi Institute for core sample research, Japan Agency for Marine-Earth Science and Technology, 3. Geochemical Research Center, Graduate School of Science, University of Tokyo

Slickenside is a glossy and smoothly surface developed on the fault slip plane. Although the slickenside is a common and well-known microstructure, its microstructural characterization and effect on the fault behaviour have not fully studied so far. To understand these points, we characterized the microstructures of natural samples and conducted the frictional experiments. The recovery samples from the experiments were also characterized.

Samples and experiment: The natural samples we characterized were slickensides found on the following rocks collected from several localities. 4-Cherts, 3-Limestones, 1-Amphibolite, 1-Serpentinite, 1-Chromitite, 1-Sandstone, 2-Mudstones, 1-Coaly mudstone and 1-Tuff breccia. The frictional experiments were conducted using limestone and gabbro blocks, and calcite powder with 45 to 75 μm in grain size, with a biaxial friction apparatus. The experimental conditions were 3 - 80 MPa of normal stress, 0.1 m/s and 30 μm/s of slip velocity. The characterization methods of samples were optical microscopy, SEM, TEM, AFM and XANES measurements.
Results and conclusion: The present characterization of natural samples demonstrates that the slickenside is composed of nano-size grains, whose aspect ratio (h/d) of height (h) and diameter (d) is constant at about 0.02 –0.05 for each sample. These nano-size grains can be identified as same minerals, not amorphous, composed of the parent rocks with some minor exceptions. This fact indicates that the nano-size grains were created during fault slip only by grinding of parent rocks without any reaction including the heating-induced reaction. Therefore, our first conclusion is that the slickenside is a product of aseismic faulting. The slickensides were created by all frictional experiments. The characteristics of these slickensides are same as those of natural samples described above. The interesting results are that the aspect ratio (h/d) of nano-size grains is constant for each experiment and tends to decrease with increasing normal stress from ca. 0.23 to ca. 0.07. The h/d values of nano-size grains composed of natural samples are much smaller than those of the recovered samples, which suggests that the studied natural slickensides were created by faulting at the higher normal stress conditions than at least 80 MPa, and preserved during exhumation from original depth to earth’ s surface. This consideration indicates that the fault having slickenside exists at depth corresponding to at least 80 MPa normal stress, ca. 3 km and more. The experimental results using limestone block having pre-existing mirror polished slip plane show that the static and dynamic friction coefficients are very low, ca. 0.3 and 0.2, respectively. In general, it is believed that the frictional sliding on pre-existing fault governs the crustal strength. Therefore, our second conclusion is that the slip behaviour of fault having slickenside might governs the crustal strength. However, the experiments using gabbro block did not show the low static and dynamic friction coefficients. Hence the further detail experiments using simulated slickenside are needed to understand the crustal strength.

Keywords: Slickenside, Nano-size grain, Shear experiment, Fault strength

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Dehydroxylation kinetics of clay minerals and its application to friction heating along an imbricate thrust in an accretionary prism

*Hirokazu Masumoto[1], Jun Kameda[1]

1. Faculty of Science, Hokkaido University

Dehydroxylation of clay minerals within fault gouges is significant for assessing transient thermogenesis due to high-velocity, frictional slip along fault zones. The clay minerals kaolinite and chlorite are common in fault zones hosted in sedimentary rocks at subduction margins. To better understand the dehydroxylation processes of these clay minerals, high-temperature X-ray diffraction (XRD) analyses were carried out by using a 1:1 mixture of kaolinite and chlorite standard samples. We evaluated the kinetic parameters of each dehydroxylation reaction by thermogravimetric analysis Thermal models of frictional heating employing this calibration show that the frictional heating can explain the reported clay mineralogy in a fossil imbricate thrust from a shallow part in an ancient accretionary prism (Shirako Fault, Japan). This result supports the previous assertion, and the observed temperature anomaly appears to demonstrate the frictional heating caused by coseismic slip on this fault.

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Origin of frictional melt in the Jurassic accretionary complex of the Mino Belt on the basis of trace element and isotope analysis

*Chizuru Ozawa[1], Tsuyoshi Ishikawa[2], Kohtaro Ujiie[1]

1. University of Tsukuba, 2. JAMSTEC

Pseudotachylytes (solidified frictional melts) in exhumed accretionary complexes have great significance for understanding the dynamics of earthquake faulting in subduction zones. However, they are rarely preserved in a recognizable form mainly due to subsequent hydrothermal alteration. Recently, a pseudotachylyte was found in the Jurassic accretionary complex of the Mino Belt, central Japan. The pseudotachylyte is ~2 mm-thick and separates gray chert above from cataclasite below. Although the pseudotachylyte has been hydrothermally altered, its microstructures are characterized by presence of fault and injection veins, intensely cracked gray chert fragments incorporated from wall rocks, and locally embayed and rounded wall rocks, suggesting thermal cracking and thermal erosion associated with increased heating. Here, we analyzed major and trace elements and Sr and Pb isotopes of the milligram-level samples taken by micro-milling technique along the structures of the pseudotachylyte, cataclasite and gray chert, as well as the black chert and black carbonaceous mudstone near the pseudotachylyte. The pseudochylyte exhibits remarkably high trace element concentrations compared to those of gray chert. The trace element composition of the pseudotachylyte requires the involvement of black carbonaceous mudstone as well as gray chert, suggesting that the frictional melt originated from the mixture of gray chert and black carbonaceous mudstone. Based on major and trace element chemistry, the mixing ratio is estimated to be ~50–60% of gray chert and ~40–50% of black carbonaceous mudstone, and the ratio is consistent with the Sr and Pb isotope compositions. Despite the hydrothermally alteration, the chemistry of the pseudotachylyte well preserves melt-derived characteristics, thus provides useful information for understanding the frictional melting on faults and its source materials.

Keywords: pseudotachylyte, frictional melting, trace element analysis

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Geochemical constraint on the origin of albite-bearing black fault rocks in the Kodiak accretionary complex

*Tsuyoshi Ishikawa[1], Asuka Yamaguchi[2]

1. Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology, 2. AORI, The University of Tokyo

The Pasagshak Point thrust in the Kodiak accretionary complex is considered to represent the paleo-plate-boundary décollement at seismogenic depths. The fault rocks in this thrust consist of cataclasites and ultrafine-grained black fault rocks (BFRs), and the latter makes up the principal shear zones (Rowe et al., 2005; Meneghini et al., 2010). The BFRs contain crystalline microlayers characterized by the presence of fine-grained albitic plagioclase (Meneghini et al., 2010). Previously Yamaguchi et al. (2014) showed that the trace element characteristics of BFRs are consistent with the occurrence of fluid-rock interactions at >350 deg. C. Here we present further trace element and isotope analyses on the same samples, and re-examine the data in detail. Plagioclase abundances (albite + anorthite) calculated from major element compositions are distinctly higher in BFRs than in host rocks and cataclasites. Distinctly high Sr concentrations and low 87Sr/86Sr ratios observed in BFRs are well correlated with the plagioclase abundances. This indicates that the petrogenesis of BFRs requires additions of Na and Sr derived from external sources, possibly migrating saline fluids. The 87Sr/86Sr ratio estimated for end-component fluid is as low as 0.705, strongly suggesting the involvement of fluids from basaltic source. Li isotope ratios of BFRs are also consistent with equilibration with basalt-derived fluids. Thus, it is likely that saline fluids largely derived from basaltic oceanic crust of the lower plate migrated through the plate boundary décollement, and frictional heating combined with comminution induced high-temperature fluid-rock interactions at >350 deg. C to produce the unique geochemical characteristics observed for BFRs.
Refs: Meneghini et al. (2010) GSA Bull., 122, 1280-1297; Rowe et al. (2005) Geology, 33, 937-940; Yamaguchi et al. (2014) Earth Planet Space, 66:58.

Keywords: fault rocks, geochemistry, fluid-rock interactions, plate-boundary faults, accretionary complex

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Importance of initial maturity and reaction kinetics on maturation of carbonaceous material and its implications for thermal maturity as a proxy for temperature in estimation of coseismic slip parameters

*Shunya Kaneki[1], Ichiba Tatsuya[1], Shuhei Yamashita[1], Tetsuro Hirono[1]

1. Graduate School of Science, Osaka University

Most of total seismic energy during earthquake slip is considered to convert into frictional heat, which activates many physicochemical reactions in faults. Various thermal indicators for detecting frictional heat recorded in fault rocks have been suggested, such as formation of pseudotachylyte and thermal transformation of fault-forming minerals. Among these reactions, thermal maturation of carbonaceous materials (CM) has been received a considerable attention, because CM changes its maturity in response to ambient temperature even with short-term heating duration.

On the basis of these backgrounds, CM maturity has been applied to estimate maximum temperature and coseismic slip parameters experienced by various faults during earthquakes (e.g., Hirono et al., 2015; Kaneki et a., 2016). These studies, however, may contain several concerns when evaluating amount of frictional heat from CM maturity: (1) mechanochemical effect, (2) kinetic effect of heating rate, (3) effect of initial maturity, and (4) cumulative effect of repeated earthquakes. Recently, Kaneki et al. (2018) and Kaneki and Hirono (2018) experimentally investigated the impacts of (1) and (2), and suggested that kinetic effects of both shear-induced mechanochemistry and heating rate can strongly dominate maturation process of CM, indicating that such kinetic effects should be considered to establish CM as a more rigorous fault geo-thermometer. However, the impacts of (3) and (4) on CM maturation process still remain unknown, leading to uncertainties in estimation of maximum temperatures from CM maturity.

In this study, we aim to understand the impact of (3) on CM maturation process and its implication for CM-based fault geo-thermometer. We adopted four grades of CM for our starting materials (lignite, bituminous coal, anthracite, and graphite), and performed low-velocity friction experiments with slip rate of 1 mm $s^{-1}$and normal stresses of 1 and 3 MPa under dry condition, to reproduce coseismic shear damage on CM samples without frictional heating. We then conducted heating experiments on both intact and sheared CM samples with targeted temperatures of 100, 200, 300, ..., 1300 ˚C (100 ˚C interval) and heating rates of approximately 1 and several hundreds of ˚C s^{-1}. We finally carried out infrared and Raman spectroscopies to evaluate maturity of both intact CM samples and products after friction and heating experiments. The results show that mechanochemical effect can enhance maturation process of lignite by ~100 ˚C whereas no significant difference between maturities of intact and sheared CM samples are present in bituminous coal, anthracite, and graphite. All CM samples, except for graphite that showed no significant change in maturity with heating, show higher reaction temperature by ~500 ˚C in heating experiments with higher heating rate. These results indicate that kinetic effects of both mechanochemistry and heating rate affect CM maturation process and the effects depends on initial maturity of CM. Thus, by taking consideration into initial maturity and kinetic effects, thermal maturation of CM could be an universal proxy for temperature in estimation of coseismic slip parameters.

Keywords: Earthquake, Carbonaceous material, Frictional heat, Initial maturity, Chemical kinetics

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Experimental investigation of cumulative effect on thermal maturation of carbonaceous material as a proxy for earthquake slip

*Tetsuro Hirono[1], Yuhtaro Shimamura[1], Shunya Kaneki[2]

1. Department of Earth and Space Science, Graduate School of Science, Osaka University, 2. Disaster Prevention Research Institute, Kyoto University

Estimation of the maximum temperature recorded in fault rocks gives us important information about earthquake enegetics and fault slip behavior, because the frictional heat is directly related to dynamic parameters and to fault-weakening mechanisms. The thermal maturity of carbonaceous material (CM) has received considerable attention as a new temperature proxy because the organochemical characteristics of CM change irreversibly with increasing temperature. Various approaches by using infrared and Raman spectroscopies, elemental composition analyzer, biomarker method, and vitrinite reflectance measurement have been performed. However, for more accurate estimation of frictional heat, not only shear-enhanced mechanochemical effects but also chemical kinetics should be considered. In particular, cumulative effect by repeated earthquake events, related to the kinetics of the maturation, has not well understood. Here we demonstrated repeated heating events on bituminous coal and anthracite by using a tube furnace. We heated the samples 1, 10, and 100 times under conditions of 100, 300, 500, 700, 900, 1100, and 1300 degree C and 40-s heating duration, and conducted infrared and Raman spectroscopic analyses on the samples after heating. The disappearance of aliphatic C-H at 500 degree C were observed on all samples, and the intensity ratio of D and G bands on the Raman spectra of all samples increased beyond 700 degree C. Thus, we could conclude no significant cumulative effect on the thermal maturation of CM under rapid heating, indicating that the detected temperature on a fault corresponds to the largest earthquake slip event.

Keywords: fault, carbonaceous material, frictional heat

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Wed. May 29, 2019 10:45 AM - 12:15 PM JST | Wed. May 29, 2019 1:45 AM - 3:15 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-SS14] Fault Rheology and Earthquake Physics

convener:Keishi Okazaki(Japan Agency for Marine-Earth Science and Technology), Hideki Mukoyoshi(Department of Geoscience Interdisciplinary Graduate School of Science and Engineering, Shimane University), Hiroyuki Noda(Kyoto University, Disaster Prevention Research Institute), Keisuke Yoshida(Tohoku University), Chairperson:Hiroyuki Noda(DPRI, Kyoto University), Keishi Okazaki(JAMSTEC)

The goal of this session is to integrate theoretical, experimental, observational, and numerical perspectives from various fields such as seismology, geodesy, geology, mineralogy, and so on, to define what is known about earthquake source processes and the physical and chemical elementary processes of faulting. This session welcomes studies that address such issues as pre-, co-, and post-seismic processes, the rheology of seismogenic faults and fault rocks, laboratory experiments on elementary processes, numerical models based on frictional laws, and estimates of the stress field in the seismogenic zones. We also welcome studies on fault-zone drilling projects and in situ stress measurements.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SSS14-13] **Fault rheology at the depth limits of the seismogenic zone**

★Invited Papers

*Berend Antonie Verberne[1] (1.Geological Survey of Japan, National Institute of Industrial Science and Technology)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SSS14-14] Fault models revisited based on friction to flow law

*Toshihiko Shimamoto[1] (1.State Key Laboratory of Earthquake Dynamics, Institute of Geology, China Earthquake Administration)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SSS14-15] Timing of Earthquakes on Intraplate Active Faults Subjected to Stress Perturbation by Megathrust Earthquakes: Insights from Earthquake Sequence Simulation

*Hiroyuki Noda[1] (1.Kyoto University, Disaster Prevention Research Institute)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SSS14-16] Physics of earthquake triggering: effect of stress perturbation to slip acceleration

★Invited Papers

*Takahiro Hatano[1] (1.Earthquake Research Institute, University of Tokyo)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SSS14-17] Foreshock activities controlled by slip rate on a 4-meter-long laboratory fault

*Futoshi Yamashita[1], Eiichi Fukuyama[1], Shiqing Xu[1] (1.National Research Institute for Earth Science and Disaster Resilience)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SSS14-18] Supersonic propagation of slow slip rupture during rock friction experiments

*Eiichi Fukuyama[1], Futoshi Yamashita[1], Shiqing Xu[1] (1.National Research Institute for Earth Science and Disaster Resilience)

Fault rheology at the depth limits of the seismogenic zone

*Berend Antonie Verberne[1]

1. Geological Survey of Japan, National Institute of Industrial Science and Technology

The limits of the seismogenic zone demarcate changes in fault behaviour with increasing depth in Earth’ s crust, from aseismic, velocity (*v*-)strengthening to seismogenic, *v*-weakening, and vice versa. Significantly, the *v*-dependence of fault strength is a material property of the sliding medium present in the core of fault, or the fault gouge. I conducted shear tests using simulated fault gouge composed of calcite ($CaCO_3$) at an effective normal stress of 50 MPa, at temperatures of 20 to 600ºC, employing sliding velocities (*v*) of 0.03 to 300 μm/s –sufficient to span the brittle-plastic transition in this material. Mechanical results showed (unstable) *v*-weakening behaviour from ~80-100ºC to ~550ºC, but stable *v*-strengthening for <80-100ºC and >550ºC. All gouges sheared at temperatures <=550˚C showed localization into nanocrystalline principal slip zones, while samples sheared at >550˚C were characterized by distributed deformation. Using the post-test micro- and nanostructures observed in calcite gouge as a basis, plus a previously established microphysical model, I argue that transitions in fault stability are caused by changes in the (nano)granular flow processes accommodating shear. Specifically, the rate of intergranular compaction by Arrhenius-type processes such as diffusion or crystal plasticity, is key to thermally-activated transitions in the velocity dependence of gouge-filled faults. At the low-temperature transition from *v*-strengthening to *v*-weakening, at shallow crustal levels representing the upper-limit of the seismogenic zone, diffusion creep (e.g. pressure solution) may be dramatically accelerated due to the nanogranular nature of the fault rock that forms. At higher temperatures, towards the base of the seismogenic zone, a transition occurs from nanogranular flow in localized faults to distributed, fully creep-controlled flow in ductile shear zones.

Keywords: earthquake, seismogenic zone, rheology, nanograins, localization, brittle-ductile

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Fault models revisited based on friction to flow law

*Toshihiko Shimamoto[1]

1. State Key Laboratory of Earthquake Dynamics, Institute of Geology, China Earthquake Administration

Friction to flow law (Shimamoto and Noda, 2014, JGR) can describe a transition from friction to flow using only friction and flow parameters, and shear zone width *w*. Friction and flow laws are described in terms of velocity and displacement, and shear strain rate and shear strain, respectively, and *w* is needed to relate velocity and shear strain rate to merge the two laws. The friction to flow law is a mixing law connecting friction and flow laws smoothly, and no other parameters are required probably because no new deformation mechanisms operate in the intermediate regime. In JpGU last year, Shimamoto and Noda argued (i) that the velocity dependency of shear resistance is by far the most heterogeneous in the intermediate regime between friction and flow, and (ii) that frictional patches can be surrounded by viscous matrix in the middle part of lithosphere because temperature for the onset of flow depends on rock types. This presentation will discuss (1) how fault models change in view of the friction to flow law, (2) how to construct realistic mechanical models of faults and plate boundaries that are usable in modelling earthquake generation, and (3) how to reproduce friction to flow transition for important rocks in laboratory.

Shimamoto and Noda (cited above) already discussed a revised fault model using results from earthquake modelling based on friction to flow law. A new problem addressed here is a question which of power law (dislocation creep) and grain-size sensitive flow law (diffusion creep or superplasticity) should be used as a flow law to describe fault properties. The latter law has often be favoured because the cores of deep shear zones are often composed of very fine-grained ultramylonites, grain size being on the order of microns or even smaller. Both flow laws are determined for calcite and plagioclase (Heard and Raleigh, 1972, GSA Bull.; Schmit et al., 1977, Tectonophysics; Rybacki and Dresen, 2000, JGR). Thus, strength profiles were constructed with the friction to flow law, assuming $w = 0.1 \sim 10$ m and velocity = 10 mm/yr. Results clearly show that diffusion creep occurs at lower stresses for both minerals (although this is not the case in laboratory experiments). Power-law creep is expected in the middle and lower parts of lithospheres, whereas diffusion creep is expected to be dominant in fault and plate-boundary zones. Thus, frictional patches can be surrounded by linear or nearly linear viscous flow matrix at some depths, and this can be quite important in analysing low-frequency earthquakes and slow slips.

Traditional fault models, started from Sibson (1977, J. Geol. Soc. London), have proposed how materials controlling friction and flow properties, types of fault rocks reflecting deformation mechanisms, and fault geometry such as fault and shear zone widths changes with increasing depth. Such models are bases for constructing realistic mechanical models for faults and plate boundaries. However, the models alone are not usable in modelling earthquakes and plate-boundary behaviours. Friction to flow law captures essential changes in fault properties with depth in a very simplified manner. Both transient and steady-state properties are included and the law can be used in earthquake modelling. However, the law for single material can never describe complex and variable properties of faults and plate boundaries. I want to discuss what has to be done to connect fault and earthquake studies, as much as possible in my presentation. Here I point out the importance of three problems; (I) to check if the friction to flow laws holds for important rocks or not in laboratory experiments, (II) to determine flow laws for important rocks constituting fault and plate-boundary zones, and (III) to determine transient flow properties in flow laws (see Noda and Shimamoto, 2010, GRL). I will give apparatus capabilities required for (I). Unfortunately,

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there are only small amount data on (II) and (III).

Keywords: Friction to flow law, fault rheology, earthquake mechanisms

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Timing of Earthquakes on Intraplate Active Faults Subjected to Stress Perturbation by Megathrust Earthquakes: Insights from Earthquake Sequence Simulation

*Hiroyuki Noda[1]

1. Kyoto University, Disaster Prevention Research Institute

Estimation of likelyhood of occurrence of intraplate large earthquakes is crutially important because of expected large amplitude of ground motion in nearby cities and short distance between source and human society which makes earthquake early warning difficult. Currently issued National Seismic Hazard Maps for Japan [2018, the Headquarter for Earthquake Research Promotion] adopts assumptions of Poisson process or Brownian passage time distribution depending on available information for each active fault. They yield rather wide distribution of temporal probability density for a timescale of the reccurence interval or the estimation error of history of events. The timelscale is typicaly much longer than recurrence intervals of megathrust earthquakes T_{cyc} which causes semi-periodic stress perturbation to intraplate faults. In the present study, effects of the semi-periodic stress perturbation to an intraplate active fault having a ductile shear zone beneath the seismogenic part [e.g., Shimamoto and Noda, 2014] are investigated by means of dynamic earthquake sequence simulation using a spectral boundary integral method [e.g., Lapusta et al., 2000].

Utsu [1974] pointed out that historical earthquakes in Southwest Japan are concentrated in -50 and +10 years from Nankai trough megathrust earthquakes. Such active periods of intraplate earthquakes may be due to semi-periodic stress perturbation by the megathrust earthquakes [e.g., Hori and Oike, 1996; Shikakura et al., 2014]. An important question is how its duration is scaled for different tectonic settings. T_{cyc} of megathrust earthquakes in Japan trench subduction zone is 500-800 years [e.g., Sawai et al., 2015] and much longer than in Nanka trough. Parameter studies on T_{cyc} and amplitude of the stress perturbation have been conducted to elucidate what controls the timing of intraplate earthquakes.

A 2D numerical simulation of a strike-slip fault [e.g., Lapusta et al., 2000] with ductile shear zone was considered as a model for an intraplate fault, accounting for a friction-to-flow fault constitutive law [Shimamoto and Noda, 2014] composed of the aging law and a quartzite flow law [Hirth et al., 2001], and effective normal stress distribution with maximum value of 50 MPa. The model was drived by far-field shear stress which was perturbed as a sawtooth wave function of variable amplitude about 1 MPa and T_{cyc} from 100 to 1000 years. If the perturbation was perfectly periodic, the system synchronized with the perturbation and the intraplate earthquakes ocurr at a specific phase in the cycle of megathrust earthquakes. If the interval was randomized by Gaussian distribution of 10% standard deviation, then the timing of the intraplate earthquakes distributed more widely, and concentrate in the latter half of the cycle, consistently with the notion of the active period. The shape of the distribution can be explained by a seismicity model based on ΔCFF [e.g., Shikakura et al., 2014], not by a rate-and-state spring-slider model [Dieterich, 1994; Ader et al., 2014]. The result of the parameter study suggests that not only the history of the activity of the fault, but also stress change on it due to recurring megathrust earthquakes or other events may be useful in constrainig the likelihood of intraplate earthquakes.

Keywords: Intraplate earthquakes, Earthquake sequense simulation, Brittle-plastic transition

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Physics of earthquake triggering: effect of stress perturbation to slip acceleration

*Takahiro Hatano[1]

1. Earthquake Research Institute, University of Tokyo

Recent observation studies have revealed that the occurrence of tremors is sensitive to faint stress changes such as ocean tides. This might not be surprising in light of the low stress drop caused by tremors. Interestingly, however, ordinary earthquakes too may be sensitive to weak stress perturbations, although it is not so common as for tremors. Dynamic triggering should be the most prominent illustration of such sensitivity, but the occurrence of ordinary earthquakes could be also correlated to ocean tides, snowfalls, and rainfalls.

To understand such sensitivities to stress perturbation in a unified point of view, here we analyze the rupture nucleation process on a fault subject to weak periodic stress modulation. Assuming the rate- and state-dependent friction law with one state variable, we calculate the threshold amplitude above which the rupture initiation exhibits correlation with the perturbation phase. It is found that the crack-like nucleation is more sensitive to the perturbations than the patch-like nucleation. The estimated threshold amplitude for the crack-like nucleation is significantly lower than the tidal stress change. Time-to-failure for the both nucleation types in the presence of perturbation is estimated, and it is not significantly affected by the stress perturbation. We also discuss the optimum frequency at which the correlation is enhanced.

Keywords: earthquake triggering

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Foreshock activities controlled by slip rate on a 4-meter-long laboratory fault

*Futoshi Yamashita[1], Eiichi Fukuyama[1], Shiqing Xu[1]

1. National Research Institute for Earth Science and Disaster Resilience

We report foreshock activities associated with evolving local slow slip events preceding the main rupture on a laboratory fault. To investigate the preparation process of laboratory earthquake with enough spatial resolution, we used a large-scale friction apparatus newly developed and installed at National Research Institute for Earth Science and Disaster Resilience (NIED) as shown in Figure 1. We used two rectangular metagabbro blocks as experimental specimens, whose nominal contacting area was 4.0 m long and 0.1 m wide. Height of each specimen was 0.2 m. Normal load was applied by eight flat jacks on the top surface of the upper specimen, and the associated pressures were kept at around 6 MPa during the experiments. After applying normal load, we applied shear load to the side surface of the lower specimen by manually pumping up a hydraulic jack, which was fixed at the western end of the apparatus. To monitor local phenomena on the fault, we installed 16 AE sensors, 40 triaxial rosette strain gauges, and 10 eddy current displacement sensors along the fault. We conducted experiments with relatively high shear loading rate (67-185 kPa/s) and low shear loading rate (2-7 kPa/s). In each experiment, displacement data showed that both the eastern and western edges of the fault kept slipping during the shear loading, though the slip rate was very low (< ~20 μm/s). It is consistent with FEM calculation that fault should start to slip at both edges in this configuration. This steady slip was significant during the experiments with low loading rate, in both quantity and area. However, such steady slip did not immediately trigger seismic events. Most of seismic events occurred just before the main rupture, and therefore should better be termed foreshocks. To understand what controls the occurrence of foreshocks, we first investigated the amount of stable slow slip accumulated after the previous main rupture. We found that foreshocks were not activated at around both fault edges even after the accumulated slip attained around 10 μm there (Figure 2a). On the other hand, foreshocks occurred around the central locked area with only a small amount of slip. We next compared the spatiotemporal distribution of foreshocks with that of slip rate. Displacement and strain data indicated that precursory slow slip began at the central locked area and then propagated outward over the fault area preceding the main rupture. We found that this slow slip had caused high slip rate (several hundreds of μm/s), which coincided with the occurrence of foreshocks (Figure 2b). These observations suggest that the key factor controlling the occurrence of foreshocks in this experiment is not the amount of accumulated slip but that of slip rate. The mechanism may be associated with the unstable fault slip triggered by fast loading in the laboratory (McLaskey and Yamashita, 2017, JGR; Xu et al., 2018, Tectonophysics), and the seismicity episodically activated in nature such as emergence of repeating earthquakes due to increased loading rate by afterslip of the 2011 *M*9.0 Tohoku-oki earthquake (Hatakeyama et al., 2017, JGR).

Keywords: Rock friction experiment, Slow slip, Foreshock, Slip rate

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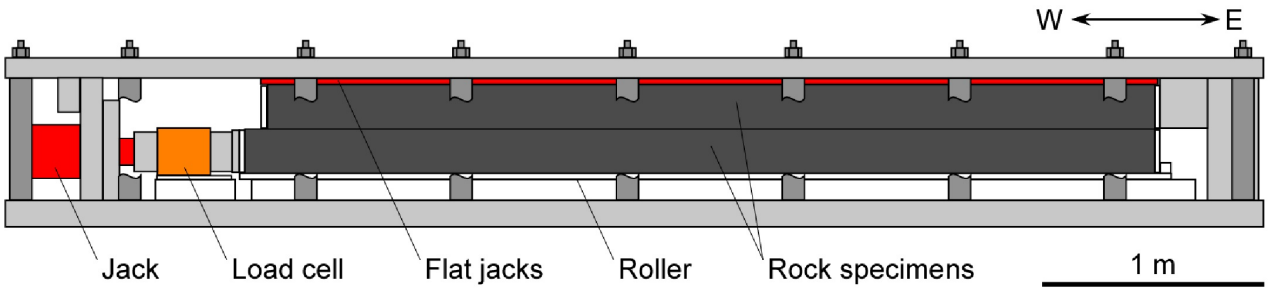


Figure 1

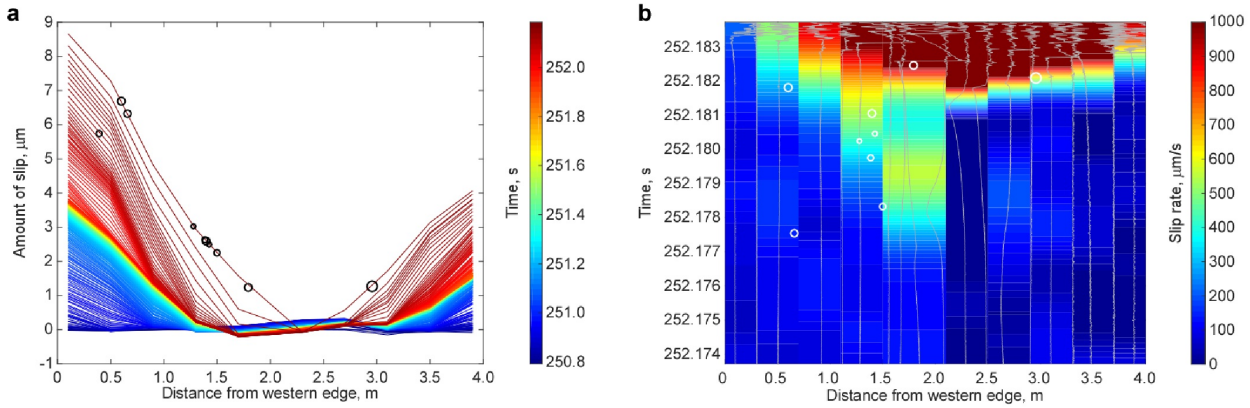


Figure 2

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Supersonic propagation of slow slip rupture during rock friction experiments

*Eiichi Fukuyama[1], Futoshi Yamashita[1], Shiqing Xu[1]

1. National Research Institute for Earth Science and Disaster Resilience

Rupture propagation speed on the fault has been considered to be slower than elastic wave velocities of the material. Exceptions were when extremely high energy is imposed, much higher than the fracture energy needed for the rupture to advance. The rupture propagating faster than the elastic velocities is called supersonic rupture. We observed such supersonic rupture propagation of slow slip events during large scale rock on rock friction experiments on a 1.5×0.1 m^2 fault using Indian metagabbro rock specimens. Such slow slip events were accompanied by low frequency vibrations whose onsets were synchronized with those of slow slip events; they also propagated faster than the elastic wave velocities of the rock. Since typical precursory slow slip and coseismic slip events have been observed on the same fault in a sequence of the friction experiment, the slow slip events with supersonic rupture might share the same friction environment as that for the typical preslip-mainshock type events. We interpret this phenomenon as an occurrence of non-linear deformation of a very thin layer on the fault surface. For linear deformation case, the limitation of propagation velocity comes from the elastic property of rock specimens, but non-linear deformation can propagate independently of the material elastic constants but the propagation velocity tend to be proportional to the strain rate. In addition, because there are several similarities between the present observation and the slow slip events observed in the subduction zone worldwide, it may provide a clue to understand these phenomena.

Keywords: supersonic rupture proapgation, rock friction experiment, slow slip event

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Wed. May 29, 2019 1:45 PM - 3:15 PM JST | Wed. May 29, 2019 4:45 AM - 6:15 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-SS14] Fault Rheology and Earthquake Physics

convener:Keishi Okazaki(Japan Agency for Marine-Earth Science and Technology), Hideki Mukoyoshi(Department of Geoscience Interdisciplinary Graduate School of Science and Engineering, Shimane University), Hiroyuki Noda(Kyoto University, Disaster Prevention Research Institute), Keisuke Yoshida(Tohoku University), Chairperson:Hiroyuki Noda(DPRI, Kyoto University), Keisuke Yoshida(東北大学大学院理学研究科 地球物理学専攻)

The goal of this session is to integrate theoretical, experimental, observational, and numerical perspectives from various fields such as seismology, geodesy, geology, mineralogy, and so on, to define what is known about earthquake source processes and the physical and chemical elementary processes of faulting. This session welcomes studies that address such issues as pre-, co-, and post-seismic processes, the rheology of seismogenic faults and fault rocks, laboratory experiments on elementary processes, numerical models based on frictional laws, and estimates of the stress field in the seismogenic zones. We also welcome studies on fault-zone drilling projects and in situ stress measurements.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SSS14-19] The role of fault damage zone in the supershear rupture of the 2018 Mw 7.5 Palu earthquake

*Lingsen Meng[1], Han Bao[1], Jean-Paul Ampuero[2], Eric Fielding[3], Cunren Liang[4], Christopher Milliner [3], Tian Feng[1], Hui Huang[1] (1.University of California Los Angeles, 2.Université Côte d'Azur and IRD, 3.Jet Propulsion Laboratory , 4.California Institute of Technology)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SSS14-20] The role of curvature in earthquake mechanics

*Pierre Romanet[1], Daisuke Sato[2], Ryosuke Ando[1] (1.Earth and Planetary Science Department, University of Tokyo, 2.Disaster Prevention Research Institute, Kyoto University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SSS14-21] **Heterogeneous source modelling by the fully dynamic simulations of earthquake cycles on a strike-slip fault and scaling relations.**

*Percy Galvez[1,5], Anatoly Petukhin[2], Paul Somerville[3], Ken Miyakoshi[2], Kojiro Irikura[4] (1.KAUST University, Saudi Arabia, 2.Geo-Research Institute, Osaka Japan, 3.AECOM, Los Angeles, USA., 4.Aichi Institute of Technology, Japan, 5.ETH Zurich, Switzerland)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SSS14-22] **Strain energy released by an earthquake: Contributions of random slip fluctuations**

*Tatsuhiko Saito[1], Akemi Noda[1] (1.National Research Institute for Earth Science and Disaster Resilience)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SSS14-23] The change in the elastic strain energy due to the 1992 Landers earthquake and triggering mechanisms of aftershock activity

*Toshiko Terakawa[1], Mitsuhiro Matsu'ura[2], Akemi Noda[3] (1.Graduate School of Environmental Studies, Nagoya University, 2.Institute of Statistical Mathematics, 3.National Research Institute for Earth Science and Disaster Resilience)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SSS14-24] Toward understanding generation mechanism of crustal earthquakes based on accumulation/release of elastic strain energy

★Invited Papers

*Akemi Noda[1] (1.National Research Institute for Earth Science and Disaster Resilience)

The role of fault damage zone in the supershear rupture of the 2018 Mw 7.5 Palu earthquake

*Lingsen Meng[1], Han Bao[1], Jean-Paul Ampuero[2], Eric Fielding[3], Cunren Liang[4], Christopher Milliner [3], Tian Feng[1], Hui Huang[1]

1. University of California Los Angeles, 2. Université Côte d'Azur and IRD, 3. Jet Propulsion Laboratory , 4. California Institute of Technology

The powerful M 7.2 earthquake that shock the Sulawesi island of Indonesia on September 28, 2018, was a seismic standout for many reasons, not the least of which is that it triggers tsunami and landslides and causes major life and economic loss in the city of Palu. In this study, integrated geophysical observations of the 2018 Mw 7.5 Palu, Indonesia earthquake, provide robust evidence of an early and persistent supershear rupture speed. Slowness-enhanced back-projection (SEBP) of teleseismic data provides a sharp image of the rupture process, consistently across multiple arrays. The inferred rupture path agrees with the surface rupture trace inferred from the net surface displacement field derived by sub-pixel InSAR image correlation. The SEBP results indicate a sustained rupture velocity of 4.1 km/s from the rupture initiation to the end, despite large fault bends. The persistent supershear speed is further validated by evidence of far-field Rayleigh Mach waves in regional seismograms. Supershear earthquakes with rupture velocity exceeding shear-wave speeds, previously observed in laboratory experiments and large strike-slip events, often have an initial sub-shear stage before they transition to supershear. The rupture speed of the 2018 Palu earthquake is supershear from very early on. The short or absent supershear transition distance can be caused by high initial shear stress or short critical slip-weakening distance, and promoted by fault roughness near the hypocenter. Steady rupture propagation at a supershear speed considered to be unstable, lower than the Eshelby speed, could result from the presence of a damaged fault zone.

Keywords: Palu Earthquake, Supershear, Fault Damage Zone

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The role of curvature in earthquake mechanics

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In recent years, many studies have tried to catch the influence of geometry in earthquake mechanics. In this paper, we suggest a new interpretation of the effect of geometry on the stress on a fault, as a direct effect of local curvature and torsion of line field of slip along the surface of the fault. Within this framework, it is possible to unify the understanding of bends, kinks and roughness, as an effect of local parameters along the fault. Starting from the representation theorem, that links the displacement in a medium to the slip distribution on his boundary, and assuming homogeneous infinite medium, we first derive a new regularized boundary element method. Using this equation, we were able to separate the influence of geometry, express by curvature and torsion of the fault surface geometry and the slip direction, from the effect of the gradient of slip. This allows us to shed a new light on the mechanical effects of geometrical complexities on fault surface. We used that new discovery to solve a paradox between smooth and abrupt kink [Tada and Fukuyama 1996] as well as re-interpret the effect of roughness on the fault: It can be shown that the effect of drag stress [Fang and Dunham 2013] along the fault it actually exactly equal to the effect of curvature along the fault.

Keywords: Fault mechanics, Curvature, Fault geometry

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Heterogeneous source modelling by the fully dynamic simulations of earthquake cycles on a strike-slip fault and scaling relations.

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Numerical modeling is a necessary tool for the assessment of variability strong ground motions in potential devastating large earthquakes. In a simulation-based seismic hazard analysis, it is critical to be able to generate a large number of physically self-consistent source models whose rupture process captures the main physics of earthquake rupture and is consistent with the spatio-temporal heterogeneity of past earthquakes. An inherent difficulty in such efforts is that, from a mechanical point of view, stress and strength heterogeneities cannot be prescribed arbitrarily as was done in earlier work. Their interdependence must be consistent with a mechanical model of deformation and stress evolution over the longer time scale of the earthquake cycle.

In this work, a set of spontaneous source models have been generated in a wide magnitude range (*Mw* 5.5-7.5) by using multicycle simulations under the rate-and-state friction law with the goal of studying the characteristics of source scaling relations and strong ground motions. To get realistic irregular seismic sequence, several realizations of 2D correlated heterogeneous random distributions of characteristic weakening distance "*Dc*" in rate and state friction are tested. A mesh grid size of 125 meters has been used to resolve properly the nucleation and cohesive zone of the seismic events. The fault is 128 km in length and 30km in width, the seismogenic width is 18km. The quasi-dynamic solver QDYN (Luo, et al., 2017) has been used to nucleate the seismic events and SPECFEM3D (Galvez et al, 2014; 2016) to resolve the rupture process. Other important parameters are the normal stress, which controls the stress drop and rupture velocity during an earthquake, and the maximum value of *Dc* distribution, that controls rupture velocity but not stress drop. Following these ideas, we perform dynamic rupture modeling to take into account the free surface effects and perform a parametrization study; parameters of our final friction model are shown in Fig.1.

In order to validate source models we compare the source scaling relations vs. seismic moment *Mo* for the modeled rupture area *S*(*Mo*), average slip of the ruptures *Dave*(*Mo*) and the slip asperity area *Sa*(*Mo*), with similar scaling relations from the source inversions. Fig. 2 shows result for *S*(*Mo*). The seismogenic zone width plays a fundamental role in the *S* vs *Mo* scaling. In fact, Luo et al. (2017) reported that events which break the whole seismogenic width and reach the free surface are exposed to an attraction effect from the free surface. This attraction effect may explain the transition regime from Stage 1 (self-similar rupture, $Mw < 6.5$) to Stage 2 ($6.5 < Mw < 7.4$). Ground motions have been also computed from our models. Their peak ground velocities (*PGV*) agree well with the GMPE values.

Acknowledgements. This study is based on the 2018 research project 'Examination for uncertainty of strong ground motion prediction for inland crustal earthquakes' by the Secretariat of Nuclear Regulation Authority (NRA), Japan. The Super Computer Shaheen II at KAUST University has been used to run the models presented in this study.

Keywords: earthquake rupture dynamics, earthquake cycles, rate-and-state friction, source scaling

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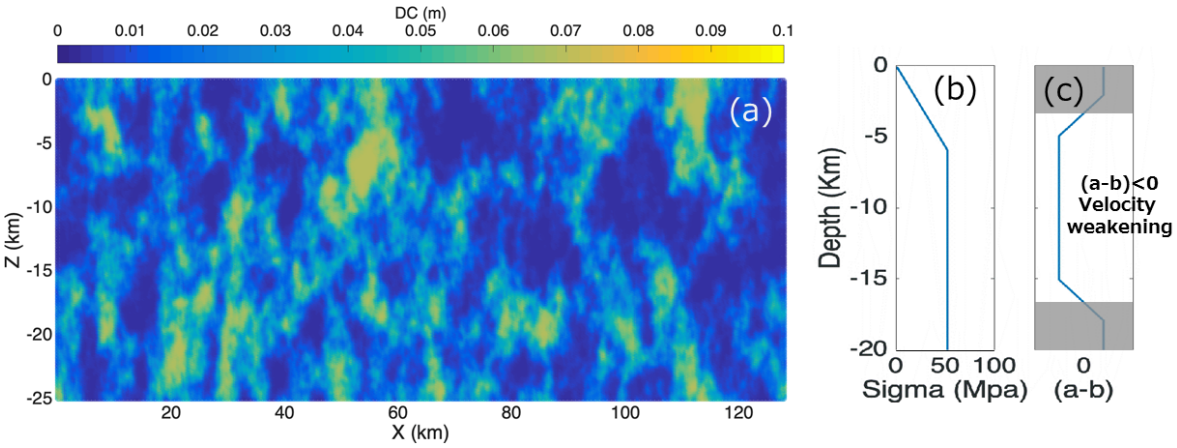


Fig 1. Friction settings: (a) heterogeneous *Dc*, (b) normal stress, and (c) *a-b* friction parameters.

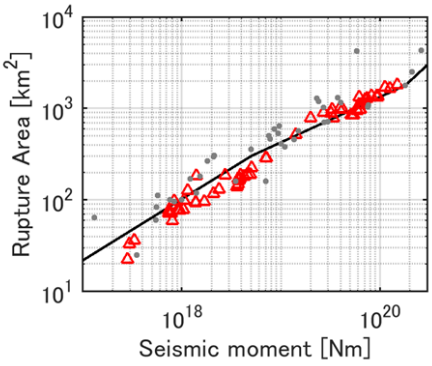


Fig 2. Comparison of *S*-values of modeled events vs. *Mo* (triangles) and observed (dots).
Line is 3-stage scaling assumed for strong-motion simulations.

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Strain energy released by an earthquake: Contributions of random slip fluctuations

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Strain energy in the lithosphere is the source of earthquake generation. For example, the shear strain energy change caused by the interplate coupling along the Nankai Trough, Japan affects the seismicity in the inland area (Saito et al. 2018 JGR). The aftershocks of the 2016 Kumamoto earthquakes were activated by the shear strain energy brought by the mainshocks (Noda et al. 2018 ACES; Tanaka et al. 2018 JpGU). The strain energy change caused by an earthquake is one of the most fundamental quantity for earthquake mechanics. When the stress change occurs uniformly on the earthquake fault (constant stress drop), a simple theoretical equation gives the relation between the seismic moment, initial stress, stress drop, and the strain energy liberated by the earthquake (e.g., Aki and Richards 2002). This relation leads that the strain energy released by an earthquake is proportional to the seismic moment. However, for actual earthquakes, the stress change on the fault is considerably heterogeneous.

The present study theoretically investigates the relation between the strain energy released by an earthquake and the seismic moment when the stress change is not uniform on the fault plane due to heterogeneous slip distribution. We assume that the initial stress is homogeneous in space and suppose that the heterogeneous slip distribution is given by the sum of the reference slip distribution causing the constant stress drop and the randomly fluctuating slip distribution. We adopt a stochastic approach using an ensemble of the slip fluctuations characterized by the power spectral density functions such as Gaussian and von Karman type function. The derived theoretical relation gives a scaling law of the strain energy with the power spectral density function of the slip fluctuation. This deduces the following results. (1) When an earthquake contains randomly fluctuating slip distribution, the liberated strain energy is smaller than that of the constant stress-drop earthquake. (2) This indicates that a representative value of stress drop becomes large due to the randomly fluctuating slip distribution in the view point of the energy partition. This study refers to this stress drop as effective stress drop. This was also reported by some studies such as Noda et al (2003 GJI) and Hirano and Yagi (2017 GJI). This study derived a theoretical equation of the effective stress drop with the power spectral density function of the random slip fluctuation. (3) When the stress change is not constant on the fault, the strain energy is not proportional to the seismic moment unless the correlation distance of the slip fluctuation is proportional to cube root of the seismic moment. (4) The energy balance gives a value of the initial stress that is required for the earthquake generation. In order to generate an earthquake, the initial stress needs to be larger than the sum of the half of the effective stress drop and the apparent stress (the apparent stress is given by rigidity, radiation energy, and seismic moment (Wyss and Brune 1968,1971)).

Keywords: strain energy, random slip fluctuations, stress

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The change in the elastic strain energy due to the 1992 Landers earthquake and triggering mechanisms of aftershock activity

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Earthquakes are physical processes to release elastic strain energy stored in the Earth’s crust by shear faulting. This quantity is essentially important for understanding earthquake generation. However, we have little knowledge on the quantity, because it is difficult to measure stress in-situ. Recently, Terakawa and Hauksson (2018) developed a method to model and estimate the 3-D absolute stress field from earthquake focal mechanism data, using the reference pore pressure as a single parameter (the reference pore pressure). In this study, we directly investigated changes in elastic strain energy, based on 3-D abosolute stress fields modeled by Terakawa and Hauksson (2018). Then, we tried to propose a new criterion to understand aftershock activity following large earthquakes instead of the change in Coulomb Failure Function (CFF), based on elastic strain energy.

First, we investigated partitioning of changes in shear and volumetric strain energies due to the 1992 Landers earthquake (M_W 7.3). Changes in volumetric strain energy did not depend on the reference pore pressure, or the level of deviatoric stress field. On the other hand, those in shear strain energy was closely related to the parameter. More shear strain energy were released when the background deviatoric stress magnitudes were higher. The elastic strain energy released by the mainshock is consumed as radiated, fracture and thermal energies. The amount of change (decrease) in the elastic stain energy must be at leaset larger than radiatied energy, which can be estimated (e.g., Kostrov, 1974; Ide, 2002). Therefore, the change in shear strain energy plays a crucial role to constrain the the most plausible reference pore pressure and eventually the level of the (absolute) deviatoric stress field.

When a stress field is compressed due to the mainshock, frictional strength as well as volumetric strain energy in the region will increase after the mainshock. This means that an increase in elastic strain energy do not necessarily mean activation of seismicity. The shear and volumetric strain energy are closely related to the average shear and normal stresses acting on faults randomly and isotropically distributed in the crust (e.g., Saito et al., 2018; Matsu’ura et al., under review). Increases in shear and volumetric strain energies have positive and negative effects on triggering aftershocks following the mainshock. In order to understand aftershock activity, we need to correctly consider both effects of the two kinds of strain energies into account. As the elastic strain energy is scalar quantity, we do not have to set any receiver faults, unlike using the change in CFF. In the source region of the Big Bear earthquake (M_W 6.5), which is the largest aftershock following the Landers mainshock, the shear strain energy increased, but the volumetric strain energy decreased. Both changes would have promoted this event. In the region just south of the hypocenter of the mainshock, the total effect from the two kinds of strain energies suggest that seismicity would have become inactive, contrary to the actual activation. Focal mechanism solutions of some of these events were normal faulting with NW-SE tension. We can understand that these events would have reactivated by decrease in fault strength under the stress field characterized by strike-slip faulting with NE-SW compression and NW-SE tension. This suggest that many aftershocks in the region may have been triggered by overpressurized fluids.

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Keywords: absolute stress fields, elastic strain energy, pore fluid pressures

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Toward understanding generation mechanism of crustal earthquakes based on accumulation/release of elastic strain energy

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Although the physical process of interplate earthquakes has been modeled from the viewpoint of accumulation and release of shear stress on plate boundaries, it is difficult to apply the framework directly to cycles of crustal (inland) earthquakes. It is necessary to assume a fault plane to obtain shear stress in a stress field, but the faults in the crust are not a continuous and unique plane of weakness like plate boundaries. Furthermore, there are many unknown faults covered by sedimentary layers.

The shear strain energy is a scalar quantity appropriate for evaluating the potential of earthquake occurrence in the case that the fault plane cannot be specified. The scalar quantity corresponds to the average value of the shear stress acting on randomly distributed cracks in the crust (Saito et al., 2018). In other words, an increase and decrease in the shear strain energy correspond to the accumulation and release of crustal stress, respectively. In addition, since the work done for shear faulting is related to the release of elastic strain energy in the surrounding region (Aki & Richards, 1980; Matsu'ura et al., 2019), the strain energy can be thought of as an essential physical quantity for earthquake generation. Evaluating the accumulate and release of the shear strain energy in the crust, therefore, would help to understand the generation mechanism of crustal earthquakes.

To evaluate the shear strain energy changes, we must have not only stress changes but also background stress fields. However, it is difficult to know the absolute value of the background stress. Under the assumption that the absolute level of the background stress is much greater than the stress changes, Saito et al. (2018) derived an expression of shear strain energy changes normalized by the differential stress of the background stress using the spatial pattern of background stress orientation and the stress changes. Then, they calculated the normalized shear strain energy changes in the inland seismogenic layer caused by interplate coupling along the Nankai Trough, and found the correlation between the shear strain energy changes and seismicity in the southwestern Japan.

In order to apply this framework to tectonic zones in the crust, Noda et al. (2018 AGU) developed a method to evaluate the shear strain energy changes using elastic/inelastic strain analysis method (Noda & Matsu'ura, 2010). Firstly, we inverted the 3-D moment tensor density distribution in the crust as the source of crustal deformation from GNSS displacement data. The 3-D elastic/inelastic strain distribution in the crust was obtained from the estimated moment tensor density distribution. The stress changes were calculated by multiplying the elastic strain distribution by assumed elastic constants. Secondly, given a background stress field, the 3-D shear strain energy changes in the crust was evaluated from the calculated stress changes.
This method was applied to coseismic and preseismic GNSS data associated with the 2016 Kumamoto earthquake. For the background stress, we used the 3-D tectonic stress field estimated by CMT data inversion (Terakawa & Matsu'ura, 2010). The coseismic shear strain energy changes were estimated from the coseismic GNSS displacement data and showed its correlation with the spatial pattern of aftershock activity. Next, we evaluated preseismic changes in shear strain energy from GNSS displacement rate data (2005~2011), and found an increase (accumulation) in a part of the Futagawa fault, which is one of the main faults coseismically slipped during the earthquake, and a large decrease (release) in the

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northeastern end of the fault, where the coseismic slip terminated. The shear strain energy change was caused by a large inelastic deformation (brittle fracture/plastic deformation) in the shallow crust along the Aso-Kuju volcanoes.

Keywords: elastic strain energy, crustal earthquake, elastic/inelastic strain, background stress field, 2016 Kumamoto earthquake

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Wed. May 29, 2019 9:00 AM - 10:30 AM JST | Wed. May 29, 2019 12:00 AM - 1:30 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[S-SS15] Active faults and paleoseismology

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Takashi OGAMI(National Institute of Advanced Industrial Science and Technology), Ryosuke Doke(Hot Springs Research Institute of Kanagawa Prefecture), Hisao Kondo(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Chairperson:Takashi Azuma(AIST), Mamoru KOARAI(Ibaraki University)

Geologic and historic information on seismic cycles and on the magnitude and source faults of past earthquakes is essential information to understand future large earthquakes. The study of past faulting and seismicity is an important issue for an interdisciplinary community of seismologists, geologists, geomorphologists, archaeologists, and historians.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

Introduction

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SSS15-05] Paleoseismological survey on the Shibetsu fault zone in the eastern part of Hokkaido, Japan

*Takashi Azuma[1], Daisuke Hirouchi[2], Koji Okumura[3], Kaoru Taniguchi[4], Masashi Omata[4], Yorihide Kohriya[4] (1.National Institute of Advanced Industrial Science and Technology, 2.Shinshu University, 3.Hiroshima University, 4.Pasco CORPORATION)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SSS15-06] Deformation of marine terrace surfaces associated with active Rokkasho fault in southern Shimokita peninsula, northern Japan

*Mitsuhisa Watanabe[1] (1.Faculty of Sociology, Toyo University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SSS15-07] **Vertical crustal movement during the past 600 years in the Kikai Island, deduced from the height distribution and ages of coral microatolls**

*Masanobu Shishikura[1], Hideaki Maemoku[2], Tomoo Echigo[3], Yuichi Namegaya[1], Tatsuya Ishiyama[4], Ryo Kinjo[2], Naoto Inoue[3] (1.Institute of Earthquake and Volcano Geology, National Institute of Advanced Industrial Science and Technology, 2.Hosei University, 3.Geo-Reserch Institute, 4.Earthquake Research Institute, University of Tokyo)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SSS15-08] Variation of coseismic fault displacements on multiple seismic cycles at a site: An example from the Kamishiro fault, Itoigawa-Shizuoka Tectonic Line active fault system, central Japan

*Naoya Takahashi[1], Shinji Toda[2] (1.Graduate school of Science, Department of Earth Science, Tohoku University, 2.International Research Institute of Disaster Science, Tohoku University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SSS15-09] High-resolution shear-wave seismic reflection surveys across the Kamishiro fault, Itoigawa-Shizuoka Tectonic Line active fault system, central Japan

*Naoki IKEGUCHI[1], Nobuhisa Matsuta[2], Kyoko Kagohara[3], Shinsuke Okada[4], Daisuke Hirouchi[5], Tatsuya Ishiyama[1], Katsuya Noda[6], Hiroshi Sato[1] (1.Earthquake Resarch Institute University of Tokyo, 2.Graduate School of Education, Okayama University, 3.Faculty of Education, Yamaguchi University, 4.Graduate school of Science, Tohoku University, 5.Faculty of Education, Shinshu University, 6.GEOSYS Inc.)

Paleoseismological survey on the Shibetsu fault zone in the eastern part of Hokkaido, Japan

*Takashi Azuma[1], Daisuke Hirouchi[2], Koji Okumura[3], Kaoru Taniguchi[4], Masashi Omata[4], Yorihide Kohriya[4]

1. National Institute of Advanced Industrial Science and Technology, 2. Shinshu University, 3. Hiroshima University, 4. Pasco CORPORATION

We conducted a paleoseimological survey on the Shibetsu fault zone in the eastern part of Hokkaido in 2018.
This fault zone has a length more than 52 km but no data was obtained about slip-rate and history of fault activeity in previous study (Hokkaido, 2004 and 2005). On a detailed topographic map with an air-borne LiDAR data, we found a new fault scarp with height of 2-5 m on fan produced the lastglacial age at Kotanuka site, and excurvated a trench (25 m in length, 8 m in width, 4 m in depth) and 4 drilling surveys (5 m in depth). We observed a high-angle fault cutting a tephra layer (Ma-l: ca.12,000 yrBP) and black soil with 40 cm on the trench wall. Based on drilling survey, the fan gravel layers, which covered with sandy sediment containing humic silt with 14C ages of 22,140-21,690 cal.BC and 20,587-20,343 cal.BC, is offset ca.3 m in vertical. We discuss the fault event and slip-rate of this fault with careful, because there are deformation of strata not only faulting but also periglacial process in the trench walls.

Keywords: active fault, paleoseismology, trenching survey, tephrochronology, the Shibetsu fault zone, Hokkaido

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Deformation of marine terrace surfaces associated with active Rokkasho fault in southern Shimokita peninsula, northern Japan

*Mitsuhisa Watanabe[1]

1. Faculty of Sociology, Toyo University

The marine terrace surfaces formed in MIS 5e and MIS 5c have successively deformed, resulting in a 1 km wide flexural scarp tilting to the east. These surfaces dipping to the same direction converged upon in the scarp. The flexure is consistent with the prevailing Neogene structure. Some bedding reverse faults are observed, which indicates that the structure is an active one. The marine terrace surfaces and the Tertiary system have been folded convincingly owing to the activity of west-dipping blind active thrust (the active Rokkasho fault), merging into the extensive submarine fault along shelf edge in the north.

Keywords: marine terrace, flexural scarp, bedding reverse fault, active fault

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Vertical crustal movement during the past 600 years in the Kikai Island, deduced from the height distribution and ages of coral microatolls

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1. Institute of Earthquake and Volcano Geology, National Institute of Advanced Industrial Science and Technology, 2. Hosei University, 3. Geo-Reserch Institute, 4. Earthquake Research Institute, University of Tokyo

The Kikai Island is known as a tectonically active region due to the MIS 5e coral terrace reaching over 200 m in altitude. Holocene marine terraces divided into four levels suggest that 1-2 m of uplift has intermittently occurred every 1500-2000 years (Sugihara et al., 2003). However, recently simulation results propose that the main factor of terrace formation is a combination of steady uplift and erosive action triggered by relatively small coseismic uplift (Shikakura, 2014). According to the geodetic observation, GNSS data shows uplifting at about 2 mm/year, but it is contradictory that the leveling survey results (comparison between Sep. 1997 and Apr. 2014) indicate subsiding at approximately 1 mm/year (Ito et al., 2015).

As described above, there are various views and observation results on the crustal vertical movement pattern of the Kikai Island. Therefore, we focused on coral microatoll which is a natural tide gauge and reconstructed the long-term crustal vertical deformation based on its distribution and age.

Since the microatoll formed by *Polites sp.*, grows on the basis of the low tide level, and records sea level change annually, it is good paleoshoreline indicator to reconstruct past crustal vertical deformation. We found a total of 25 living microatolls at three areas in the northern part, eastern part and southern part of the Kikai Island and one emerged microatoll. We obtained detailed cross-sections of five living micro-atolls and sliced samples of emerged microatoll to take a CT-scan image, and also obtained some samples for 14C age which were calibrated of marine reservoir effect based on data of Hirabayashi et al. (2017).

In the northern area (Onozu), the height of the top surface of all living microatolls was almost flat at -1.01 - 1.07 m (TP), and the maximum was 78.8 cm in radius. Emerged microatoll found in this area is 270 cm in radius. Its shape of the top surface is almost flat but the altitude is decreasing gently from the center (-0.80 m TP) to the edge (-0.87 m TP) and is 20 cm higher than the living microatolls. From the CT scan image, 237 lines of annual band can be counted in the range of 260 cm showing clearly growing in the horizontal direction. Therefore, the mean horizontal growth rate is estimated to 1.1 cm/year. It is consistent with 14C age data which shows AD 1305-1425 in the center and AD 1489-1650 in the margin. Based on the growth rate obtained from analysis of emerged microatoll, the age of growth of the living microatoll in this region can be estimated to about 72 years ago.

The largest one of the living microatolls confirmed in the eastern area (Kadon) has a radius of 145.6 cm and can be estimated to about 132 years ago, which is no contradiction to the 14C age of the center (AD 1680-1880). The shape of the top surface is roughly horizontal throughout the growth period, but the altitude is slightly uneven between -1.06 m (TP) and -1.20 m (TP).

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Based on the above results, the relative sea level change of the Kikai Island slowly decreased by 7 + α cm within 300 years from the 14th to the 17th century, and rapidly fall by 20 - α cm at the 17th century or in the period until the 19th century. Also, since at least 137 years ago, the sea level is almost stable while fluctuating about 10 cm at the maximum. Although it is difficult to distinguish the crustal deformation and the eustatic sea level change, if it is regarded that all of the change was the tectonic influence, it can be denied the steady uplift at a constant rate for the past 600 years. The rapid sea level fall during the 17th century or until the 19th century may have been an intermittent coseismic uplift.

Keywords: Kikai Island, earthquake, crustal movement, sea level change, coral microatoll

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Variation of coseismic fault displacements on multiple seismic cycles at a site: An example from the Kamishiro fault, Itoigawa-Shizuoka Tectonic Line active fault system, central Japan

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Predicting coseismic fault slip at a site on an active fault is crucial from the view point of fault displacement hazard assessment. The characteristic earthquake model, where an amount of coseismic slip at a point on a fault is roughly consistent through seismic cycles (Schwartz & Coppersmith, 1984), has been widely accepted and applied for hazard assessment. However, recent paleoseismic studies, high-resolution topographic data and quantitative more precise dating techniques have revealed that many faults do not repeat persistently their characteristic displacements (e.g., Zielke, 2018).To further discuss this issue, however, more case studies in particular on a dip-slip fault are required.
We estimated co-seismic slips of paleo-earthquakes at Oide site (36.7˚N, 137.87˚E) on the Kamishiro fault and evaluated variability in co-seismic slips through seismic cycles. The Kamishiro fault is a reverse fault which is located at the northernmost part of the Itoigawa-Shizuoka Tectonic Line active fault system in Japan. Advantages of this fault are that the co-seismic slip distribution of the most recent event, the 2014 Nagano-ken-hokubu earthquake (Mw 6.2), is precisely measured by field observation and differential LiDAR analysis, and that there is a flight of displaced terraces that record slips of recent earthquakes. Several paleoseismic studies share the evidence for the penultimate and the antepenultimate events that occurred in AD 1714 and ~1.2 ka (AD 841 or AD 762) respectively, whereas the event ages older than 1.2 ka are not well constrained. Here we mapped five displaced terraces (T1-T5, from the older) at Oide using aerial photographs taken by the US Armed Forces in the 1940s. Then, we estimated cumulative net slip of T1, T2 and T5 terraces using a tool developed by Wolfe et al. (2018) which incorporates topographic and fault properties with uncertainties and enables us to objectively estimate a plausible cumulative net slip. We made 30 topographic profiles for each terrace, and sought the mean and standard deviation of the cumulative net slip. We also constrained terrace ages based on radio carbon dating. As a result, we estimated coseismic slips of the penultimate and the antepenultimate events, 1.5±0.2 m and 2.7±0.4 m, respectively. Next, we performed a Monte Carlo simulation to estimate slips of events before the antepenultimate earthquake and then explore a possible range of CV (Coefficient of Variation) for co-seismic slips. CV is a ratio of a data set’ s standard deviation to mean and used to assess variability. Low CV indicates co-seismic slips are nearly the among seismic cycles, and high CV (close to 1) means slips are variable. Because previous paleoseismic studies found one to three earthquakes occurred between T1 formation (5-2.7 ka) and 1.2 ka, we iteratively computed one to three co-seismic slips before 1.2 ka so that the simulated slip sequences can reproduce the cumulative terrace offsets. This approach enabled us to calculate CV that ranged from 0.3 to 0.5 (1 σ), which indicates that a recent sequence of co-seismic slips at Oide does not follow the characteristic earthquake model but varies in a narrow range.

Keywords: Active fault, Paleoseismology, Co-seismic slip, Monte Carlo simulation

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High-resolution shear-wave seismic reflection surveys across the Kamishiro fault, Itoigawa-Shizuoka Tectonic Line active fault system, central Japan

*Naoki IKEGUCHI[1], Nobuhisa Matsuta[2], Kyoko Kagohara[3], Shinsuke Okada[4], Daisuke Hirouchi[5], Tatsuya Ishiyama[1], Katsuya Noda[6], Hiroshi Sato[1]

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Coseismic net fault slip based on very shallow fault trajectories offers insights to understand properties of source faults for assessing seismic risk from crustal earthquakes in the overriding plate. To illuminate very shallow fault geometries, we carried out new shear-wave very shallow seismic reflection profiling across coseismic surface ruptures emerged along the Kamishiro fault, a northernmost segment of the Itoigawa-Shizuoka tectonic line (ISTL) active fault system, during the 2014 Nagano-ken-hokubu earthquake (Mw = 6.2) (c.f., Hirouchi et al., 2015; Ishimura et al., 2015; Katsube et al., 2017; Okada et al., 2015).

We collected seismic data along six seismic lines (Shiojima, North-Oide, South-Oide, Wing-21, Iimori, Horinouchi, respectively) in 2017 and 2018 by using Electrodynamic Vibrator System (ELVIS; GEOSYM) as an SH seismic source, a land streamer composed of 96 channels, and recording system GEODE (GeoMetrics). Acquisition parameters are: sweep length, 10 sec: sweep frequency, 20-120 Hz: source intervals, 1 m (2 m only in the Wing 21 seismic line); receiver intervals: 0.5 m; sampling rate: 1 msec.

By correlation of processed depth sections based on standard CMP stacking with surface geology and drill-hole data, the seismic sections up to a depth of approximately 100 m resolve thrust geometries extending from the 2014 coseismic surface ruptures that are mostly consistent with previous results in field mapping (e.g., Togo and Hasegawa, 2015; Lin et al., 2015; Okada et al., 2015), ground-penetrating radar (Kimura and Taniguchi, 2015; Nakano and Une, 2015). Our new seismic sections also successfully illuminate previously unrecognized blind thrust faults deforming Quaternary sediments which were not activated during the 2015 event. Our results show that shear-wave seismic reflection surveys using Electrodynamic Vibrator System and a land streamer are very effective to obtain detailed subsurface images of not only active faults but also unrecognized blind thrust structures.

Keywords: seismic reflection survey, Kamishiro fault, active fault, coseismic surface rupture, Itoigawa-Shizuoka Tectonic Line, subsurface structure

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Wed. May 29, 2019 10:45 AM - 12:15 PM JST | Wed. May 29, 2019 1:45 AM - 3:15 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[S-SS15] Active faults and paleoseismology

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Takashi OGAMI(National Institute of Advanced Industrial Science and Technology), Ryosuke Doke(Hot Springs Research Institute of Kanagawa Prefecture), Hisao Kondo(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Chairperson:HISAO KONDO(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Nobuhiko Sugito(Hosei University)

Geologic and historic information on seismic cycles and on the magnitude and source faults of past earthquakes is essential information to understand future large earthquakes. The study of past faulting and seismicity is an important issue for an interdisciplinary community of seismologists, geologists, geomorphologists, archaeologists, and historians.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SSS15-10] Paleoseismic investigations on the un-ruptured section during the 2014 earthquake along the Kamishiro fault, ISTL active fault zone, Central Japan

*Hisao Kondo[1], Hideki Kurosawa[2], Yoko Hirakura[2], Keita Takada[3], Kohei Abe[2], Miwako Ito[2], Atsuo Igarashi[3], Tetsuya Ikeda[3], Atsushi Miwa[2] (1.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2.OYO Cooperation, 3.Fukken Co., Ltd)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SSS15-11] P-wave seismic reflection profiling across the northern central ISTL active fault system, central Japan

*Haruo Kimura[1], Hisao Kondo[2], Yasuhiko Akinaga[3], Shigeru Okamoto[3], Masaki Suehiro[3] (1.Central Research Institute of Electric Power Industry, 2.Geological Survey of Japan, AIST, 3.Hanshin Consultants Co., Ltd.)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SSS15-12] History of interplate earthquakes along the Sagami Trough from uplifted coasts in the Boso Peninsula

*Junki Komori[1], Masanobu Shishikura[2], Ryosuke Ando[1] (1.The University of Tokyo, 2.The National Institute of Advanced Industrial Science and Technology)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SSS15-13] Inferring location and activity of the Iriyamase fault, the Fujikawa-kako fault zone, based on boring core sample analyses and physical fault model

*Namiki Ryo[1], Ryosuke Ando[1], Masanobu Shishikura[2] (1.The University of Toyko, 2.National Institute of Advanced Industrial Science and Technology)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SSS15-14] **Coastal submergence events identified by fossil diatoms and plant macrofossils at Ukishima-ga-hara adjacent to the Suruga Trough (eastern Nankai Trough), central Japan**

*Yuki Sawai[1], Arata Momohara[2], DAN MATSUMOTO[1], Yumi Shimada[1,3] (1.Geological Survey of Japan, AIST, 2.Chiba University, 3.University of Tsukuba)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

Discussion

Paleoseismic investigations on the un-ruptured section during the 2014 earthquake along the Kamishiro fault, ISTL active fault zone, Central Japan

*Hisao Kondo[1], Hideki Kurosawa[2], Yoko Hirakura[2], Keita Takada[3], Kohei Abe[2], Miwako Ito[2], Atsuo Igarashi[3], Tetsuya Ikeda[3], Atsushi Miwa[2]

1. Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2. OYO Cooperation, 3. Fukken Co., Ltd

We perfomed paleoseismological invetigations on the un-ruptured fault section along the Kamishiro fault, ISTL active fault zone, central Japan. The un-ruptured section extends for about 15 km, consisting of the southernmost section of the Kamishiro fault. The northern most section have activated during the 2014 Nagano-ken Hokubu earthquake, Mj 6.7. Near Lake Nakatsuna, the Kamishiro fault forms tentonic geomorphic features such as fault scarp on the lucustrin terrace and fluvial terrace, monoclinal scarp on the lowland. Beside the eastern side of Lake Nakatsuna, we obtained two bore holes in order to estimate vertical slip rate based on lucustrin terrace deposite at hanging-wall side and fine sediments at foot-wall side. We estimated about 1.0 mm/yr of vertical slip rate as the minimum value. The fault exposure at the depth of -29 m in the borehole core at the foot-wall side implies that thrust front is located at the west of the borehole site. It indicates that the slip rate at present is the minimum estimatation. 350 meter south of this site, we obtained several Geoslicer across the fault scarp. The scarp hight is about 2 m. Based on geomorphic and geologica section, we identified two paleoseismic events after the depositon of alluvial fun deposite. At this moment, we estimated that the most recent event occurred after 664 A.D. More carbon dating samples will allow us to constrain teh timing of paleoseismic events. Near the sourthern most termination of the Kamishiro fault, south of Lake Kizaki, we re-investigated timing and slip per event during 5-6 paleoseismic events. Here, 2-3 events has been identified based on the shallow geologic section up to 6 m deep revealed by Geoslicer technique. We added four borehole cores to identify thrust structures and older events. At present, fine sediments and carbon dating results yeild 1.0 mm/yr of vertical slip rate after 1.2 ka. More dating results will provide high-resolution chronology of past events and slip per events, that will help us to discuss the occurrence of past multi-segment earthquakes.

Keywords: active fault, paleoseismology, ISTL active fault zone

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P-wave seismic reflection profiling across the northern central ISTL active fault system, central Japan

*Haruo Kimura[1], Hisao Kondo[2], Yasuhiko Akinaga[3], Shigeru Okamoto[3], Masaki Suehiro[3]

1. Central Research Institute of Electric Power Industry, 2. Geological Survey of Japan, AIST, 3. Hanshin Consultants Co., Ltd.

We carried out P-wave seismic reflection profiling to reveal the subsurface structure across the northern central Itoigawa–Shizuoka tectonic line active fault system. Obtained migrated depth-converted section has shown a steeply (about 75 degree) eastward dipping fault.

Keywords: Itoigawa–Shizuoka tectonic line active fault system, East Matsumoto Basin fault, active fault, seismic reflection profiling, subsurface structure

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History of interplate earthquakes along the Sagami Trough from uplifted coasts in the Boso Peninsula

*Junki Komori[1], Masanobu Shishikura[2], Ryosuke Ando[1]

1. The University of Tokyo, 2. The National Institute of Advanced Industrial Science and Technology

We surveyed tectonically uplifted coast, Heisa-ura, in the southernmost part of the Boso Peninsula, central Japan, for the estimation of the recurrence history of subduction earthquakes. The megathrust earthquakes along the Sagami Trough, located to the south of Tokyo, are known to repeatedly occur as represented by the 1703 M8.2 Genroku Kanto Earthquake. The interval time of these earthquakes is previously believed to be longer than 2,000 years from the investigations of the marine terraces in the Boso Peninsula (e.g. Nakata+, 1980). However, the recent dating survey indicated that their interval time might be 500–800 years at the shortest (Komori+, 2017) and required more detailed investigation. The Heisa-ura coast, we surveyed in this study, has not been investigated well before because no significant landform such as marine terraces are developed there. This region is, however, considered to suffer the fastest averaged uplift rate in the surrounding area from the recent study of the marine terrace distribution. Thus the buried sedimentary structure in Heisa-ura possibly records the emergence history of this coast. Here we show the result of the detailed geological survey using Geoslicer done in Heisa-ura for the first time. We obtained 8 sedimentary structure ~2 m deep along a survey line perpendicular to the coast. This investigation revealed that shoreface deposit contains shell fragments is placed deeper than 0.5–1.0 m beneath the surface. Additionally, the sedimentary structure is different between the survey points above and below the estimated elevation of the paleo-shoreline angle. These results indicate that the sedimentary structure beneath the Heisa-ura coast might records the chronicle of crustal deformations which has not been explored. This survey would give us several important factors for the discussion of the mechanisms of the subduction earthquakes along the Sagami Trough and the future hazard assessment of them.

Keywords: Sagami Trough, interplate earthquakes, marine terrace

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Inferring location and activity of the Iriyamase fault, the Fujikawa-kako fault zone, based on boring core sample analyses and physical fault model

*Namiki Ryo[1], Ryosuke Ando[1], Masanobu Shishikura[2]

1. The University of Toyko, 2. National Institute of Advanced Industrial Science and Technology

The Fujikawa-kako (estuary) fault zone, located in the northern end of the Suruga-Nankai-trough, is claimed to be possible to be activated with the Nankai megathrust earthquakes, resulting in fatal damage in this region. However, it is difficult to accurately estimate the activity of the Iriyamase fault, which is considered as one of the most active faults in this fault zone, because no clear tectonic landform is found on the alluvial fan developed in the Fujikawa estuary area. Recently, three boring cores drilled in the Fujikawa estuary area are preliminarily analyzed by Shisikura et al. (2018). The KNB core is taken at the west side of the Fuji river as well as the hanging wall side of the Iriyamase fault, whose location is estimated by AIST (2016); The SKB core is at the west side of the Fuji river and the footwall side; the FGB core is at the east side of the river and the footwall side.

Based on the result of these analyses, it is estimated that the average displacement rate of Iriyamase fault is about 1~3 m / ky, which is smaller than the previous estimates (Yamazaki, 1992). Moreover, it is also pointed out that the both hanging wall and footwall sides of Iriyamase fault has been subsiding in the long term because Late Holocene terrestrial sediments are buried at the depth beneath the present sea level even in the KNB core located at the hanging side. According to the depth of layers deposited in the peak of the postglacial transgression, this subsiding rate is estimated to be at the 3m/ky.

In this presentation, we show the result of radiocarbon dating and a diatom analysis in these three cores based on more detail analyses of the core samples. Furthermore, we construct physical models based on these results to consider the underlying tectonic conditions.

The diatom analysis of the SKB core shows that diatoms are rarely found at depths shallower than 56 m, and the shallower strata are found to be terrestrial sediments. This result agrees with the long-term subsidence suggested by Shisikura et al. (2018). Moreover, the average displacement rate of Iriyamase fault is estimated about 2 m / ky by comparing the results of the diatom analyses of two cores (KNB and SKB). In order to understand the tectonic origin of the long-term subsidence in the Fujikawa estuary area, we construct the two physics-based models, called the Fuji volcano model and the fault model. In the Fuji volcano model, we calculated the amount of the subsidence caused by the isostasy effects due to the development of the Fuji volcano; the amount of subsidence is calculated to be about 0.7m by the volume increase of Fuji volcano in the past 17 thousand years, 41.37 km^3 (Miyazi, 2007). Thus, this result is far smaller than the amount of the long-term subsidence based on the boring core analysis. In the fault model, we calculate the average displacement rate of the Iriyamase fault, assuming faults as the finite rectangles in the semi-infinite elastic medium based on Okada (1992). We assume two faults to explain both the subsidence at the KNB core and the vertical offset between KNB and SKB; fault A is located between KNB and SKB and Fault B is located in the western side of KNB. The result shows that the average displacement rate of fault B is required to be much larger than that of fault A, because subsidence due to fault B in its footwall side must overcome the uplift due to fault A in the hanging side of fault A.

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Keywords: Fujikawa-kako fault zone, Suruga trough, Tōkai earthquake, Active fault, Boring survey

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Coastal submergence events identified by fossil diatoms and plant macrofossils at Ukishima-ga-hara adjacent to the Suruga Trough (eastern Nankai Trough), central Japan

*Yuki Sawai[1], Arata Momohara[2], DAN MATSUMOTO[1], Yumi Shimada[1,3]

1. Geological Survey of Japan, AIST, 2. Chiba University, 3. University of Tsukuba

We identified eight episodic submergence events based on paleontological analyses on peaty sediment samples at Ukishima-ga-hara lowland in Shizuoka Prefecture, central Japan. Lithostratigraphy of sediment samples from Ukushima-ga-hara has no clear changes in facies, but changes in compositions of diatom assemblages and plant macrofossils suggest episodic submergence events. For example, at about 2.3 m and 3.1 m below the ground surface, while aerophilic diatoms (such as *Diadesmis contenta*) dominate underlying peaty layer, freshwater and brackish planktonic taxa (*Aulacoseira* and *Thalassiosira*) abound in overlying layer. Radiocarbon ages of plant macrofossils taken from samples just above and below the event horizons were used to constrain event ages. As the results of applying Bayesian estimation, the youngest one may be correlated with either 1707 or 1498 earthquake. The second one was with either 1361 or 1498 earthquake. The third one covers ages of 1096 and 887 earthquakes. These submergence events may be generated with coastal deformation associated with subduction zone earthquake along Suruga Trough and/or active fault earthquake at Fujikawa-kako-fault zone.

Keywords: submergence event, diatom, plant macrofossil, radiocarbon dating, Fujikawa-kako fault zone

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Wed. May 29, 2019 1:45 PM - 3:15 PM JST | Wed. May 29, 2019 4:45 AM - 6:15 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[S-SS15] Active faults and paleoseismology

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Takashi OGAMI(National Institute of Advanced Industrial Science and Technology), Ryosuke Doke(Hot Springs Research Institute of Kanagawa Prefecture), Hisao Kondo(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Chairperson:Takashi Ogami(AIST), Koji Okumura(Hiroshima University)

Geologic and historic information on seismic cycles and on the magnitude and source faults of past earthquakes is essential information to understand future large earthquakes. The study of past faulting and seismicity is an important issue for an interdisciplinary community of seismologists, geologists, geomorphologists, archaeologists, and historians.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SSS15-15] Shallow structures and tectonic geomorphology of active blind thrusts imaged by new hi-resolution seismic reflection profiling, Hokkaido, Northern Japan

*Tatsuya Ishiyama[1], Naoko Kato[1], Hiroshi Sato[1], Taro Koike[2], Katsuya Noda[2] (1.Earthquake Research Institute, University of Tokyo, 2.Geosys, Inc.)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SSS15-16] Paleo-seismological survey on the Idenokuchi fault, Nishihara village, Kumamoto prefecture

*Daisuke Ishimura[1], Hiroyuki Tsutsumi[2], Naoya Takahashi[3], Ryuhei Oda[1], Jun Matsukaze[1], Heitaro Kaneda[4], Motoya Kobayashi[4], Yasuhiro Kumahara[5], Makoto Kobayashi[6], Toshihiko Ichihara[7] (1.Department of Geography, Tokyo Metropolitan University, 2.Department of Environmental Systems Science, Faculty of Science and Engineering, Doshisha University, 3.Department of EarthScience, Tohoku University, 4.Graduate School of Science, Chiba University, 5.Graduate School of Education, Hiroshima University, 6.Research Center for Volcanic Hazards and Their Mitigation, Tokyo Metropolitan University, 7.Sedimentary Environments Research)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SSS15-17] Paleoseismic investigations of the Hinagu fault zone, Kumamoto, Japan: Preliminary result of trenching survey at Yatsushiro city

*Yukari Miyashita[1], Takashi Azuma[1], Yusuke Komine[2], Masao Kametaka[2], Midori Kishiyama[2] (1.Institute of Earthquake and Volcano Geology, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2.Dia Consultants Co. Ltd.)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SSS15-18] Seismic trenching on offshore part of the Hinagu Fault Zone, Kyushu, Japan −3D structure and paleo-seismicity of offshore dextral strike-slip fault

*Takashi OGAMI[1], Shintaro Abe[2], Kenjiro Mukaiyama[3], Shigeyuki Suda[4] (1.Geological Survey of Japan, AIST, 2.ADEP, 3.Kawasaki Geological Engineering Co. Ltd., 4.JGI Inc.)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SSS15-19] Conductivity Structure models of large and small slip regions at the 2016 Kumamoto earthquake sequence

*Satoru Yamaguchi[1], Yuto Yamanaka[2], Akira Mimura[1], Kazuki Fkue[1], Daigo Furukawa[1], Tada-nori Goto[3], Hisatoshi Koji[3], Sota Kawaguchi[3], Koki Aizawa[4], Shinichi Takakura[5] (1.Department of Geosciences, Graduate School of Science, Osaka City University, 2.Faculty of Science, Osaka City University, 3.Department of Urban Management, Graduate School of Engineering, Kyoto University, 4.Institute of

Seismology and Volcanology, Kyushu University, 5. Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SSS15-20] The Timing and Extent of the Last Surface Rupture Event on the Himalayan Frontal Thrust in Central Nepal around Butwal

*Koji Okumura[1], Soma Nath Sapkota[2], Prakash Pokhrel[2], Hisao Kondo[4], Takuya Furuhashi[3] (1.Graduate School of Letters, Hiroshima University, 2.Department of Mines and Geology, 3.Taiheiyo Cement Corporation, 4.Geological Survey of Japan, AIST)

Shallow structures and tectonic geomorphology of active blind thrusts imaged by new hi-resolution seismic reflection profiling, Hokkaido, Northern Japan

*Tatsuya Ishiyama[1], Naoko Kato[1], Hiroshi Sato[1], Taro Koike[2], Katsuya Noda[2]

1. Earthquake Research Institute, University of Tokyo, 2. Geosys, Inc.

Active structures of central Hokkaido are characterized by north-striking active thrusts along the western flanks of the Hidaka Mountains and eastern flanks of the Kabato Mountains. Whereas structural styles and positions of active thrusts along the Umaoi and Kurisawa Hills are clearly related to frontal Hidaka fold-and-thrust belt, structural relations between east-facing folded fluvial terraces along the eastern flanks of the Kabato Mountains and pre-Neogene basement-cored folds remain poorly understood. In addition, geomorphic expression of active faults/folds along the northern Yubari Mountains is quite insufficiently recognized in contrast to both their northern southern extension. To define these unsolved questions, we collected new seismic reflection data from the eastern flank of the Kabato Mountains, through alluvial plain of the Ishikari River to the western flank of the northern Yubari Mountains, by use of both ca. 14.5 km long array of seismic recorders at 20 m intervals and a vibroseis truck as seismic sources at 10 m intervals. Our processed seismic profile based on standard CMP stacking and its preliminary interpretation suggest the eastern flank of the Kabato Mountains is underlain by a tight, east-vergent, asymmetric anticline that deforms Paleogene to Pliocene sediments. Synclinal and anticlinal axial surfaces newly identified on folded, middle to late Pleistocene fluvial terraces on the eastern flank of the Kabato Mountains are apparently consistent with those recognized in the seismic section. This may suggest recent growth of the fault-related anticline and activities of underling west-dipping blind thrusts imaged in this experiment. In contrast to the east-vergent asymmetric anticline beneath the eastern flank of the Kabato Mountains, structural styles beneath the western flank of the northern Yubari Mountains in the eastern half of the section include more gentle westerly dipping Pliocene-Pleistocene (?) sedimentary units with steeper dip panels, possibly suggesting an east-dipping blind thrust fault. Previously unrecognized, very subtle, west facing scarps on alluvial plain and late Pleistocene fluvial terraces are consistent with these underlying thrusts and may indicate their recent fault activities.

Keywords: Active fault, Ishikari Lowland, Seismic reflection profile, Blind thrust, Hokkaido

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Paleo-seismological survey on the Idenokuchi fault, Nishihara village, Kumamoto prefecture

*Daisuke Ishimura[1], Hiroyuki Tsutsumi[2], Naoya Takahashi[3], Ryuhei Oda[1], Jun Matsukaze[1], Heitaro Kaneda[4], Motoya Kobayashi[4], Yasuhiro Kumahara[5], Makoto Kobayashi[6], Toshihiko Ichihara[7]

1. Department of Geography, Tokyo Metropolitan University, 2. Department of Environmental Systems Science, Faculty of Science and Engineering, Doshisha University, 3. Department of EarthScience, Tohoku University, 4. Graduate School of Science, Chiba University, 5. Graduate School of Education, Hiroshima University, 6. Research Center for Volcanic Hazards and Their Mitigation, Tokyo Metropolitan University, 7. Sedimentary Environments Research

In the 2016 Kumamoto earthquake, surface ruptures appeared not only on the Futagawa fault, source fault of this event but also on the other active faults. Especially, on the Idenokuchi fault located about 2 km south of and subparallel to the Futagawa fault, normal fault scarps (10 km length and Max. 2 m vertical offset) appeared (Toda et al., 2016). Toda et al. (2016) presented that the slip-partition occurred using the Futagawa (strike-slip fault) and Idenokuchi (normal fault) faults, indicating the structural relationship between both faults. Additionally, in considering the 2016 event, there is one question whether the activity of Idenokuchi fault coincides that of the Futagawa fault or not. Recent paleoseismological survey (Kumahara et al., 2017; Iwasa et al., 2018; Shirahama et al., 2018; Toda et al., 2018; Tsutsumi et al., 2018; Ueta et al., 2018) revealed that 3 or 4 events including the 2016 event were estimated since Kikai-Akahoya (K-Ah) tephra (7.3 ka; Machida and Arai, 2003) fall. Thus, if the Idenokuchi fault ruptures together with the Futagawa fault, we would find multi-events on the Idenokuchi fault during the last seven thousand years.

We excavated a 14-m-long, 6-m-wide, 3-m-deep trench on the antithetic fault of the Idenokuchi fault, where we found 30-60 cm vertical offset associated with the 2016 event. In the laboratory, we conducted tephra analysis and radiocarbon dating. Now, we are measuring radiocarbon dates, and thus will estimate depositional and event ages in our presentation.

On the trench walls, we recognized clear, but complex normal and reverse faults. A main normal fault with a high dip angle bounded basement rocks and soil just below the 2016 surface rupture. On the hanging wall side, we found many antithetic normal faults and reverse faults. In the soil sediments, we identified K-Ah tephra (thickness of 40 cm) based on volcanic glass morphology and refractive index. Soil sequence on the hanging wall side is shown from the surface: surface soil, brown soil, black soil (paleosol1), brown soil, K-Ah, black soil (paleosol2) and yellowish soil.
At present, we identified at least four events including the 2016 event since paleosol2. Especially, after K-Ah deposition, we confidently three events including the 2016 event, corresponding with the frequency of the Futagawa fault activity (Kumahara et al., 2017; Toda et al., 2018; Tsutsumi et al., 2018; Ueta et al., 2018). This preliminary result suggests that the Idenokuchi fault ruptured with the Futagawa fault. Additionally, we also identified a few probable events and will discuss this with radiocarbon dates in the presentation.

Keywords: 2016 Kumamoto earthquake, Idenokuchi fault, Paleo-seismological survey, K-Ah tephra, Normal fault

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Paleoseismic investigations of the Hinagu fault zone, Kumamoto, Japan: Preliminary result of trenching survey at Yatsushiro city

*Yukari Miyashita[1], Takashi Azuma[1], Yusuke Komine[2], Masao Kametaka[2], Midori Kishiyama[2]

1. Institute of Earthquake and Volcano Geology, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2. Dia Consultants Co. Ltd.

We conducted paleoseismic investigations such as drilling and trenching surveys across the Hinagu segment of the Hinagu fault zone, Kumamoto, Japan. The result based on the careful trench wall observation and preliminary radiocarbon dating of sediments show that paleoearthquake cycle of the Hinagu segment is shorter than previous evaluation of the fault.

Keywords: Hinagu fault zone, 2016 Kumamoto Earthquake, paleoseismology, trenching survey

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Seismic trenching on offshore part of the Hinagu Fault Zone, Kyushu, Japan −3D structure and paleo-seismicity of offshore dextral strike-slip fault

*Takashi OGAMI[1], Shintaro Abe[2], Kenjiro Mukaiyama[3], Shigeyuki Suda[4]

1. Geological Survey of Japan, AIST, 2. ADEP, 3. Kawasaki Geological Engineering Co. Ltd., 4. JGI Inc.

As a part of "Comprehensive research project for the major active faults related to the 2016 Kumamoto earthquake" of MEXT, we conducted offshore-fault surveys at the offshore part of the Hinagu-Fault-Zone, Kyushu, Japan. We have obtained ultra-high-resolution 3D-seismic data and two offshore drilling cores, and integrated them to clarify detailed geological structure and paleo-seismicity of the fault zone since the Last glacial maximum (LGM).

We chose coastal area of the Yatsushiro Sea, off the Tsunagi town, Kumamoto Prefecture, as study area. The sedimentary body of the postglacial period is formed thicker than 10 m at the area. Inside a rectangle area of 1 km by 2 km, we obtained ultra-high-resolution 3D-seismic data using the boomer source. Two drilling cores are obtained at both sides of the target fault.

3D geological structure and shape of the fault are figured out based on the 3D-seismic data. We distinguished extensional duplex structure at right-stepover section along the fault, which strongly suggest dextral strike-slip faulting. The structural depression associated with the extensional duplex would emphasize vertical faulting, which would provide clues to clarify the paleo-seismic events based on sedimentary analysis.

Two drilling cores penetrates the sedimentary body of the postglacial period, and are classified into Facies B, A4, A3, A2 and A1, in ascending order. Our interpretion of them are followings. Facies B: Sediment before LGM. Facies A4: Terrestrial sediment after LGM. Facies A3: Muddy bay sediment of transgressive stage. Facies A2: Sandy sediment overlapping ravinement surface. Facies A1: Sandy and muddy bay sediment of highstand. Based on 3D-seismic data, we classified strata of facies A4, A3, A2 and A1 into 7 seismic units (U7-U1, in ascending order) . The seismic units of U7-U3 are composed of facies A4 and A3. The seismic unit of U2 and U1 correspond with facies A2 and A1, respectively. The basement of seismic unit of U7 corresponds to the boundary of facies B/A4, and is interpreted as an erosional surface during lowstand of LGM around 18 ka.
Thickness of the seismic unit of U7, U5, U3, U2 and U1 changes abruptly at the fault, which should have result of 5 faulting events of E5-E1, in ascending order. Based on age-depth curve at drilling site on the downthrown side of the fault, faulting events of E5-E3 could be estimated as followings. E5: 18 ka-12.01 cal kBP, E4: 9.96-9.50 cal kBP, E3: 8.86-8.62 cal kBP. E2 should occurred during formation of seismic unit U2, which corresponds to the sediment of facies A2 (8.31-1.65 cal kBP). E1 displaces top of seismic unit U2, and we don’ t recognize displacement inside U1 and sea floor. Therefore, E1 should have occurred just before U1 deposition. Facies A1 corresponds to U1 and its deposition started after 1.59 cal kBP. Therefore, E1 should have occurred just before 1.59 cal kBP.
This study successfully demonstrated "3D-seismic trenching", which comprises ultra-high-resolution 3D seismic survey and offshore drilling surveys, can figure out detailed geological structure and paleo-seismicity of strike-slip fault.

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Keywords: offshore active fault survey, Holocene, paleo-seismicity, offshore drilling survey, 3D-seismic survey

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Conductivity Structure models of large and small slip regions at the 2016 Kumamoto earthquake sequence

*Satoru Yamaguchi[1], Yuto Yamanaka[2], Akira Mimura[1], Kazuki Fkue[1], Daigo Furukawa[1], Tada-nori Goto[3], Hisatoshi Koji[3], Sota Kawaguchi[3], Koki Aizawa[4], Shinichi Takakura[5]

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The 2016 Kumamoto earthquake sequence in Japan started with M_{JMA} 6.5 foreshock and the M_{JMA} 7.3 mainshock occurred 28 hours after the foreshock. The events occurred mainly within the Hinagu and Futagawa fault zone, which are known to be active faults.
Asano and Iwata (2016), Kubo *et al.* (2016), and Kobayashi *et al.* (2017) analyzed the detailed source rupture process of the foreshock, mainshock, and another notable event and proposed the source rupture models. It is important and interesting to reveal conductivity structure of the fault and compare it the source rupture models above mentioned because resistivity structure is one of the crucial elements to reveal subsurface structure of the fault.
We made magnetotelluric (MT) surveys using an audio- frequency MT (AMT) method, which is suitable for revealing shallow part (0 -2 km in depth) with high spatial resolution, along two lines (MSK and NSH lines) of ~2 km across the Futagawa Fault. The MKS line crosses the large slipped region and along the line, we made measurements at 11 stations. The NSH line crosses the small slipped region and along the line, we made measurements at 14 stations. We obtained two-dimensional resistivity models between depths 0 - ~1.0 km along the two lines, we call them MSK model and NSH model, respectively.
We recognize two common conducive regions in both models. One is highly and near vertical conductor below the surface fault traces of the Futagawa Fault. The conductor is located just beneath the surface fault trace in the MSK model and is shifted south in the NSH model. Another is deep and wider conductor which includes deep part of the conductor mentioned above. This conductor of the MSK model is wider and shallower than that of the NSH model. These features are consistent with that of source rupture models, further we can say that our conductivity models figured out more detailed subsurface structure of the Futagawa Fault.

Keywords: 2016 Kumamoto earthquake sequence, Futagawa fault, magnetotellurics, resistivity, active fault

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The Timing and Extent of the Last Surface Rupture Event on the Himalayan Frontal Thrust in Central Nepal around Butwal

*Koji Okumura[1], Soma Nath Sapkota[2], Prakash Pokhrel[2], Hisao Kondo[4], Takuya Furuhashi[3]

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The 2015 Gorkha earthquake ruptured only the deeper northern part of the thrust during the Mw 7.8 earthquake, but did not rupture the surface and shallow portion of the Himalayan Frontal Thrust (HFT) in south. Since then, the evaluation of the potential of the future surface rupture event on the HFT in central Nepal in south of 2015 rupture became an important task for paleoseismology. Mishra et al. (2016), Bollinger et al. (2016), and Wesnousky et al. (2017) proposed respective 1100 CE, 1344 CE and/or 1408 CE, and 1221 CE to 1262 CE (possibly 1255 CE) for the timing of the last surface-rupture event. Each report eliminates the timing of earthquake proposed by the other authors. Therefore, it is necessary to think over the possibility of multiple events in short (less than 100 km) segments or of misleading radiocarbon dates. Also, the existence and the east termination of 1505 CE Indian central seismic gap event (Malik et al., 2017) are not certain yet. In order to solve the rupture history and rupture extents in central and western Nepal, we excavated two trenches across the HFT around the city of Butwal. One is at 12 km west of Butwal at Sorauli (27.70˚N 83.36˚E) and another is at 60 km ESE of Butwal at Susto (27.48˚ N 83.86˚E). Around the Sorauli trench site there is no clear continuous scarp along the Siwalik hill front, but ~100 m wide zone of alluvial surface adjacent to the foot of the hills tilt toward south and juxtaposed to flat alluvial surface. The boundary between the tilted surface and the flat plain is continuous and looks like the active front of a flexure scarp. The trench across a small scarp on the tilted surface did not expose any fault, but a fine sand layer was tilted towards the boundary. An Baesian model of radiocarbon dates indicates the timing of tilting is between 1328 CE and 1435 CE. This period coincides with the 1344 CE earthquake (Bollinger et al., 2016). The Susto trench in the east of Butwal was dug into the foot of ~20 m high fault/flexure scarp below an uplifted terrace surface. In this trench also, 13˚ south-dipping fine sand layers appeared but the fault was below the water table and not exposed. The timing of the tilt in Susuto trench as well as results from investigation in further west in the boundary area between 1344 CE and 1505 CE event will be reported.

Keywords: Himalayan frontal thrust, paleoseismology, trenching study

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Wed. May 29, 2019 3:30 PM - 5:00 PM JST | Wed. May 29, 2019 6:30 AM - 8:00 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[S-SS15] Active faults and paleoseismology

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Takashi OGAMI(National Institute of Advanced Industrial Science and Technology), Ryosuke Doke(Hot Springs Research Institute of Kanagawa Prefecture), Hisao Kondo(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Chairperson:Ryosuke Doke(Hot Springs Research Institute of Kanagawa Prefecture), Mamoru KOARAI(Ibaraki University)

Geologic and historic information on seismic cycles and on the magnitude and source faults of past earthquakes is essential information to understand future large earthquakes. The study of past faulting and seismicity is an important issue for an interdisciplinary community of seismologists, geologists, geomorphologists, archaeologists, and historians.

3:30 PM - 4:00 PM JST | 6:30 AM - 7:00 AM UTC

[SSS15-21] Linear surface ruptures detected by SAR - - *the Kumamoto earthquake, the Northern Osaka earthquake and the Hokkaido Eastern Iburi earthquake*

★Invited Papers

*Satoshi Fujiwara[1], Hiroshi Une[1], Takayuki Nakano[1], Hiroshi Yarai[1], Tomokazu Kobayashi[1], Yu Morishita[1] (1.GSI of Japan)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SSS15-22] Acquisition of micro-landforms in the forest using small UAV-LiDAR: An example from surface rupture of the 2008 Iwate-Miyagi Nairiku, Japan, earthquake

*Asaka Konno[1], Taro Suzuki[2], Shinji Toda[1] (1.International Research Institute of Disaster Science, Tohoku University, 2.Waseda University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SSS15-23] **Bayesian Inference and Forecast on Renewal Processes for Recurrent Earthquakes with Uncertain Occurrence Times**

*Shunichi Nomura[1], Yosihiko Ogata[1] (1.The Institute of Statistical Mathematics)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SSS15-24] **Slip rate of the Chaman fault: estimates based on ^{10}Be exposure dating for offset geomorphic surfaces in Afghanistan**

*Zakeria Shnizai[1], Yuki Matsushi[2], Hiroyuki Tsutsumi[1] (1.Doshisha University, 2.Kyoto University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

Discussion

Linear surface ruptures detected by SAR -- *the Kumamoto earthquake, the Northern Osaka earthquake and the Hokkaido Eastern Iburi earthquake*

*Satoshi Fujiwara[1], Hiroshi Une[1], Takayuki Nakano[1], Hiroshi Yarai[1], Tomokazu Kobayashi[1], Yu Morishita[1]

1. GSI of Japan

1. Introduction

The radar interferogram of ALOS-2 for the 2016 Kumamoto earthquake (M7.3) generally shows elastic deformation caused by the main earthquakes but many other linear discontinuities showing displacement are also found (Fujiwara et al., 2016).

We also found similar linear surface ruptures of the Northern Osaka earthquake on June 18, 2018 (M6.1) and the 2018 Hokkaido Eastern Iburi earthquake (M6.7).

In this presentation, we will show the characteristics of these linear surface ruptures.

2.General characteristics of the linear surface ruptures

The linear surface ruptures are those that Sangawa *et al.* (1985) presented about active faults in the southern part of Suruga Bay West Coast, and did not cause a large earthquake independently and the faults moved as a result of other large earthquakes.

The followings are the common features of the linear surface ruptures:

(1) The standard length of them is several kilometers, with linear or gentle curvilinear shape. The displacement is on the order of a few centimeters to several tens of centimeters.
(2) They are far from the seismogenic fault, and it is unlikely that they are the main seismic fault itself or the branch faults.
(3) There is no evidence that they generated large earthquake ground motions at the time of the main earthquake.
(4) They were likely moved passively, and it is considered to be the resultant faults, not the cause of the main big earthquake.
(5) Since there is a correlation between the topography and the displacement, some of them are recognized as "active faults" from their topographical features. Therefore, there is a possibility that similar fault movements have been accumulating from the past.
(6) The direction of strike and the displacement pattern of them are consistent with the surrounding stress field.

3. Characteristics for each earthquake

3-1) 2016 Kumamoto Earthquake
(1) About 230 linear surface ruptures have been confirmed.

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(2) The form of displacement accounts for most of the normal fault.
(3) The interval, depth and displacement of them are almost constant and uniform for each area, and they form several groups of the linear surface faults.
(4) There are fault groups of similar shape from Beppu Bay to Unzen in the central part of Kyushu, Japan. This implies a possibility that there is a common form of them in central Kyushu.
(5) ΔCFF based on the fault model of the Futagawa fault zone and the Hinagu fault zone for the Kumamoto earthquake can not explain the cause of the displacement of them.

3-2) Northern Osaka earthquake on June 18, 2018
(1) The linear surface rupture was recognized at a place coincident with one of the faults of the Arima–Takatsuki fault zone (Makami fault). Makami fault has been confirmed that it moved at the time of the 1596 Keicho–Fushimi earthquake (M 7.5).
(2) Although the right–lateral fault component is dominant, the rupture does not reach the surface of the ground, but the displacement of the deviation component spreads by a width of about several hundred meters.
(3) On the linear surface rupture, vertical displacement of the south side down is found.
(4) According to the long-term observation before the earthquake, a wide belt around the linear surface rupture has continuously sunk.
(5) The general crustal deformation due to the main shock is small, and it is about several cm at the maximum.

3-3) 2018 Hokkaido Eastern Iburi earthquake
(1) The displacement shows east–west shortening, and there are almost no vertical components. Then, they can be described as reverse fault motion with very low dip angle.
(2) The trace on the ground surface is not a straight line but a somewhat complicated curve that follows the terrain.
(3) The traces of them have not been recognized as active faults.
(4) In the seismic exploration (Yokokura et al., 2014), deviations in the basement are recognized just under them and they may be a hidden fault.

Keywords: Kumamoto earthquake, Northern Osaka earthquake, Hokkaido Eastern Iburi earthquake, Crustal deformation, Active fault, ALOS-2

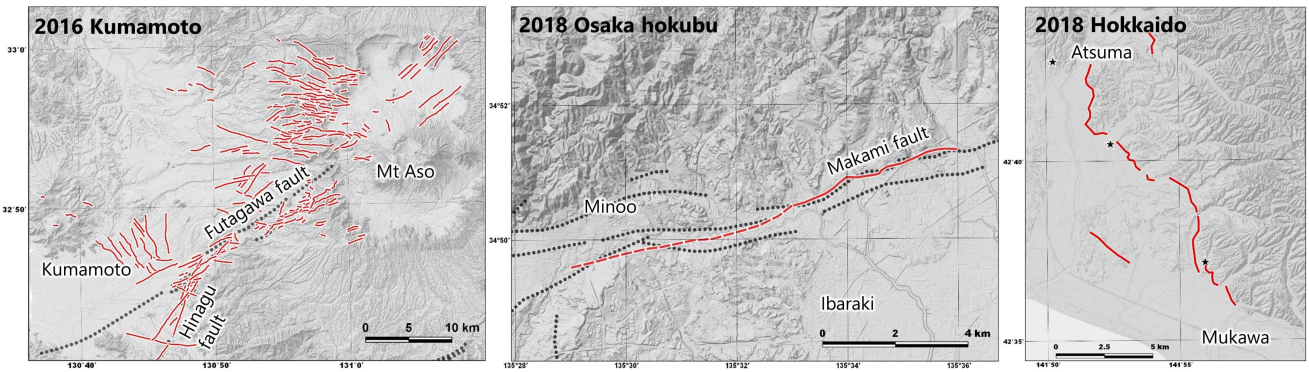


Figure Comparison of linear surface ruptures for three earthquakes.
The red lines demote linear surface ruptures. The black dotted lines demote known active faults by HERP.
The stars denote estimated fault positions by seismic reflection survey (Yokokura et al., 2014)

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Acquisition of micro-landforms in the forest using small UAV-LiDAR: An example from surface rupture of the 2008 Iwate-Miyagi Nairiku, Japan, earthquake

*Asaka Konno[1], Taro Suzuki[2], Shinji Toda[1]

1. International Research Institute of Disaster Science, Tohoku University, 2. Waseda University

For active fault research, photogrammetry (e.g., Photoscan) with UAV (Unmanned Aerial Vehicle) has been introduced to map surface ruptures for the recent earthquakes. However, this method has mainly two drawbacks: it is necessary to set reference points (GCP: Ground Control Point), and it cannot be applied to ground in the dense forest. A small LiDAR equipment attached to the UAV laser is expected to overcome these issues. Although this approach is considered to be effective for detailed mapping of earthquake surface ruptures, none of the papers has been published such an application in the forest. Here we investigate the effectiveness of UAV laser surveying under the forest comparing to the topographical data acquired by terrestrial laser survey (Maruyama et al., 2008; Yoshimi et al., 2010) for the surface rupture that appeared at the 2008 Iwate Miyagi Nairiku earthquake.

Our study field is along the ~0.7-km-long surface rupture located in the north-east of the Aratozawa Dam. The heights of the free faces was several tens of cm to 2 m. We conducted the UAV flights at an altitude of 50-70 m on November 15, 2018. The area is densely covered with cedar plantations and broad-leaved trees, and thus surface rupture is almost invisible from aerial photographs. For the UAV aviation laser surveying, DJI Matrice 600 Pro owned by Waseda University was used. Six GNSS receivers mounted on the UAV allows us to precisely calculate the UAV location only with the errors of the attitude (0.1 °) and the position (1 cm). Based on the precise position information of the UAV, we attached the LiDAR equipment Velodyne's VLP-32C to the UAV to acquire detailed topographical data in the forest. We filtered the point cloud data using Landforms of ISP's software, and then extracted only the ground surface removing the points reflected from vegetation. The swath of ~0.16 km^2 along the surface rupture, measured in about 15 minutes of flight, enable us to provide about 69-million-point cloud data. Among them, the ground point data of ~200,000 points were only screened (~0.3%). Even though it is much fewer than the 8 million points obtained by terrestrial laser surveying of Mariuyama et al. (2008), the points are more homogeneously distributed and data loss is small. Since the terrestrial laser irradiates the beam to the horizontal direction from the installed machine, the data could not be acquired from a blind spot behind trees. In terms of data precision, we confirmed the DEM model from UAV LiDAR is comparable with the terrestrial LiDAR DEM with centimeter-order accuracy. An absolute advantage of the UAV LiDAR is overwhelmingly short operation that allows us to perform not only urgent post-earthquake survey but also repeating measurements to follow degradation process of fault scarps.

Acknowledgements. This research was supported by ImPACT program of Japan Science and Technology Agency.

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Maruyama, T., Toda, S., Yoshimi, M., Omata, M., Kohriya, Y., & Nihei, T. (2008). Ground-based LiDAR Mapping of Surface Rupture Associated with the 2008 Iwate-Miyagi Nairiku, Japan, Earthquake (Mw 6.9). In Eos Trans. AGU, Vol. 89, p. Meet. Suppl., Abstract T53D-1998.

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Yoshimi, M., Maruyama, T., & Toda, S. (2010). Surface deformation extracted from trees ' tilt around surface ruptures of the 2008 Iwate-Miyagi inland earthquake, Japan, using ground-based LiDAR point clouds. In Eos Trans. AGU, Vol. 91, p. West. Pac. Geophys. Meet. Suppl., Abstract T33A-07.

Keywords: UAV LiDAR, Terrestrial LiDAR, Micro-landforms, Surface rupturing, 2008 Iwate-Miyagi Nairiku, Japan, earthquake

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Bayesian Inference and Forecast on Renewal Processes for Recurrent Earthquakes with Uncertain Occurrence Times

*Shunichi Nomura[1], Yosihiko Ogata[1]

1. The Institute of Statistical Mathematics

We discuss parameter inference and forecast in renewal processes for recurrent earthquakes suffering from uncertainties in their occurrence times. Exact likelihood and hazard evaluation in point process theory involves multiple integral with respect to uncertain occurrence dates and are often difficult to calculate even numerically. Alternatively, Monte Carlo simulation of the uncertain occurrence histories can be used for the evaluation by calculating the integrated functions for respective simulated histories and simply averaging them. We apply a renewal model with the Brownian Passage Time (BPT) distribution to Japanese paleoseismic catalog in which at least 2 latest events are specified for each fault segment. It is shown that the Monte Carlo method yields almost the same results as numerical integration. In parameter inference, we assume a common coefficient of variation (COV) parameter for recurrence intervals of Japanese paleoearthquakes due to scarcity of their histories. From datasets in 73 inland paleoseismic sites in Japan, we obtain a Bayes estimate of the common COV at 0.50, which is significantly larger than the COV estimate at 0.24 currently applied in the long-term forecast held by the Headquarters for Earthquake Research Promotion (HERP) of Japan. The difference in COV’ s estimates makes critical influences on long-term probability forecast in several fault segments. We also show numeric experiments of parameter inference and forecast for virtual active fault and compare Bayesian inference and forecast to plug-in methods with maximum likelihood estimates.

Keywords: Bayesian forecast, Coefficient of variation, Renewal process

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Slip rate of the Chaman fault: estimates based on ^{10}Be exposure dating for offset geomorphic surfaces in Afghanistan

*Zakeria Shnizai[1], Yuki Matsushi[2], Hiroyuki Tsutsumi[1]

1. Doshisha University, 2. Kyoto University

Afghanistan is located in a tectonically active part of the world near the collision boundary between the Eurasian and Indian plates. The Chaman fault traverses the eastern part of the country and is a major left-lateral strike-slip fault that accommodates much of the differential movement between the Indian and Eurasian plates. The fault starts from Makaran coast and extends to northeast through the Chaman City, Pakistan. Then it extends to north-northeast into Afghanistan and runs in west of Kabul and finally merges with the Pamir faults system. It is ~1000 km long and strikes from N10˚E to N35˚E. High slip-rates of the fault are known by previous works in the Pakistan side. In Afghanistan no research has been done, therefore we prepared a detailed fault map based on visual images interpretation and previous literatures. The fault offset older and younger alluvial fans and stream deposits of late Pleistocene and Holocene age. Along the fault, relative ages of geomorphic surfaces are known but their absolute ages are unknown. In the absence of absolute ages for faulted deposits, it is not possible to determine the fault slip-rate. Therefore we have conducted cosmogenic dating as was done in Pakistan side to provide age controls for fluvial deposits in the study area. Terrestrial Cosmogenic Nuclide (TCN) uses the interactions between cosmic rays and nuclides in transported boulders, and therefore is an excellent method to directly date alluvial deposits. TCN is particularly useful in Afghanistan due to lack of terrestrial organic materials for radiocarbon dating. Our study focuses on three different areas located at Wardak Province. One of the sites is Ghat Bandakul south of Kabul where the distal part of alluvial fan deposited at the mouth of a stream channel is offset left-laterally. The fan slopes 3-5˚ westward for ~1 km from the foot of the Syah-Tapa Mountain. The deposits are composed of clay, sandstone and granitic clasts originating from bedrocks. Analysis of ALOS images and field work indicate that younger and older terrace risers are displaced left-laterally along the fault for 165 m and 235 m respectively. We collected 6 samples from the top 1-3 cm of each desired sandstone boulders that were >1m in diameter and well-embedded in surface to ensure their long-term stability. The sandstone has large amounts of quartz mineral, which yields ^{10}Be TCN nuclide ideal for dating deposits over Quaternary timescale. Samples were processed at the laboratories of DPRI, Kyoto University and MALT, University of Tokyo.
Based on ~165 m displaced alluvial fan with a ^{10}Be exposure age of ~46 kyr, we obtained the first geomorphologically determined slip-rate of 3.5 mm/yr along the Chaman fault. This slip-rate is considerably smaller than the geologically and geomorphologically defined slip-rates of 19–24 mm/yr and 33 mm/yr along the fault in the border region of Afghanistan and Pakistan. Along the southern section at Ghazni and Zabul Provinces, we mapped east-dipping thrust faults as well as the multiple fault splays indicating a complex interplay between left-lateral faulting and northwest compression, which may cause slower slip-rate at the northern end of the fault. We plan to date two other alluvial surfaces in the southern part of the study area to determine exact slip-rate of the fault in Afghanistan.

Keywords: Chaman fault, 10Be exposure dating, offset geomorphic surface , Afghansitan

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Wed. May 29, 2019 1:45 PM - 3:15 PM JST | Wed. May 29, 2019 4:45 AM - 6:15 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[S-SS17] Seismic evidence of volcanic roots

convener:Naofumi Aso(Tokyo Institute of Technology), Yohei Yukutake(Hot Springs Research Institute of Kanagawa Prefecture), Chairperson:Naofumi Aso, Yohei Yukutake

Magma transport system beneath volcanoes is a key to understand long-term geodynamics and the evolution of the Earth. Especially, deep long-period earthquakes around the Moho beneath active volcanoes are supposed to relate to the magma transport system, although their activities and mechanisms are not understood well. Revealing the role of deep long-period earthquakes in the magma transport system is a key to understand deep volcanic roots around the lower crust, including deep magma chambers. It is therefore essential to estimate complete seismicity with a high-resolution hypocenter distribution and focal mechanisms of deep long-period earthquakes, based on innovative techniques including template matching, relocation methods using waveform cross-correlations, and waveform inversions. Also, high-resolution seismic imaging using advanced tomography techniques, including tomography using ambient noise interferometry, with a dense seismic network is essential to visualize the magma transport system. We welcome studies to understand volcanic roots from a variety of seismological approaches including but not limited to the methods mentioned above.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SSS17-01] Spectral characteristics of deep low frequency earthquakes at Mount Fuji

★Invited Papers

*Motoo Ukawa[1] (1.Nihon University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SSS17-02] Deep low-frequency earthquakes corresponding to the 2011 and 2018 eruptions in Kirishima volcano

*Ryo Kurihara[1], Kazushige Obara[1], Akiko Takeo[1], Yusaku Tanaka[1] (1.Earthquake Research Institute, The University of Tokyo)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SSS17-03] Origin of long-duration of deep low-frequency earthquakes and activity of shallow low-frequency earthquakes beneath northeastern Japan

*Masahiro Kosuga[1], Taichi Haruyama[1], Yuki Matsuno[2], Iori Narita[2], Takuto Maeda[1] (1.Graduate School of Science and Technology, Hirosaki University, 2.Faculty of Science and Technology, Hirosaki University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SSS17-04] Deep low-frequency earthquakes, tomography and magmatic system beneath active volcanoes

★Invited Papers

*Dapeng Zhao[1] (1.Department of Geophysics, Tohoku University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SSS17-05] Seismic imaging of deep structure beneath active volcanoes

*Junichi Nakajima[1] (1.Department of Earth and Planetary Sciences, Tokyo Institute of Technology)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SSS17-06] Deep low-frequency volcanic earthquakes and their implication for deep crustal processes in the magmatic arc

*Haruhisa Nakamichi[1] (1.Sakurajima Volcano Research Center, Disaster Prevention Research Institute, Kyoto University)

Spectral characteristics of deep low frequency earthquakes at Mount Fuji

*Motoo Ukawa[1]

1. Nihon University

Source processes of deep low frequency (DLF) earthquakes beneath volcanoes have poorly understood, mainly because of the small magnitudes of the earthquakes. In this study, we investigate spectral characteristics of the DLF earthquakes beneath Mount Fuji, focusing 11 events with long durations of 5 to 20 minutes including relatively large maximum earthquakes of M0.9 to M1.8. Spectral characteristics of earthquakes, as well as the amplitudes of seismic waves, provide us constraints for their source models. In the present spectral analysis, wavelet analysis with Morlet analyzing wavelet is applied to the DLF events. The results show following characteristics of the DLF earthquakes. The predominant frequencies of the 11 events range relatively narrow frequency band of 1 to 2 Hz. High frequency components of mainly 5-10 Hz are superposed onto the main low frequency waves in the events with large amplitudes. One event shows gradual change of the predominant frequency from 1.5 Hz to 1.0 Hz during 5 minutes. Source models of DLF earthquakes should explain the above spectral characteristics.

Keywords: Deep low frequency earthquakes, Spectra, Mount Fuji

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Deep low-frequency earthquakes corresponding to the 2011 and 2018 eruptions in Kirishima volcano

*Ryo Kurihara[1], Kazushige Obara[1], Akiko Takeo[1], Yusaku Tanaka[1]

1. Earthquake Research Institute, The University of Tokyo

Deep low-frequency earthquakes (LFEs), or sometimes called as deep long-period earthquakes (DLPs), are earthquakes whose dominant frequencies are lower than those of regular earthquakes of the same magnitudes. Deep LFEs occur beneath Kirishima volcano in southwest Japan at the depths of about 10-15 km and 20-25 km according to the catalog of Japan meteorology agency (JMA), while deep LFEs at most volcanoes in Japan occur at the depth of about 30 km.The LFEs near volcanoes can be a key to reveal physical processes of volcanic activities including eruptions because deep LFE activities are supposed to correlate with eruptions. For example, White (1996) showed that the deep long-period earthquakes (DLPs), so-called LFEs, occurred before the 1991 eruption of Pinatubo volcano, Philippine. Shapiro et al. (2017) showed the relationship between DLPs and long period earthquake near the surface beneath the Klyuchevskoy volcano group at Kamchatka, Russia. However, the relationships are still unknown in many volcanoes in Japan. Takahashi and Miyamura (2009) analyzed deep LFEs all over Japan using the catalog of JMA and concluded that they could not find deep LFEs corresponding with the surface volcanic activity such as eruptions. In fact, LFEs were constantly observed in Kirishima volcano in the JMA catalog. In this study, in order to reveal the relationships between activities of volcano such as eruptions and activities of deep LFEs, we first investigated spatial distribution of LFEs by relocation of the hypocenters of LFEs occurred from April 2004 to December 2015 in the JMA catalog using Network correlation coefficient method (Ohta and Ide, 2011). We then obtained time-series change of LFEs by comprehensive detection of deep LFEs based on matched filter technique (Gibbons and Ringdal, 2006; Shelly et al., 2007) from April 2004 to March 2018.

In results of relocation, hypocenters of the deep LFEs are concentrated in small clusters at the depth of 13 km and 22 km, especially many LFEs are located at the depth of about 22 km. On the other hand, result of the matched filter technique shows that deep LFEs at the depth of 23-25 km are activated for about two years including 2011 subplinian eruptions of Shinmoe-dake in Kirishima volcano group. The period of activation corresponds to the period of crustal deformation due to the volume change of the magma reservoir located beneath Ebino plateau at the depth of about 8 km (Nakao et al., 2013). From both results, we find that deep LFEs activated in the two years are located at the depth of 23-25 km, deeper than the locations of deep LFEs which constantly occurred from 2004 to 2018. Waveforms of deep LFEs activated around the 2011 eruptions have different characteristics such as lower frequencies and weak P wave onsets. The locations of activated deep LFEs migrated from shallow part to deep part of the small cluster at the depth of about 23-25 km during the two years of activation. In addition, there are some characteristic deep LFEs which were intensively observed in the periods of phreatic eruptions from March 2010 to July 2010 and phreatomagmatic eruptions from June 2011 to September 2011.Activation of deep LFEs was also observed in the period of eruptions in 2018, however, the depth and waveforms of the deep LFEs are same as those of deep LFEs which constantly occur at the depth of 20-23 km.
These results suggest that the deep LFEs occurring at the depths of 20-25 km are triggered by fluid flow. The difference of deep LFEs in 2011 and 2018 suggest that the fluid paths of the 2011 eruptions and 2018 eruptions are different. Activation of deep LFEs was not observed at the depth of 13 km in the periods of both eruptions, therefore, this deep LFEs may correspond to Ohachi volcano which did not erupt in the periods.

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Keywords: Deep low-frequency earthquake, Kirishima volcano

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Origin of long-duration of deep low-frequency earthquakes and activity of shallow low-frequency earthquakes beneath northeastern Japan

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We investigated the origin of long duration of deep low-frequency (DLF) earthquakes and the activity of shallow low-frequency (SLF) earthquakes beneath northeastern Japan. Source mechanism of DLF events has attracted attention because the events are anomalous with very low predominant frequencies and with a very deep hypocentral location, suggesting a possible link to a magma transport system. Previous studies have shown that the source mechanisms are variable, double couple, CLVD, and single force, among the events. However, the other aspect of the characteristics of DLF events, long duration of the seismic signal, has not been well studied. We firstly searched for typical DLF events with low frequency and long duration. ThenWe we evaluatedthe frequency content by employing frequency index (FI) defined by the logarithm of the amplitude ratio of spectra between high- low-frequency ranges. We specify specified the range as 2–4 Hz and 10–20 Hz for low- and high-frequency ranges, respectively. These ranges correspond to the predominant frequencies of DLF and shallow ordinary earthquakes. We specified determined the location of typical DLF eventsbased on the FI and durationmeasurements. For the case of Hijiori in Yamagata prefecture, long-lasting (> 10 s) monochromatic vibration is was in phase among the stations, which suggests that the source effect is the origin of extended coda is a source origin rather than some path effects. Spectrogram of this event shows no hint of overtones expected from a resonance mechanism. We next numericallysimulated seismograms from several source models by the OpenSWPC code for seismic wave propagation in 2D/3D media. Simulation indicates that the resonance of seismic waves in a low-velocity body could produce monochromatic vibration, but under an exceptional condition of the size and physical properties of the resonant body, and restricted location of the initial source that trigger the resonance. We are conducting the following simulation for a moving source through multiple channels of the fluid transport system.

Event detection using FI is effective for SLF earthquakes that have no low-frequency flag in the JMA earthquake catalog. We searched for the SLF events in the Hakkoda area in Aomori prefecture and the Hakodate area in southern Hokkaido. SLF events in Hakkoda exhibit a cylindrical distribution beneath the Odake volcano in a depth range from the surface to about 5 km, clearly separated from the distribution of VT earthquakes around the volcano. Since the activity of SLF events are restricted in time when the expansion of volcanic body was suggested by GNSS observation, the SLF activity probably related to a magmatic activity of the volcano. In Hakodate area, the SLF earthquakes are located apart from the active volcano, Esan, and with focal depths shallower than 10 km. We confirmed the depth of several SLF earthquakes by adding travel time data from our two temporary seismic stations just above the SLF sources. Thus, the SLF events in this area are collocated with ordinary high-frequency events. Investigation of the generation mechanism of SLF earthquakes in the brittle regime is also important to comparably understand the mechanism of DLF earthquakes in the ductile regime.

Keywords: low-frequency earthquakes, Frequency Index, duration

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Deep low-frequency earthquakes, tomography and magmatic system beneath active volcanoes

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We made a systematic study of deep low-frequency earthquakes, high-resolution tomography and magmatic system beneath active volcanoes on the Japan Islands. Low-frequency earthquakes (LFEs) in the lower crust and uppermost mantle are widely observed, and they occur not only along the subducting Philippine Sea (PHS) slab interface but also beneath active arc volcanoes. The volcanic LFEs are still not well understood because of their limited quantities and less reliable hypocenter locations. We used seismic tomography to determine detailed three-dimensional (3-D) P and S-wave velocity (Vp and Vs) models of the crust and upper mantle beneath the Japan Islands, and used the obtained 3-D Vp and Vs models to relocate the volcanic LFEs precisely (Niu et al., 2008; Yu et al., 2018). Our results show that the volcanic LFEs can be classified into two types: pipe-like and swarm-like LFEs, and both of them are located in or around zones of low-velocity (low-V) and high-Poisson's ratio (high-σ) in the crust and uppermost mantle beneath the active volcanoes. The pipe-like LFEs may be related to fluid migration from the lower crust or the uppermost mantle, whereas the swarm-like LFEs may be related to local magmatic activities or small magma chambers. The number of LFEs sometimes increases sharply before or after a nearby large crustal earthquake that may cause cracks and fluid migration. The spatiotemporal distribution of the LFEs may indicate the track of migrating fluids. As compared with the tectonic LFEs along the PHS slab interface, the volcanic LFEs are more sensitive to fluid migration and local magmatic activities. High pore pressures play an important role in triggering both types of LFEs.

We also investigated the 3-D seismic structure of source areas of the 6 October 2000 Western Tottori earthquake (M 7.3) and the 21 October 2016 Central Tottori earthquake (M 6.6) that occurred near the Daisen volcano in SW Japan (Zhao et al., 2018a). The two large events took place in a high-velocity (high-V) zone in the upper crust, whereas low-V and high-σ anomalies are revealed in the lower crust and upper mantle. LFEs (M 0.0–2.1) occurred in or around the low-V and high-σ zones, which reflect upward migration of magmatic fluids from the upper mantle to the crust under the Daisen volcano. The nucleation of the Tottori earthquakes may be affected by the ascending fluids. The flat subducting PHS slab has a younger lithosphere age and so a higher temperature beneath the Daisen and Tottori area, facilitating the PHS slab melting. It is also possible that a PHS slab window has formed along the extinct Shikoku Basin spreading ridge beneath SW Japan, and mantle materials below the PHS slab may ascend to the shallow area through the slab window. These results suggest that the Daisen adakite magma was affected by the PHS slab melting and upwelling flow in the upper mantle above the subducting Pacific slab.

Detailed 3-D Vp, Vs and σ images of the crust and upper mantle beneath Kyushu are determined, with a focus on the source area of the 2016 Kumamoto earthquake (M 7.3) that occurred in the Beppu-Shimabara graben (BSG) where four active volcanoes and many active faults exist (Zhao et al., 2018b). The 2016 Kumamoto earthquake took place in a high-V and low-σ zone in the upper crust, which is surrounded and underlain by low-V and high-σ anomalies in the upper mantle. This result suggests that, in and around the source zone of the 2016 Kumamoto earthquake, strong structural heterogeneities relating to active volcanoes and magmatic fluids exist, which may affect the seismogenesis. Along the BSG, low-V and high-σ anomalies do not exist everywhere in the upper mantle but mainly beneath the active volcanoes, suggesting that hot mantle upwelling is not the only cause of the

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graben. The BSG was most likely formed by joint effects of northward extension of the Okinawa Trough, westward extension of the Median Tectonic Line, and hot upwelling flow in the mantle wedge beneath the active volcanoes.

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Keywords: deep low-frequency earthquakes, seismic tomography, active volcano

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Seismic imaging of deep structure beneath active volcanoes

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Seismological observations clearly show that flux melting in the mantle wedge is a deep source of magmatism in subduction zones and generated melts are transported to the continental crust through a mantle upwelling flow. However, physical processes of magmatism beneath deep crust are poorly understood. Here I review seismological structures (seismic velocity and attenuation, S-wave reflectors, and low-frequency earthquakes) beneath active volcanoes in Japan, focusing on deep magma chambers and possible pathways of magmatic fluids to the upper crustal levels.

Keywords: S-wave reflector, seismic tomography, low-frequency earthquakes

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Deep low-frequency volcanic earthquakes and their implication for deep crustal processes in the magmatic arc

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Under temperatures and pressures of the lower crust and the upper mantle, rocks typically deform in a ductile manner, and it is unlikely that a sufficient deviatoric stress accumulates to generate brittle failure. However, earthquakes do occur in the upper mantle and in the lower crust beneath active volcanoes, and they are known as volcanic deep low-frequency earthquakes (VDLFs). They release energy mostly in the low-frequency range (<5 Hz), and are characterized by emergent arrivals and long-duration codas. VDLF activity observed at depths of 10-50 km in Japan, the Philippines, Alaska, and the Western US (Power et al., 2004; Ukawa, 2005; Nichols et al. 20011) has generally been attributed to magma transport in the mid-to-lower crustal and uppermost mantle regions. However, because VDLF seismicity is infrequent, with relatively weak and emergent signals, the relationship between deep magma transport and seismic radiation remains poorly understood. Dense seismic observation systems in boreholes, such as the high-sensitivity seismograph network “Hi-net” in Japan (Obara et al. 2005), are effective at detecting not only non-VDLFs (Obara, 2002) but also VDLFs. Since 1997, the Japan Meteorological Agency has routinely detected and located DLFs using the Hi-net dataset, and have identified DLFs in and around most quaternary volcanoes in Japan (Takahashi and Miyamura, 2009). Several studies have attempted to estimate source mechanisms of VDLFs in Japan. The first attempt, carried out by Ukawa and Ohtake (1987), provided a single force as the source mechanism of a VDLF beneath Izu-Ohshima by using the particle motion directions of *S*-waves. More recently, strike-slip type and non-double-couple source mechanisms were obtained using waveform inversions for VDLFs in Northeast Japan (Nishidomi and Takeo 1996; Okada and Hasegawa, 2000). Nakamichi et al. (2003; 2004) estimated the source mechanisms of Mts. Iwate and Fuji through the moment tensor inversion of spectral ratios of body waves, using data from a dense seismic network. The authors explained the source mechanisms as the motion of a tensile crack coupled either with a shear crack or with a chamber. No significant common features have been found in these estimated source mechanisms of VDLFs in Japan. The depths of VDLFs correspond to the depth interval where CO_2-rich fluids are expected to be liberated from ascending basaltic magmas, suggesting that such fluids play an important role in facilitating earthquake instabilities in the presence of tectonic stresses. The striking temporal correlation between VDLF activity and CO_2 gas emissions has been pointed out by Mammoth Mountain (Hill, 1996) and Izu-Ohshima (Watanabe, 2013). However, a temporal correlation between the VDLF activity and surficial geological and shallow geophysical activity is currently debated. The intrusion of basaltic magma before the eruption of Mt. Pinatubo in 1991 was correlated with VDLFs (White, 1996), and temporal correlations are clear for the 1998-1999 unrest of Mt. Iwate, where VDLF seismicity started 5 days before the initiation of the volcano tectonic (VT) seismicity (Nakamichi et al., 2003). We are currently investigating this correlation for the volcanic activity of Sakurajima, which is located in the southern part of the Aira caldera. There is a correlation between VT and VDLF seismicity in the Aira caldera since 2000. For example, both VT and VDLF increased in number between 2017 and 2018. On the other hand, no clear correlation between the VDLF seismicity and the eruption activity of Sakurajima volcano has been identified thus far.

Keywords: Deep low-frequency volcanic earthquake, Non-double-couple source mechanism, Volcanic activity

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[J] Oral | S (Solid Earth Sciences)：S-MP Mineralogy & Petrology

Wed. May 29, 2019 9:00 AM - 10:30 AM JST | Wed. May 29, 2019 12:00 AM - 1:30 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[S-MP32] Deformed rocks, Metamorphic rocks and Tectonics

convener:Yumiko Harigane(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Yoshihiro Nakamura(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Chairperson:Yoshihiro Nakamura(産総研), Yumiko Harigane(産総研)

We invite all researchers who aim to understand the dynamics of the earth's crust and mantle at the plate boundaries, to discuss the latest results from various viewpoints. The scope will include contributions through petrology and structural geology as well as various techniques including rheology and transformation of heat and mass.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SMP32-01] Argon release mechanism of deformed phengite

*Tetsumaru Itaya[1] (1.Engineering Geology Center, Hiruzen Institute for Geology and Chronology)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SMP32-02] Detrital zircons from a traverse along the Asemi River (Sanbagawa Metamorphic Belt, Shikoku, Japan): U-Pb geochronology and Hf isotopic composition

*Ulrich Knittel[1], Shigeyuki Suzuki[2], Monika Walia[3], Juan-Hsi Lee[4], Hao-Yang Lee[5] (1.RWTH Aachen University, 2.Okayama University, 3.Nat. Taiwan University , 4.Chung Cheng University, 5.Academia Sinica)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SMP32-03] Tectonic process of the Sanbagawa eclogite: zircon U–Pb and REE composition analyses

*Shogo Aoki[1], Kazumasa Aoki[2], Tatsuki Tsujimori[3], Yuta Tsuchiya[1], Daichi Kato[2] (1.Department of Biosphere-Geosphere Science, Okayama University of Science, 2.Department of Applied Science, Okayama University of Science, 3.Center for Northeast Asian Studies, Tohoku University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SMP32-04] Petrological implications of a new occurrence of retrogressed eclogite from the Sanbagawa belt of southwest Japan

*Tomoki Taguchi[1], Shunsuke Endo[2], Yohei Igami[1,3], Akira Miyake[1] (1.Graduate School of Science, Kyoto University, 2.Interdisciplinary Faculty of Science and Engineering, Shimane University, 3.Institute of Materials and Systems for Sustainability, Nagoya University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SMP32-05] *P-T* estimations of Kashio mylonite in Oshika, Nagano, Japan: Constraints on the amalgamation of Ryoke and Sambagawa belts

*Yoshihiro Nakamura[1], Yutaka Takahasi[1], Tohru Danhara[2], Hideki Iwano[2], Takehumi Hirata[3] (1.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2.Kyoto Fission-Track Co., Ltd., 3.Geochemical Research Center, The University of Tokyo)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SMP32-06] **Static phenomena retained by garnet during exhumation of metamorphic rocks**

*Masaki Enami[1], Yui Kouketsu[2] (1.Institute for Space–Earth Environmental Research, Nagoya University, 2. Nagoya University)

Argon release mechanism of deformed phengite

*Tetsumaru Itaya[1]

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The author has proposed the argon release from phengites in HP-UHP metamorphic rocks by their ductile deformation in the exhumation and cooling of the metamorphic sequences to explain the relationships between K-Ar phengite ages and the metamorphic grade since Itaya and Takasugi (1988). This argon release hypothesis has not been accepted for 20 years until Nuong et al. (2008) described the age (K-Ar phengite)-temperature-structure relations in the Ishigaki high-pressure schist belt, southern Ryukyu Arc, Japan. Its main reason would be that the argon release mechanism is vague. Recently, the author made its mechanism clear in the literature that is in submission to journal. This paper will focus on the argon release mechanism of deformed phengites.

Cosca et al. (2011) described the effect of deformation on radiogenic argon retentivity from high pressure experiments (10kb and 600 ˚C over a period of 29 hours, giving ca. 10% shortening) performed on rock samples of peraluminous granite containing euhedral muscovite and biotite. Intragrain in-situ $^{40}Ar/^{39}Ar$ analyses for deformed muscovite provided 309 to 264 Ma, consistent with 0-16 % argon loss relative to the undeformed muscovite (311 Ma). They interpreted that the reduction in the effective diffusion length scale in naturally deformed rocks occurs most probably through productions of mesoscopic and submicroscopic defects such as stacking faults. The extreme size reduction of phengite observed at domains close to the rigid garnet in pelitic schists of the Sanbagawa belt are identical to the reduction in the effective diffusion length scale described by Cosca et al. (2011), likely enhancing the argon release. The Sanbagawa pelitic schists suffered extremely long deformation (longer than 31 million years) during the exhumation and had the extremely slow exhumation rate (slower than 0.7 mm/y). In this case, the phengite could grow up with “Ostwald ripening phenomenon” consuming the extremely fine-grained phengite close to the rigid garnet. The size reduction and “Ostwald ripening” growth would continue to become final stage of static phengite crystal size (0.02-0.06 mm in width and 0.4-1.0 mm in length) observed in matrix. During these processes phengite could experience chemical change depending on local bulk chemistry under the P/T conditions changing from moment to moment during the exhumation, making heterogeneous chemistry. On the other hand, Lago di Cignana UHP unit in western Alps suffered relatively quick deformation (shorter than 5 million years) during the exhumation and had the extremely fast exhumation rate (15 - 26 mm/y). In this case, the phengite crystals could record heterogeneously deformed domains in a crystal as well as among the grains, resulting in heterogeneous argon release. In fact, the laser step heating $^{40}Ar/^{39}Ar$ analyses of single phengite crystal in the UHP schists of Lago di Cignana provided significantly irregular age spectrum in comparison with the phengite from the Sanbagawa schists of which the age spectra show the perfect plateau for both the phengite separates and a phengite crystal.

A muscovite in metagranitoid from Grand Paradiso Massif in western Alps yielded heterogeneous age values, giving 54 to 218 Ma (Beltrando et al., 2013). The dated points by the crystal edge are significantly younger than the ages in the part far from the edge. These features suggest that the submicrosopic defects occurring preferentially near the crystal edges are affected by the rubbing with other phases, enhancing preferentially the argon release.

Keywords: deformation of phengite, duration of deformation, in-situ Ar-Ar ages, exhumation rate, argon release mechanism, effective diffusion length scale

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Detrital zircons from a traverse along the Asemi River (Sanbagawa Metamorphic Belt, Shikoku, Japan): U-Pb geochronology and Hf isotopic composition

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Sanbagawa Belt is a classic high-P/low-T metamorphic belt that is exposed over a distance of about 1000 km on Kyushu, Shikoku and Honshu Islands in Japan. The age of this belt has been the focus of many studies in recent years since the discovery of young detrital zircon grains (80 - 95 Ma), younger than the presumed age of peak metamorphism.

Samples for this study come from a traverse along the Asemi River in central Shikoku. Dating of single zircon grains using the LA–ICP–MS U–Pb dating method shows that zircons from all sites investigated are younger than 90 Ma and thus the protoliths are younger than the previously accepted age of metamorphism for this part of the Sanbagawa Belt at ca. 116 Ma. Our sampling sites include the site sampled by Minamishin et al. (1979) which is the reference for metamorphism at ca. 116 Ma in this part of the belt. We therefore conclude that the linear arrays found by Minamishin et al. are mixing lines rather than isochrones. Another sample was taken within the area recently delineated as having experienced eclogite facies metamorphism prior to overprinting in the epidote-amphibolite facies(Taguchi et al., 2018). This implies that the eclogite facies metamorphim took place after 90 Ma, the maximum deposition age of the protolith.

Within the detrital zircon populations contained in the Sanbagawa meta-sediments several age groups are recognized that are also known from SE China. However, compared to those from mainland China, zircons from the Sanbagawa meta-sediments are usually characterized by higher eHf(T) values suggesting higher input of material derived from the depleted mantle. For example, eHf(T) values of zircons of the age group 82-116 Ma range from -2.4 to +9.6 and those of the 127–146 Ma group have altogether positive eHf(T) values of +11.5 to +19.0 indicating depleted mantle sources. We envisage these zircons to have been derived from the ocean side of a magmatic arc. All grains in the range 215-250 Ma are characterized by negative eHf(T) ranging from -2.3 to -15.2, suggesting re-melting of already existing crust.

Keywords: Sanbagawa Belt, detrital zircon, U-Pb dating, Hf-isotopes

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Tectonic process of the Sanbagawa eclogite: zircon U–Pb and REE composition analyses

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High-pressure and low-temperature (HP) metamorphic rocks in the Pacific-type orogeny are relicts of deeply-subducted accretionary prisms along the past subduction zones. The geochronological data of the HP rocks provide us with the time-scale information involved in material cycle from surface to deep mantle.
The Sanbagawa metamorphic belt in SW Japan is one of well-studied HP metamorphic belts in the world. However, the timing of the prograde metamorphism, especially of the eclogite-facies metamorphism has been controversial (e.g. Okamoto et al., 2004; Wallis et al., 2009).In order to solve this issue, we applied in-situ zircon U–Pb age and rare earth element (REE) composition analyses to the Sanbagawa eclogite in central Shikoku.
Igneous core and metamorphic rim domains of the separated zircons can be recognized, based on their cathodoluminescence images and Th/U ratios. The U–Pb datings of those domains clearly show existence of two different metamorphic units in the Sanbagawa metamorphic belt; i.e., one is ca. 120-100 Ma older metamorphic unit and the other is ca. 90 Ma younger one. Chondrite-normalized REE patterns obtained from the metamorphic rims in both units show no Eu anomaly and HREE depletion. These characteristics suggest that each unit suffered the eclogite-facies metamorphism at ca. 120-100 Ma and ca. 90 Ma, respectively.
Our new data combined with the mode of occurrence of the Sanbagawa eclogite in Shikoku are suggestive of the following tectonic scenario:
1. The highest-grade part of the older unit was subducted to the depth over 15 kbar at ca. 120 Ma, and stagnated there until ca. 90Ma.
2. The highest-grade part of the younger unit underwent the eclogite-facies metamorphism at ca. 90 Ma, and was juxtaposed with the eclogite of the older unit at the depth.
3. Both units were exhumed at the same time after the juxtaposition.

Keywords: Sanbagawa metamorphic belt, zircon U–Pb dating, rare earth element

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Petrological implications of a new occurrence of retrogressed eclogite from the Sanbagawa belt of southwest Japan

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The Sanbagawa belt is one of the most famous subduction-related high-pressure (HP) metamorphic belts in the world, and the metamorphic facies series of the belt reaches the eclogite facies. Sanbagawa eclogites are found within coarse-grained mafic-ultramafic masses (Iratsu type) and their surrounding fine-grained mafic, pelitic, and siliceous schists (Seba type) in central and eastern Shikoku, southwest, Japan (Aoya & Endo, 2017 JGSJ). However, the regional extent of the eclogite facies region (eclogite unit) has not yet been established because most were overprinted by lower-pressure assemblages during the exhumation stage. In order to document the eclogite facies metamorphic features of the belt, we recently conducted comprehensive petrological studies of the pelitic schists in the Asemi-gawa region of central Shikoku (Taguchi & Enami, 2014a, 2014b JMPS; Taguchi et al., 2019 JMG). Our previous studies have revealed that a new eclogite unit exists in a limited high-grade area of this region and is composed primarily of pelitic schists. A number of petrological studies have been conducted on the mafic lithology of this region (e.g. Otsuki & Banno, 1990 JMG; Aoki et al. 2009 Lithos; Uno et al., 2015 CMP). However, none of these works recognize the presence of a definitive eclogitic indicator (omphacite, jadeite) within the mafic lithologies, which contrasts with the other eclogite units of Shikoku. This hinders the reliable reconstruction of the extent of the eclogite facies metamorphism in the Sanbagawa belt. Based on an integrated petrological and mineralogical approach, this study reports that mafic schist with garnet + omphacite + quartz paragenesis was first discovered in the Asemi-gawa region. The mafic schist occurs as thin layers within pelitic schist of the albite–biotite zone. This rock includes abundant garnet porphyroblasts up to 5 mm in diameter and shows prograde-type compositional zoning with no textural or compositional break. Omphacite in the mafic schist only occurs as inclusions in garnet, and albite is the major Na phase in the matrix, suggesting that the mafic schist represents highly retrogressed eclogite. The omphacite in the sample displays a strong Raman peak at 678 cm^{-1}, and concomitant Raman peaks are all consistent with those of the reference omphacite Raman spectrum. Transmission electron microscopy (TEM) observations showed that the selected area electron diffraction pattern of the omphacite is compatible with the common *P*2/*n* omphacite structure. The combination of Raman geothermobarometries and conventional thermodynamic calculations gives peak (pressure–temperature) *P*–*T* conditions of 1.7–2.0 GPa and 440–540 ˚C for the mafic schist. The peak *P*–*T* values are comparable to those of the schistose eclogitic rocks (Seba type) in other Sanbagawa eclogite units of Shikoku. These findings suggest that most of the schistose eclogites and associated metasedimentary rocks along the Sanbagawa subduction zone probably share similar simple *P*–*T* histories.

Keywords: eclogite, FIB–TEM, omphacite, Raman spectroscopy, Sanbagawa belt

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P-T estimations of Kashio mylonite in Oshika, Nagano, Japan: Constraints on the amalgamation of Ryoke and Sambagawa belts

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Sambagawa (*LTHP*-type) and Ryoke (*HTLP*-type) metamorphic belts are classically termed as a “paired metamorphic belt” and closely related to the island arc magmatism and regional metamorphism in subduction zone (e.g., Brown, 2010). Although almost all Ryoke metamorphic belt in SW Japan are not directly in contact with Sambagawa metamorphic belt, Oshika area in Nagano prefecture, Japan, is one of the few examples of the geological field where can be directly observed the amalgamation of Ryoke and Sambagawa belts along the Median Tectonic Line (MTL). Hence, it is the best place for discussing the relationship between metamorphism and deformation related to the tectonic evolution of MTL. Our detailed investigations of both metamorphic rocks lead to be constraints on the exhumation tectonics of *HPLT*-type metamorphic rocks and tectonic evolution from ductile to brittle deformations in subduction zone.

In this area, it is well known that the medium-*T* mylonite (so called “Kashio mylonite”) is widely exposed along the MTL (Takagi, 1986). We newly found that the low-*T* mylonites, as indicated by the Z-maximum *c* -axis lattice preferred orientations (LPOs) of recrystallized quartz, were also distributed. Both Ryoke and Sambagawa metamorphic rocks were deformed by low-*T* mylonitization within ~500m of the MTL. The mineral stretching with a gentle plunge to the NNE or SSW, suggesting the sinistral shearing, are well developed on the mylonite foliation. In the low-*T* mylonite zone, garnet porphyroclasts showed a significant chemical zoning of the grossular (X_{Grs}) from core to rim. The mylonite foliation was composed of white mica (Si in apfu = 3.38-3.49) and chlorite (X_{Mg} = 0.39-0.41). Based on the chemical analyses of recrystallized minerals, we attempted to apply the geothermometry and barometry. The *P-T* conditions of the low-*T* mylonites were estimated at 420~450 ˚C /0.5-0.6 GPa. A part of the Ryoke pelitic gneiss origin mylonites was estimated at ~540 ˚C /0.9 GPa. These *P-T* conditions of the mylonites are consistent of peak *P-T* conditions during Sambagawa metamorphism (e.g., Enami et al., 1994), suggesting the amalgamation of Ryoke and Sambagawa metamorphic belt during mylonitization.

In addition, U-Pb ages of zircons in the Kashio mylonite of Ryoke metamorphic belt were analysed by LA-ICPMS. The prominent age spectra of the mylonite showed 69.0 +/- 0.6 Ma (*n*=10), suggesting the solidification age of host Ryoke granite. Our data on protolith demonstrate a younger age than previously reported ages during mylonitization (>83 Ma, Kubota and Takeshita, 2008; or 95~85 Ma, Takagi, 1997). This suggests that the host Ryoke granite and Sambagawa metamorphic rocks were deformed by low-*T* mylonitization during 58-69 Ma. After the mylonitization and amalgamation of both metamorphic rocks, the exhumation of Ryoke and Sambagawa belts might be occurred owing to the change in plate motion at around 55 Ma (Seton et al. 2015).

[Reference] M. Brown, Gondwana Research, 18 (2010) 46-59. H. Takagi, J. Struct. Gel. 8 (1986) 3-14. M. Enami, S.R. Wallis, Y. Banno, 116 (1994), 182-198. Y. Kubota, T. Takeshita, Island Arc, 17, (2008) 129-151. H. Takagi, Chikyu, 19 (1997) 111-116. K. Shibata, H. Takagi, J. Geol. Soc. Jpn., 94 (1988) 35-50.

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M. Seton, N. Flament, J. Whittaker, R.D. Muller, M. Gurnis, D.J. Bower, Geol. Rea. Let. 42 (2015) 1732-1740.

Keywords: Mylonite, EBSD, Ryoke metamorphic belt, Sambagawa metamorphic belt

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Static phenomena retained by garnet during exhumation of metamorphic rocks

*Masaki Enami[1], Yui Kouketsu[2]

1. Institute for Space–Earth Environmental Research, Nagoya University, 2. Nagoya University

Electron back scatter diffraction (EBSD) method was employed for the analysis of crystallographic orientations of garnet grains to discuss tectonic behavior of various types of metamorphic rocks during exhumation. Selected metamorphic rocks were coesite-eclogite from the Sulu belt, China, granulite in the Mogok belt, Myanmar, and epidote-amphibolite and quartz schist of eclogite and non-eclogite units, respectively, in the Sanbagawa belt, Japan. The garnet grains are grouped into segmentation and honeycomb types. The segments forming an aggregate, which formed by hydration reaction during the exhumation stage, share similar crystallographic orientations, with misorientations of less than 3—4°. This suggests that the segmentation textures were not formed by deformational crush and the grains recorded a static environment during exhumation. The Sulu and Mogok garnet grains segmented under granulite-upper amphibolite facies conditions have been continually exhumed to the earth's surface without incurring specific deformation and/or rotation. The garnet grains in the epidote-amphibolite from the Sanbagawa eclogite unit were once fragmented by hydration reactions during exhumation and have subsequently become unified by hydration reactions during prograde epidote-amphibolite facies metamorphism. This fact indicates that the Sanbagawa garnet grains in the eclogite unit have recorded static conditions during the hydration and dehydration stages. Honeycomb garnet in a quartz schist from the Sanbagawa non-eclogite unit, which formed during prograde stage under the lower epidote-amphibolite facies, also shows no evidence suggesting deformation processes. This sample might not have undergone significant deformation during exhumation from depths of 25—30 km (0.8—0.9 GPa) to the earth's surface. Such undeformed phenomena recorded in these metamorphic garnet grains during exhumation might have been promoted by episodic exhumation, buoyancy-driven and static exhumation of the metamorphic belt, or local concentration of tectonic stress and heterogeneities of deformation impacts caused by the contrast of lithologic competency and tectonic discontinuity development.

Keywords: EBSD, exhumation, garnet, metamorphic rock

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[J] Oral | S (Solid Earth Sciences)：S-MP Mineralogy & Petrology

Wed. May 29, 2019 10:45 AM - 12:15 PM JST | Wed. May 29, 2019 1:45 AM - 3:15 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[S-MP32] Deformed rocks, Metamorphic rocks and Tectonics

convener:Yumiko Harigane(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Yoshihiro Nakamura(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Chairperson:Tomoki Taguchi(京都大学　大学院理学研究科), Kenta Yoshida(JAMSTEC)

We invite all researchers who aim to understand the dynamics of the earth's crust and mantle at the plate boundaries, to discuss the latest results from various viewpoints. The scope will include contributions through petrology and structural geology as well as various techniques including rheology and transformation of heat and mass.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SMP32-07] Garnet zoning suggesting the correlation between the Higo and Abukuma metamorphic rocks

*Tadao Nishiyama[1], Yuto Wakida[1] (1.Department of Earth and Environmental Sciences, School of Science, Graduate School of Science and Technology, Kumamoto University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SMP32-08] $FeAlO_3$ phase at ultrahigh-temperature metamorphic conditions: Evidences from the sillimanite—Fe_2O_3 and sillimanite—Fe_3O_4 systems at 9 kbar and 1050 °C

*Toshisuke Kawasaki[1], Tatsuro Adachi[2], Hiroaki Ohfuji[1], Yasuhito Osanai[2] (1.Ehime University, 2.Kyushu University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SMP32-09] **Halogens in nanogranitoids entrapped during granulite facies to ultrahigh-temperature metamorphism in the lower crust**

*Fumiko Higashino[1], Tetsuo Kawakami[2] (1. Graduate School of Environmental Studies, Tohoku University, 2.Graduate School of Science, Kyoto University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SMP32-10] Significance of high-Ti biotite and anatectic conditions of paragneiss in the Oki-Dogo Island, Japan

Hiroshi Yoshida[1], *Shunsuke Endo[1], Mai Fujiwara[1], Atsushi Kamei[1] (1.Department of Earth Science, Interdisciplinary Faculty of Science and Engineering, Shimane University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SMP32-11] Eclogite-to-granulite transition in the Ufipa Complex (Tanzania): the time-lag between collision and the granulitization

*Morita Isamu[1], Tatsuki Tsujimori[1], Nelson Boniface[2], Shogo Aoki[3], Kazumasa Aoki[3] (1.Tohoku University, 2.University of Dar es Salaam, 3.Okayama University of Science)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SMP32-12] **Switching of metamorphic growth kinetics due to volume fraction of metamorphic fluid**

*Kazuhiro Miyazaki[1] (1.Orogenic Processes Research Group, Institute of Geology and Geoinformation, Geological Survey of Japan/National Institute of Advanced Industrial Science and Technology)

Garnet zoning suggesting the correlation between the Higo and Abukuma metamorphic rocks

*Tadao Nishiyama[1], Yuto Wakida[1]

1. Department of Earth and Environmental Sciences, School of Science, Graduate School of Science and Technology, Kumamoto University

The Higo and Abukuma metamorphic rocks are both Cretaceous low P/T metamorphic rocks, located in central Kyushu (the former) and in northeast Japan (the latter), respectively. The correlation between the two metamorphic rocks has been discussed in terms of SHRIMP U-Pb ages of plutonism, metamorphism and sedimentation (Sakashima et al., 2003), although they are separated by more than 1,000 km. This paper presents new evidence for this hypothesis by reporting garnet zoning in the Higo metamorphic rock (HMR) which is very similar to that in the Abukuma metamorphic rock (AMR).

Pelitic and psammitic gneisses in the garnet-cordierite zone in the HMR contains commonly garnet crystals, which are subhedral to euhedral grains of several millimeters in size. We examined chemical zoning of these garnets from 41 samples of pelitic gneiss in the Kousadake area, Kousa and Tomochi Towns, Kumamoto Prefecture. Typical mineral assemblage of the pelitic gneiss is garnet + biotite + K-spar + plagioclase + quartz ± cordierite ± sillimanite. Ilmenite, titanite, and rutile (less common) occur as inclusions in garnet. Garnet zoning can be classified into three types: flat, simple and complex types. The flat type shows no concentration gradient of any component from the core to the rim. The composition ranges from Prp9Alm68Sps3Grs20 to Prp20Alm73Sps3Grs4, depending on the bulk composition of the sample. The simple type shows a gradual change in composition from the core richer in Sps and Grs components (Prp15Alm51Sps26Grs8) to the rim richer in Alm component (Prp15Alm61Sps19Grs3). The complex type has several variations in the zoning, however, all the variations show discontinuous or rapid changes in composition. The complex A type consists of the plateau-like core richer in Sps and Grs components (Prp2Alm36Sps33Grs29) and the rim richer in Alm and Prp components (Prp23Alm67Sps7Grs3). The complex B type shows a core-mantle-rim structure. The core is nearly constant composition with Prp6Alm61Sps14Grs19, followed by a rapid increment of Grs component up to 28 mol % associated with counterpart decrement of Alm and Sps components in the mantle (Prp6Alm58Sps8Grs28). In the rim, Grs and Sps components gradually decrease with counterpart increment of Prp and Alm components to Prp12Alm73Sps5Grs10. The Grs contents in the core of the complex A type and also in the mantle of the complex B type are much higher than those of the simple and flat types, indicating higher pressure condition for the formation. Garnets with these three types of zoning occur randomly in the garnet-cordierite zone of the studied area, suggesting the different nucleation timing of these garnets rather than diffusive homogenization of zoning in higher grade rocks (Yoshimura,1995).

The complex A and B types of zoning are quite similar to those of sector-zoned garnets from the AMR reported by Hiroi et al. (1998), who suggested the followings. These zonings may indicate three stages of garnet growth at different pressures: the earliest stage characterized by relatively low T (~650 C) and medium P (~0.6 GPa), the second stage with much higher pressure up to 1.2 GPa, and the third stage with higher T (~800 C) and lower P (~0.5 GPa). Thus, the HMR may have experienced the P-T path similar to that of the AMR. This similarity of the P-T path together with the consistency of the age of plutonism, metamorphism and sedimentation (Sakashima et a., 2003) strongly suggests that the HMR and AMR may have formed the same geological terrane. The tectonics leading to the large-sale displacement between

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the HMR and AMR can be either a nappe tectonics or strike-slip tectonics, although this study cannot provide any information on the tectonics.

References: Hiroi, Y. et al., (1998) JMG, 16, 67-81; Sakashima, T. et al., (2003) Jour. Asian Earth Sci., 21, 1019-1039. Yoshimura,Y.(1995) Mem. Fac. Sci. Kumamoto Univ., 14, 1, 1-18.

Keywords: garnet, zoning, Higo metamorphic rock, Abukuma metamorphic rock

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$FeAlO_3$ phase at ultrahigh-temperature metamorphic conditions: Evidences from the sillimanite—Fe_2O_3 and sillimanite—Fe_3O_4 systems at 9 kbar and 1050 ℃

*Toshisuke Kawasaki[1], Tatsuro Adachi[2], Hiroaki Ohfuji[1], Yasuhito Osanai[2]

1. Ehime University, 2. Kyushu University

Two high pressure experiments at 9 kbar and 1050 ℃ under moisture condition reveal $FeAlO_3$ phase is stable under ultrahigh-temperature metamorphic conditions. $FeAlO_3$ and corundum newly crystallised accompanying SiO_2-rich melt and vapour among sillimanite crystals from the mixture of Rundvågshetta sillimanite and reagent-grade Fe_2O_3 (weight ratio of 95:5) within Pt capsule. We found no hematite in the charge. In contrast, we found $FeAlO_3$ phase, SiO_2-rich melt and vapour among sillimanite from the mixture of Rundvågshetta sillimanite and reagent-grade Fe_3O_4 at (weight ratio of 86:14) within AuPd capsule. We found a domain composed by $FeAlO_3$, corundum, magnetite—hercynite spinel and ulvöspinel at the bottom part of the charge. The domain was contact with melt among sillimanite. The present results suggest the possibility that $FeAlO_3$ phase would be an index mineral of ultrahigh-temperature metamorphism for the partially melted Fe—Al-rich granulites under hydrous and oxidised environments.

Keywords: FeAlO3 phase, sillimanite, corundum, spinel, ultrahigh-temperature granulies

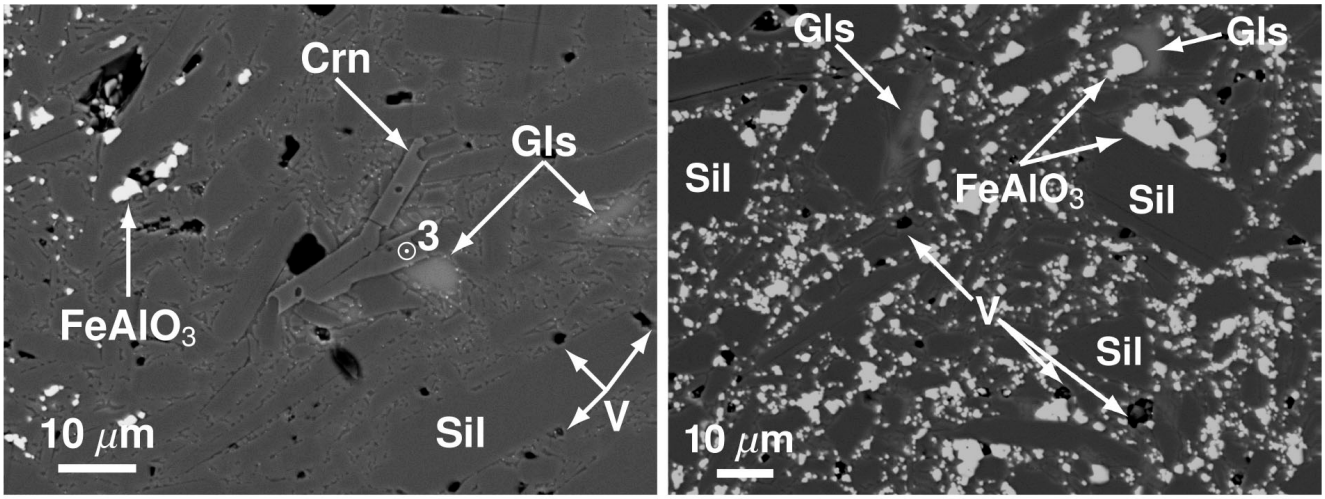


Fig. 1. Backscattered electron image (BSEI) of run products recrystallised from the mixture of Rundvågshetta sillimanite and Fe_2O_3 in the Pt capsule (left: run no. 171018A) and the mixture of Rundvågshetta sillimanite and Fe_3O_4 in the AuPd capsule (right: run no. 171018D) at 9 kbar 1050 ℃ under moisture condition. Left: euhedral corundum with fine vapour hole, $FeAlO_3$ phase, glass and vapour (dark holes) fill among sillimanite crystals. Number 3 is the analysed point by Raman spectroscopy. Right: euhedral 5–10 μm size $FeAlO_3$ phase and fine (<1 μm) $FeAlO_3$ phase are scattered among sillimanite crystals accompanying melt and vapour (dark hole). Crn, corundum. $FeAlO_3$, $FeAlO_3$ phase. Gls, glass. Sil, sillimanite. V, vapour.

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Halogens in nanogranitoids entrapped during granulite facies to ultrahigh-temperature metamorphism in the lower crust

*Fumiko Higashino[1], Tetsuo Kawakami[2]

1. Graduate School of Environmental Studies, Tohoku University, 2. Graduate School of Science, Kyoto University

Granulite facies to ultrahigh-temperature (UHT) metamorphic terranes in the deep crust are considered as a potential source region of granitoid melts that eventually form plutons (e.g., Sawyer et al., 2011; Brown et al., 2011). Melt inclusions such as “nanogranitoids” and “felsite inclusions” recently found from such granulite facies and UHT metamorphic terranes are the explicit evidence of partial melting (Cesare et al., 2009; 2015; Hiroi et al., 2014). Such inclusions enable us to estimate the melt composition formed by partial melting (Cesare et al., 2015) and to estimate the timing of partial melting when combined with pressure-temperature-time (*P-T-t*) paths (Kawakami et al., 2013; 2016).
In determining the melt compositions using nanogranitoids, re-melting and re-homogenization of nanogranitoid inclusions using piston cylinder is often performed, and nanogranitoids with decrepitation texture are avoided from such experiments (Cesare et al., 2015). However, nanogranitoids that has decrepitation texture are common in high-*T* pelitic gneisses (e.g., Hiroi et al., 2014; Cesare et al., 2015; Kawakami et al., 2016) and if development of such texture is related to the *P-T* path of the host rock as in the case of fluid inclusions (Vityk and Bodnar, 1995), neglecting the decrepitated nanogranitoids might mean neglecting of specific metamorphic history. Therefore, efforts in determining chemical compositions of melt inclusions of decrepitated nanogranitoid inclusions is also valuable. Among various chemical aspects, information on major halogens (F and Cl) in lower crustal nanogranitoids is extremely poor (e.g., Cesare et al., 2015; Acosta-Vigil et al., 2016; Ferrero et al., 2018). This study aims to provide some new data on the halogen contents in nanogranitoids to better understand the partial melting in the granulite facies active lower crust using fully crystallized nanogranitoids.
Nanogranitoid inclusions are found as inclusions in garnet from granulite facies mafic and pelitic gneisses from Balchenfjella (Sør Rondane Mountains, East Antarctica). Mineral assemblages of the large-sized (>100 μm) nanogranitoid inclusions are Bt + Pl + Qtz in mafic gneiss, and Bt + Pl + Qtz + And + Sil in pelitic gneiss. Mesoperthite in the nanogranitoid inclusion and in the matrix of the pelitic gneiss gave temperature of >900 ºC based on ternary feldspar thermometry. These observation evidences that Balchenfjella experienced UHT metamorphism and the nanogranitoid inclusions represent the UHT melt. The re-integrated composition of nanogranitoids range from granodioritic in the mafic gneiss to granitic in the pelitic gneiss, and mostly peraluminous. The peraluminous melt compositions might be a result of post-entrapment interaction between the melt and host garnet. F/Cl ratio of biotite in the nanogranitoids can be an indicator of F/Cl of the nanogranitoid melts, and low F/Cl ratio observed in this study contrasts with high values observed in peraluminous silicic melts from intrusive and extrusive igneous rocks. This suggests that F/Cl ratio in shallower level silicic igneous rocks is mainly controlled by the magmatic processes in the shallow crust, and chemical characteristics of source rocks or F/Cl ratio of the original melts in the source region is of secondary importance.

Keywords: nanogranitoids, partial melting, chlorine, fluorine

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Significance of high-Ti biotite and anatectic conditions of paragneiss in the Oki-Dogo Island, Japan

Hiroshi Yoshida[1], *Shunsuke Endo[1], Mai Fujiwara[1], Atsushi Kamei[1]

1. Department of Earth Science, Interdisciplinary Faculty of Science and Engineering, Shimane University

The Oki Gneiss exposed on the eastern side of the Oki-Dogo Island in SW Japan consists mainly of paragneiss and subordinate orthogneiss. These lithologies were originated from Paleoproterozoic (~1800 Ma) clastic rocks and granitoids, and subjected to low-P/T type metamorphism associated with anatexis at around 240 Ma (Tsutsumi et al., 2006; Cho et al., 2012). The Oki Gneiss must be a key to understand the correlation with Precambrian basements in the Korean Peninsula and Permo-Triassic tectonic framework of East Asia. In the present study, we conducted field survey in the entire areas of the Oki Gneiss and examined the spatial extent and P–T conditions of high-grade metamorphism and anatexis. Although structures of the Oki Gneiss were affected by intensive Cenozoic volcanic activities, the main foliation (gneissosity) largely strikes E–W and dips to the south or north. Migmatitic gneiss shows complex ptigmatic folding, but outcrops showing polyphase deformation are uncommon and the main foliation probably represents a single deformation phase. Migmatitic pelitic gneiss consists of biotite- and sillimanite-rich melanosome and plagioclase- and quartz-rich leucosome parallel to the main foliation, and is commonly cut by discordant leucogranite dikes. The peak mineral assemblage of aluminous pelitic gneiss is garnet + biotite + sillimanite + cordierite + plagioclase + quartz + spinel (hercynite-gahnite) + ilmenite + rutile + graphite or its partial assemblages. Spinel only occurs in southern areas. Occasionally, euhedral andalusite enclosing sillimanite occurs in the leucosome, and they might be cotectic minerals crystallized during cooling. Garnet grains are chemically homogeneous except for the reverse-zoned (i.e., increase in Mn and decrease in Mg) grain margins. However, some garnet in northern localities faintly preserves growth zoning characterized by high Mn, Ca and Y contents at the core of garnet grains. To estimate peak-T conditions, we used Ti-in-biotite and Zr-in-rutile geothermometers for biotite and rutile in equilibrium with quartz and zircon. High-Ti biotite (up to 5.9 wt% TiO_2) is found as inclusions in garnet and tiny rounded grains completely enclosed within single crystals of matrix quartz or plagioclase. These high-Ti biotite grains imply high-T metamorphism (up to 760˚C), but high-Ti biotite in garnet shows significantly higher Mg#, suggesting Fe-Mg exchange with the host garnet during cooling. Coarse-grained platy biotite aligned in the gneissosity shows low Ti and is associated with low-Zr rutile and sillimanite, suggesting re-equilibration (~550–650˚C) and pervasive ductile deformation during an early retrograde stage. High-Zr rutile (1200–1700 ppm Zr) only occurs as inclusions in garnet with no any associated cracks, and implies high-T conditions of ~750–780˚C. Presuming high-Ti biotite in quartz/plagioclase and homogenous core of garnet are in equilibrium at the thermal peak, combination of conventional geothermobarometers gives peak P–T conditions of ~0.42–0.60 GPa and 760–780˚C for samples from widely-spaced localities. Samples from southern localities tend to show lower P conditions. Calculated phase equilibria verify the coexistence of cordierite, garnet and spinel during anatexis at the estimated peak conditions for the southern samples. The ubiquitous occurrence of high-Ti biotite implies the Oki Gneiss entirely underwent high-grade metamorphism (transitional upper amphibolite to granulite facies). Taken together, the Oki Gneiss represents a Paleoproterozoic basement that was overprinted by a 240 Ma thermal event associated with ductile flow, low-P/T metamorphism and anatexis at mid-crustal levels (~15–20 km).

Keywords: Oki Gneiss, biotite, metamorphism

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Eclogite-to-granulite transition in the Ufipa Complex (Tanzania): the time-lag between collision and the granulitization

*Morita Isamu[1], Tatsuki Tsujimori[1], Nelson Boniface[2], Shogo Aoki[3], Kazumasa Aoki[3]

1. Tohoku University, 2. University of Dar es Salaam, 3. Okayama University of Science

Eclogite-to-granulite transition found in the collisional tectonic regime can provide not only regional tectonic history but also basic principles underlying crustal thickening attributed to the continent-continent collision at convergent plate boundary. In order to understand the dynamics and timescale of collision-induced crustal thickening, we conducted petrological and geochronological research for partially granulitized eclogite and associated metamorphic rocks of the Ufipa Complex (Tanzania).

The Ufipa Complex is a newly confirmed Neoproterozoic metamorphic complex that is equivalent to the Mozambique Belt formed during 'Pan-African orogeny'. Granulitized eclogite is a coarse-grained kyanite-bearing retrograde eclogite with the major mineral assemblage of garnet + omphacite + kyanite + rutile; kyanite contains both omphacite and clinozoisite. Kyanite-free eclogite is medium-grained less-retrograded, bimineralic eclogite. Garnet–omphacite–kyanite–quartz geothermobarometry yielded a P = ~1.9–2.1 GPa and T = ~920–960°C for eclogite stage and P = ~1.3–1.6 GPa and T = ~900–940℃ for high-pressure granulite stage.

LA-ICPQMS zircon U–Pb geochronology for the eclogites revealed that time-lag Δt between collision at ~588 Ma and granulite-facies recrystallization at ~559 Ma was ~30 m.y. Zircon growth during eclogite-facies was confirmed by both mineral inclusions and trace-element abundances. In-situ zircon dating using petrographic thin-sections also confirmed the timing of granulitization. The inferred Δt of ~30 m.y. is consistent with other continental collision zones even in Cenozoic orogens in the literatures.

Keywords: Eclogite, Granulitization, Zircon U-Pb age, In-situ dating, Neoproterozoic, East Africa

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Switching of metamorphic growth kinetics due to volume fraction of metamorphic fluid

*Kazuhiro Miyazaki[1]

1. Orogenic Processes Research Group, Institute of Geology and Geoinformation, Geological Survey of Japan/National Institute of Advanced Industrial Science and Technology

In general, it is predicted that the growth kinetics should switch from interface-controlled to diffusion-controlled kinetics with increasing grain size. Rate constant and diffusion coefficient are required for estimate the critical grain size for the switching. It is assumed that the effective diffusivity is a product among diffusivity of solute in water, volume fraction of metamorphic fluid and tortuosity. Using rate constant of silicate in aqueous fluid and diffusion coefficient of solutes in aqueous fluids, the switching will occur around 1 mm in diameter at 500 degree C and 1 G Pa with 0.02 volume % of metamorphic fluid. The switching will occur around 1 cm with 0.2 volume % of metamorphic fluid, and will occur around 10 cm with 2 % volume of metamorphic fluid, respectively. Accompanying the switching with diffusional instability, growth kinetics can be predicted by degree of supersaturation. Recently, degree of supersaturation or reaction affinity, which is a function of degree of supersaturation, were reported from different metamorphic belts (e.g. Miyazaki, 2015; Spear and Pattison, 2017). Typical value for reaction affinity of the nucleation of a porphyroblast, such as garnet, is 300 J/mol oxygen (Spear and Pattison, 2017). Using this value, diffusional instability will occur above 1 μm. Therefore, garnet should grow unstable and result in highly irregular morphology after the switching. However, such garnet is rare in general regional metamorphic belt. In other word, existence of euhedral to subhedral garnet larger than cm-scale implies interface-controlled growth under sufficient metamorphic fluid condition at deep crustal depths. Unlike in the case of garnet porphyroblast, matrix mineral, such as phengite, probably grew by interface-controlled dissolution-precipitation with non-hydrostatic condition, because supersaturation of the dissolution-precipitation is perhaps much lower than that of net-transfer reaction and size of phengite is usually less than 1 mm.

Keywords: Metamorphism, Metamorphic reaction, Garnet

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[J] Oral | S (Solid Earth Sciences)：S-MP Mineralogy & Petrology

Wed. May 29, 2019 3:30 PM - 5:00 PM JST | Wed. May 29, 2019 6:30 AM - 8:00 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[S-MP32] Deformed rocks, Metamorphic rocks and Tectonics

convener:Yumiko Harigane(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Yoshihiro Nakamura(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Chairperson:Shunsuke Endo(島根大学 総合理工学部 地球科学科), Ryosuke Oyanagi(国立研究開発法人 海洋研究開発機構 地球内部物質循環研究分野)

We invite all researchers who aim to understand the dynamics of the earth's crust and mantle at the plate boundaries, to discuss the latest results from various viewpoints. The scope will include contributions through petrology and structural geology as well as various techniques including rheology and transformation of heat and mass.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SMP32-13] Early Paleozoic subduction-zone metamorphism in Japan: A geochronological reappraisal of Kitomyo Schists

*Shota Matsunaga [1], Tatsuki Tsujimori[1], Atsushi MIYASHITA[2], Shogo Aoki[3], Kazumasa Aoki[3] (1.Tohoku University, 2.Seikei University, 3. Okayama University of Science)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SMP32-14] Dating a 'princess': U–Pb age determination of 'nunakawaite' (strontio-orthojoaquinite)

*Tatsuki Tsujimori[1], Tomomi Hara[1], Yuzuki Shinji[1], Tomohiro Ishizaka[1], Hiroshi Miyajima[2], Jun-Ichi Kimura[3], Shogo Aoki[4], Kazumasa Aoki[4] (1.Tohoku University, 2.Fossa Magna Museum, 3.JAMSTEC, 4.Okayama University of Science)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SMP32-15] Modeling of the progressive evolution of subducting slab composition by sparse modeling

*Kenta Yoshida[1], Tatsu Kuwatani[1,2], Kenta Ueki[1], Ryosuke Oyanagi[1], Shotaro Akaho[3] (1.Japan Agency for Marine-earth Science and Technology (JAMSTEC), 2.PRESTO, Japan Science and Technology Agency, 3.National Institute of Advanced Industrial Science and Technology (AIST))

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SMP32-16] Bayesian statistical evaluation method for detrital zircon geochronology: Applications

*Tan Furukawa[1], Tatsuki Tsujimori[2], Shogo Aoki[3], Kazumasa Aoki[4] (1.Tohoku University, Department of Earth Science, 2.Tohoku University, 3.Faculty of Biosphere-Geosphere Science, Okayama University of Science, 4.Department of Applied Science Okayama University of Science)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SMP32-17] 3D structural analysis using X-ray Computed Tomography technique: a case study for fault rocks from the Nojima Fault, southwest Japan

*Takafumi Nishiwaki[1], Aiming Lin[1], Bingcheng Liu[1] (1.Kyoto University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SMP32-18] High- and low-stress subduction zones recognized in the rock record

*Kazuhiko Ishii[1], Simon Richard Wallis[2] (1.Department of Physical Science, Graduate School of Sciences, Osaka Prefecture University, 2.Department of Earth and Planetary Science, Faculty of Science, The University of Tokyo)

Early Paleozoic subduction-zone metamorphism in Japan: A geochronological reappraisal of Kitomyo Schists

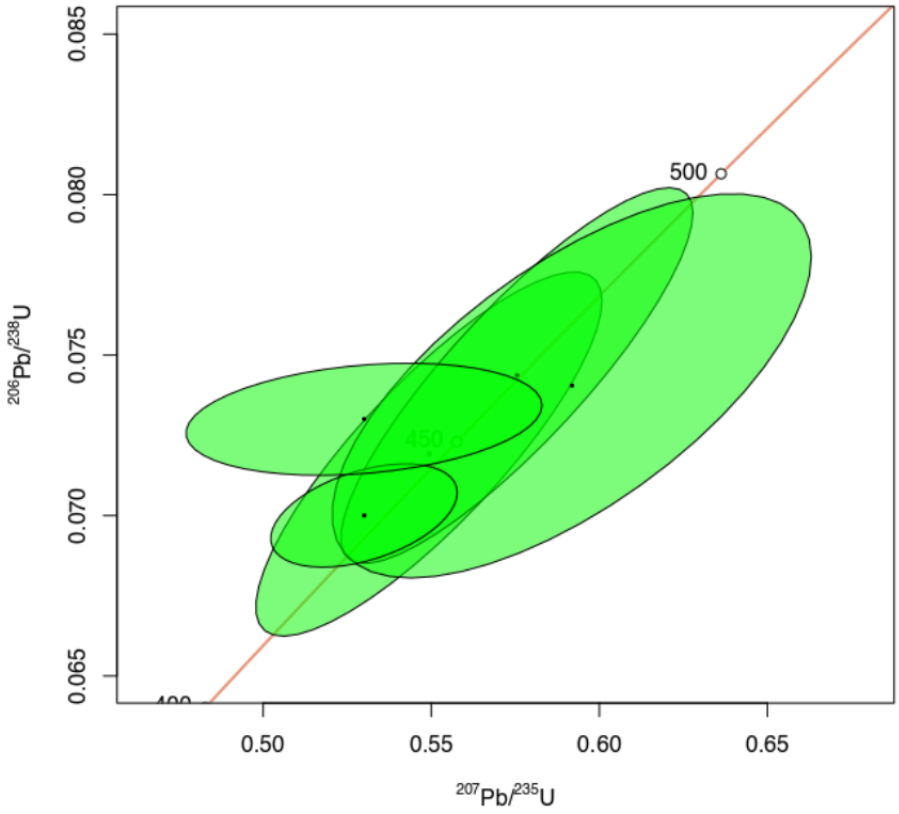
*Shota Matsunaga [1], Tatsuki Tsujimori[1], Atsushi MIYASHITA[2], Shogo Aoki[3], Kazumasa Aoki[3]

1. Tohoku University, 2. Seikei University, 3. Okayama University of Science

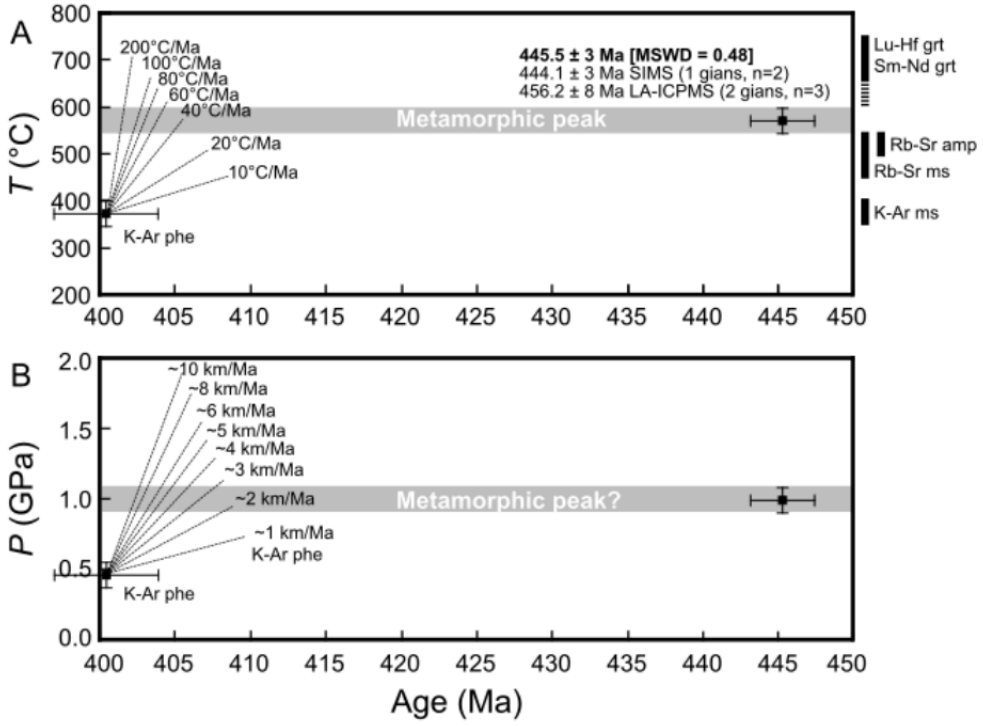
Early Paleozoic subduction-related high-pressure metamorphic rocks have been reported from the Kitomyo Schists of the Kurosegawa Belt (Maruyama and Ueda 1975 [doi: 10.2465/ganko1941.70.47]) and the Fuko Pass Metacumulates (FPMC) of the Oeyama Belt (Tsujimori and Liou 2004 [doi: 10.1111/j.1525-1314.2004.00515.x]). In order better to understand the earliest subduction zone record of the ‘proto-Japan’, we revisited the Kitomyo Schists petrologically and gecohronologically. The metasedimentary sample is a well-deformed, quartzo-feldspathic mica schist, with the mineral assemblage of garnet + clinozoisite + phengite (Si p.f.u. = 3.3–3.5) + quartz + albite. Euhedral grains show distinct prograde chemical zoning in spessartine decrease toward the rims. The lack of biotite, oligoclase and paragonite indicate that the schist underwent a HP intermediate type metamorphism. The metabasaltic rock is a well-deformed, amphibolite. Although the amphibolite was overprinted severely at a greenschist-facies condition, relict barroisitic amphibole [B]Na (Na in the B-site) = ~0.69 and rutile, indicating HP metamorphism. LA-ICPQMS and HR-SIMS zircon geochronology yielded 445.5 ±3 Ma for the timing of HP intermediate type metamorphism of the Kitomyo Schists. Metamorphic zircon in metasedimentary sample is characterized by lower U (117–132 μg/g) and lower Th (34–143 μg/g) than detrital magmatic zircons. Our reapproval suggests that the Kitomyo Schists formed in an Early Paleozoic subduction zone with geothermal gradient in the order of ~15°C/km. Such a relatively high geothermal gradient in the subduction zone has produced the HP intermediate type metamorphism. The earliest subduction record in the ‘proto-Japan’ was not ‘cool’ enough to produce blueschist.

Keywords: metamorphic zircon, zircon geochronology

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LA-ICPQMS and HR-SIMS U-Pb analysis of metamorphic zircons. Data are plotted on Concordia diagram



P-T condition of metamorphism

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Dating a 'princess': U–Pb age determination of 'nunakawaite' (strontio-orthojoaquinite)

*Tatsuki Tsujimori[1], Tomomi Hara[1], Yuzuki Shinji[1], Tomohiro Ishizaka[1], Hiroshi Miyajima[2], Jun-Ichi Kimura[3], Shogo Aoki[4], Kazumasa Aoki[4]

1. Tohoku University, 2. Fossa Magna Museum, 3. JAMSTEC, 4. Okayama University of Science

'Nunakawaite' (strontiojoaquinite) is an orthorhombic variety of strontiojoaquinite [$Sr_2Ba_2(Na,Fe)_2Ti_2[Si_4O_{12}]_2O_2(O,OH)_2 \cdot H_2O$]; it is a rare joaquinite group mineral that is only found in a riebeckite-bearing albitite in the serpentinite-matrix mélange of the Itoigawa–Omi area. The mineral was originally named after 'Princess Nunakawa' (*nunakawa hime*) in the Japanese Shinto mythology '*Kojiki*'.

'Nunakawaite' is characterized by remarkably high Ba, Zr, Nb, Zn, LREEs, MREEs, and enriched in U (35.8–721 $\mu g \cdot g^{-1}$), Pb (2.2–31 $\mu g \cdot g^{-1}$), and Th (7.42–2365 $\mu g \cdot g^{-1}$). LA-ICPMS analyses show highly variable U/Pb ($^{238}U/^{206}Pb$ = 9.245–68.98) and Pb ($^{207}Pb/^{206}Pb$ = 0.0758–0.756) isotope ratios, and the scattered trend define an isochron line with a lower intercept at 89.19 ±1.07 Ma. The 'nunakawaite' U–Pb age confirms that the 'nunakawaite'-hosted riebeckite-bearing albitite formed at late Cretaceous. This implies that the serpentinite-matrix mélange unit with early Paleozoic jadeitites and late Paleozoic blueschist, eclogite and amphibolite was reactivated by a significantly younger tectonic event.

In-situ Sr-Pb isotope analyses show two different isotope trends between Sr-rich accessory minerals in riebeckite-bearing albitite ('nunakawaite' and ohmilite) and those in jadeitite (itoigawaite, stronalsite, vesvianite, Sr-rich epidote). The Sr-Pb isotopes also support the idea that the riebeckite-bearing albitite formed by a fluid-induced metasomatic event different from the jadeitite-forming metasomatism at early Paleozoic. The formation of riebeckite-bearing albitite at ~90 Ma is coeval with late Cretaceous granitic intrusion of the Omi area (youngest zircon U–Pb: 90.8 ±1.1 Ma: Nagamori et al. 2018). The granitic intrusion might have acted an important role in the formation of 'nunakawaite'. In other words, reactivation of metasomatic mineralization in the Paleozoic serpentinite mélange is recorded in the Cretaceous riebeckite-bearing albitite.

Keywords: 'nunakawaite' (strontio-orthojoaquinite), U–Pb dating, metasomatism, serpentinite mélange, Itoigawa–Omi area

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Modeling of the progressive evolution of subducting slab composition by sparse modeling

*Kenta Yoshida[1], Tatsu Kuwatani[1,2], Kenta Ueki[1], Ryosuke Oyanagi[1], Shotaro Akaho[3]

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The progressive evolution of subducting rocks under intermediate high-*P/T* type metamorphism is modelled by using thermodynamic calculation combined with mass-transfer calculation. On the basis of non-negative matrix factorization analysis, Yoshida et al. (2018 J. Metamorph. Geol.) pointed out the evolutional change of the composition of metapelites collected from the Sanbagawa metamorphic belt. The evolutional change can be approximated as the increase of stoichiometric garnet, which may have resulted from the fixation of garnet and the effusion of other components by high-temperature aqueous fluids. To model this progressive compositional evolution more quantitatively, we performed mass-transfer calculation to determine a specific reference frame of the evolutionally-changing whole-rock compositions. Generally, mass-transfer calculation defines one or multiple immobile elements on the basis of petrographic observation, common knowledge of mobility of elements, deviation of the concentration among the dataset used, and so on (e.g., Baumgartner and Olsen, 1995; Ague 2011). The Data-driven Isocon analysis, newly proposed method applying a sparse modeling approach, is designed to determine reference frame of mass-transfer being mostly free from the arbitrariness to choose immobile element(s), and also applicable for the case where no elements can be assumed as a completely immobile element (Kuwatani et al., 2019 in this meeting M-GI33). This new method defines a reference frame of a series of dataset on the basis of the data structure, finding a least-mobile (not necessary to be “immobile”) element. To figure out the mass gain/loss behavior of the subducting metapelites, applying the Data-driven Isocon analysis is suitable because (1) the dataset show weak but mostly monotonous compositional trend (Yoshida et al., 2018); (2) it is difficult to assume a specific immobile element on the basis of the petrographic observation provided previously. We performed the Data-driven Isocon analysis to the major component dataset of the metapelites collected from the Sanbagawa metamorphic belt of the central Shikoku (Goto et al., 1996). The Isocon analysis indicated a total of 6% of mass loss during the progressive metamorphism, which is characterized by the decrease of Na and Si and the increase of divalent cations assuming Al as the least-mobile element. This result indicated that the evolutional change of the Sanbagawa metapelites is characterized not only by mass loss possibly because of the high-temperature fluid, but also some addition of mafic components. Among the high metamorphic grade zone (> garnet zone) of the relevant area, common existence of the ultramafic blocks are observed, suggesting the previous contact with the wedge mantle (Aoya et al., 2013). The addition of the mafic components may have originated from the material transfer from the ultramafic bodies. On the basis of actual mass loss obtained from the Isocon analysis and the thermodynamic modelling, the water production rate can be calculated (e.g., Dragovic et al., 2018). From the chlorite zone (approximately 350 degC, 0.5 GPa) to the oligoclase-biotite zone (approximately 610 degC, 1.0 GPa), water production rate of 64 kg/m3/Myr, being consistent with the previously indicated values (6-90 kg/m3/Myr: Peacock, 1989; 5-20 kg/m3/Myr: Lyubetskaya and Ague, 2009), was obtained.

Keywords: Sanbagawa metamorphic belt, subduction zone, sparse modeling, deep fluid

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Bayesian statistical evaluation method for detrital zircon geochronology: Applications

*Tan Furukawa[1], Tatsuki Tsujimori[2], Shogo Aoki[3], Kazumasa Aoki[4]

1. Tohoku University, Department of Earth Science, 2. Tohoku University, 3. Faculty of Biosphere-Geosphere Science, Okayama University of Science, 4. Department of Applied Science Okayama University of Science

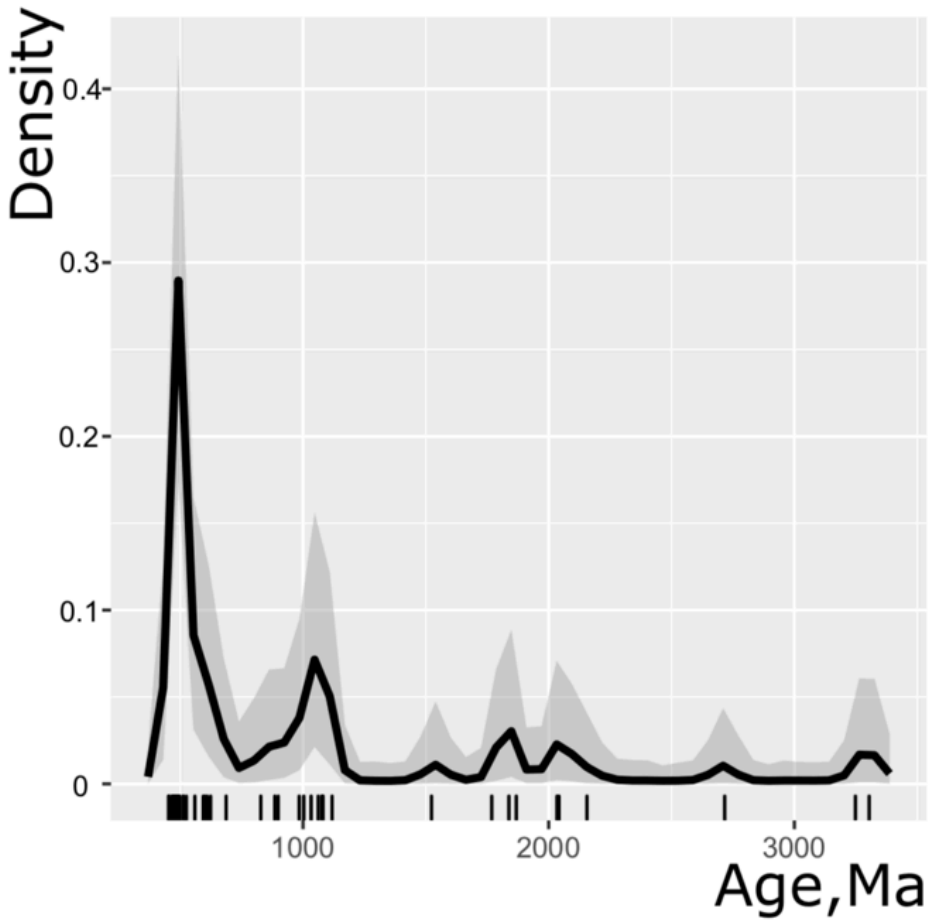
Detrital zircon geochoronology is an essential method for determining the provenance and maximum depositional age of sedimentary and metamorphic strata. The age distribution is conventionally evaluated by using histograms. However the lack of the statistical verification of the histograms can cause misunderstanding of data. In order to overcome the raised statistical issues, we established new statistical evaluation method to evaluate distribution for detrital zircon ages, based on Bayesian Statistics (Furukawa and Tsujimori, 2019 JpGU, session M-GI33). As the application of our new statistical evaluation method, LA-ICPMS U-Pb dating for detrital zircon separates from the Carboniferous lawsonite-bearing metagreywacke of the Osayama serpentinite mélange (OSM) and the Cretaceous arkose sandstone of the Akaiwa Formation (AFS), Tetori Group was conducted.

The OSM of the Renge Belt tectonically overlies the pre-Triassic geotectonic units of the Chugoku Mountains (e.g., Tsujimori 1997 Min. Mag.; Tsujimori and Itaya 1999 IAR). The geological and lithological features are similar to those of late Paleozoic blueschist-bearing serpentinite mélange units of the Kurosegawa Belt in Shikoku, Kyushu and Kii Peninsula. Our new data shows that the OSM zircons show at least bimodal age distributions at ~500 Ma and ~1,100 Ma with 95% certainty; the group of the oldest concordant ages reaches 3,300 Ma and the youngest concordant age was 412 Ma.Comparison with existing data in the literatures (e.g. metasediments in the Kii Peninsula: Yoshimoto et al. 2013 JMPS), our Bayesian-based statistical evaluation shows a strong similarity.

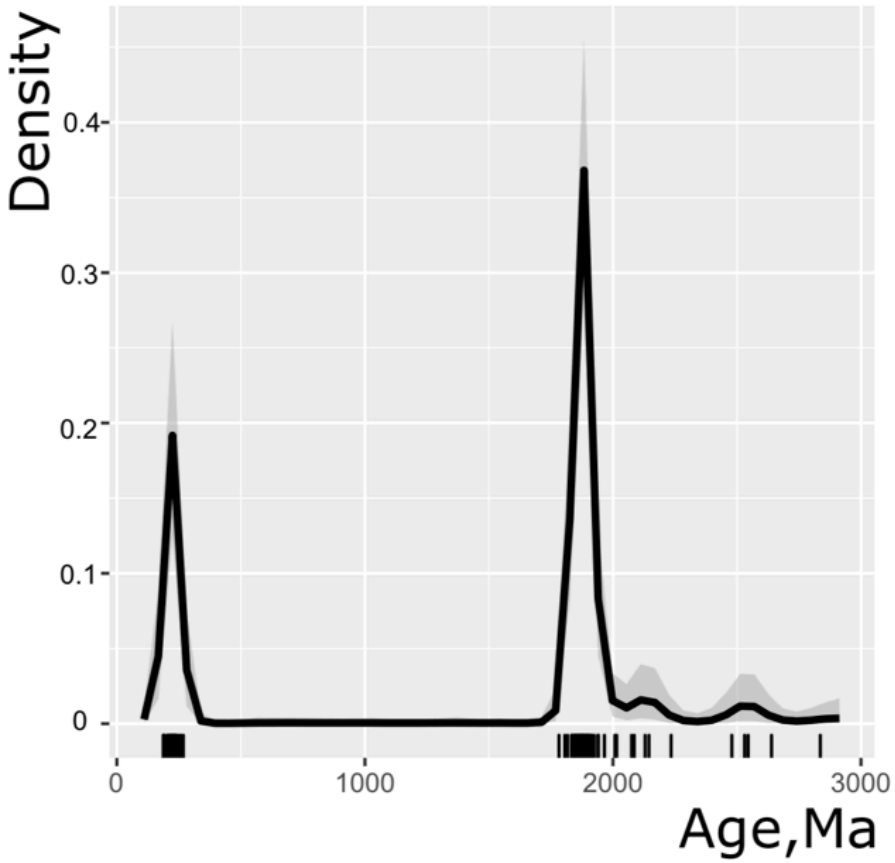
We also applied our new evaluation method to the Tetori Group sandstones. The youngest grain yields 187 Ma, and the oldest concordant age was 2,940 Ma. Our evaluation found statistical 'discrepancy' with more than 90% certainty between our AFS data and the existing data of the Itsuki Formation (Kawagoe et al., 2012 Mem. FPDM), which stratigraphically occupy higher portion of the AFS and unconformably overlies the AFS. Throughout the two applications, we introduce how our new statistical evaluation works and its advantages in geological sciences.

Keywords: Bayesian statistics, detrital zircon geochoronology

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The distribution of OSM detrital zircons and its 95% credible interval



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3D structural analysis using X-ray Computed Tomography technique: a case study for fault rocks from the Nojima Fault, southwest Japan

*Takafumi Nishiwaki[1], Aiming Lin[1], Bingcheng Liu[1]

1. Kyoto University

Fault rock structures in active fault shear zone can contain important information of seismic slip mechanism (e.g. Lin et al, 2013; Lin and Nishiwaki, 2019). The micro- to macro-structural characteristics of fault rocks formed pass entirely throughout faulting periods, resulting in a broad suite of deformation processes being recorded by deformation structures and textures in spatial within the fault zone (Lin, 2008). Therefore, to understand the spatial variation of meso- and microstructures of fault shear zones, it is important to analyze the three dimensional (3D) images of fault rocks.
In this study, we conducted the 3D structural analysis using X-ray computed tomography (XCT) technique for the cataclastic rock samples including fault gouge obtained from the scientific drilling project "Drilling into Fault Damage Zone (DFDZ)" penetrated throughout the Nojima Fault (NF) Zone that triggered the 1995 M_w 6.9 Kobe earthquake. XCT technique is a non-destructive imaging analysis using CT-value, a function of density and chemical composition. Drilling investigations and 3D structural analyses of drill cores reveal that a ~60 m wide fault damage zone containing a 10–30 cm thick fault gouge zone developed along NF (Nishiwaki et al., 2018; Lin and Nishiwaki, 2019). The fault gouge zone consists of many different color gouge layers 1-2 mm to ~10 cm thick in both sides of the fault plane. In the gouge layer, there is foliations oriented parallel or sub-parallel to the boundaries of each gouge layer. XCT analysis shows the 3D structural features as followings: 1) the main fault plane shows a sharp boundary between two fault gouge layers and cut or offset all other fault gouge layers and fragments, 2) foliations developed within individual fault gouge layers defining the composite planer structures on the X-Z section which show a right-lateral shear sense as that inferred from the topographical and geological evidence, and 3) fine-grained materials were injected into the cataclastic rocks and formed veinlet network structures with complicated spatial variation. These results indicate that the XCT imaging technique is a powerful tool to study 3D deformational structures and textures of fault rocks combining with conventional structural analysis.
References:
1) Aiming Lin, 2008. Fossil Earthquakes: The Formation and Preservation of Pseudotachylytes. Springer, Berlin, 348p (ISBN 978-3-540-74235-7).
2) Lin, A., Yamashita, K., Tanaka, M., 2013. J. Struct. Geol., 48, 3-13. http://dx.doi.org/10.1016/j.jsg.2013.01.005.
3) Lin, A., Nishiwaki, T., 2019. Geophys. Res. Lett., doi: 10.1029/2019GL081927. https://doi.org/10.1029/ 2019GL081927.
4) Nishiwaki, T., Lin, A., Lin, W., 2018. Geophys. Res. Lett., 45, 12814-12820, https://doi.org/10.1029/2018GL079317.

Keywords: Nojima fault, fault rock, structural analysis, CT scan

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High- and low-stress subduction zones recognized in the rock record

*Kazuhiko Ishii[1], Simon Richard Wallis[2]

1. Department of Physical Science, Graduate School of Sciences, Osaka Prefecture University, 2. Department of Earth and Planetary Science, Faculty of Science, The University of Tokyo

Knowledge of the frictional strength along subduction plate boundaries is an essential part of understanding the conditions necessary for plate tectonics, the processes leading to great earthquakes occur along subduction megathrusts and the thermal structure of subduction zones. The frictional strength of faults increases with depth until ductile deformation becomes dominant and is usually expressed as the ratio of shear to normal stress known as the coefficient of friction, mu or the apparent coefficient, mu', when the effects of fluid pressure are taken into account. Lamb (2006) uses force balance for forearc domains to infer mu' = 0.03-0.09 along subduction boundaries. Gao and Wang (2014) infer mu' = 0.02-0.13 based on the comparison between heat flow data and numerical modeling, while England (2018) estimates relatively uniform values mu' = 0.05-0.07 from analytical modeling of heat flow data. In addition, a global 3D thermo-mechanical model presented by Osei Tutu et al. (2018) suggests the average mu' along plate boundaries is required to be <= 0.05 to match the observed present-day plate motion and net rotation.

The published estimates of mu' for subduction boundaries are significantly lower than Byerlee's Law (mu' ~ 0.4, assuming hydrostatic fluid pressure) and closer to values published for seismic slip rates with mu' ~ 0.1 (Di Toro et al., 2011). However, estimates for different subduction zones or obtained by different methods show variations over an order of magnitude. It is desirable to obtain direct estimates of shear stresses from ancient subduction zones both as an independent test of the suggested values and because if high- and low-stress subduction zones can be identified in the ancient record then observations of the associated geology can help identify those characteristics that are responsible for differences in shear strength along subduction zone boundaries.

Thermal modelling shows that high- and low-stress subduction zones can potentially be recognized in the ancient record based on the shape of the prograde P-T path in the forearc region. For all but very young and very slowly subducting slabs, high-stress subduction can be distinguished by curved P–T paths with higher P/T gradients at greater depths. Low-stress subduction over the same domain results in straight paths.

The Cretaceous Sanbagawa belt of SW Japan records metamorphism developed as a result of rapid (20-24 cm/yr) subduction of the Izanagi plate with a slab age of around 60 Ma. The prograde P-T paths show the characteristics predicted for high-stress subduction. Comparisons with thermal modelling suggest an apparent coefficient of friction, mu', of > 0.11, and the corresponding peak shear stresses are ~60 MPa.

Prograde P–T paths and geochronological information from high grade blocks of the Franciscan Complex, USA, indicate rapid cooling during the initial 10-20 Myr subduction with low mu' <= 0.02.

P–T paths in subduction-type metamorphic belts have the potential to be used as paleo stress indicators. Examining differences between high- and low-stress subduction-type metamorphic belts can help determine what controls the strength of different subduction boundaries and assess the potential for

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great earthquakes in modern settings.

Keywords: High pressure metamorphic rocks, Stress along subduction boundaries, Sanbagawa belt, Franciscan complex

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[J] Oral | S (Solid Earth Sciences)：S-MP Mineralogy & Petrology

Wed. May 29, 2019 9:00 AM - 10:30 AM JST | Wed. May 29, 2019 12:00 AM - 1:30 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-MP33] Physics and Chemistry of Minerals

convener:Seiji Kamada(Frontier Research Institute for Interdisciplinary Sciences, Tohoku University), Masahiro KAYAMA(Department of Earth and Planetary Material Sciences, Faculty of Science, Tohoku University), Chairperson:Seiji Kamada(FRIS, Tohoku Univ.)

In this session, we will discuss the physics and chemistry of the Earth and planetary materials (including amorphous and melts) based on the results obtained from various experimental methods such as X-ray diffraction, FT-IR, Raman spectroscopy, electron microscopic observations, and computer simulations.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SMP33-01] High-temperature Raman spectroscopic study of CO_2-containing melanophlogite

*Masami Kanzaki[1] (1.Institute for Planetary Matereials, Okayama University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SMP33-02] Synthesis of barium carbonate with calcite structure and rotational disorder of carbonate ions

*Hiroyuki Kagi[1], Ayaka Saito[1], Kazuki Komatsu[1], Jun Kawano[2] (1.Geochemical Research Center, Graduate School of Science, University of Tokyo, 2.Fuculty of Science, Hokkaido University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SMP33-03] In-situ Raman spectroscopy of ε-FeOOH under high pressures

*Osamu Ikeda[1], Tatsuya Sakamaki[1], Akio Suzuki[1] (1.Department of Earth Science, Graduate School of Science, Tohoku University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SMP33-04] **Strong hydrogen-bond generation in dense hydrous magnesium silicate phase E observed by single-crystal neutron diffraction**

*Narangoo Purevjav[1], Takuo Okuchi[1], Christina Hoffmann[2] (1.Institute for Planetary Materials, Okayama University, 2.Neutron Scattering Division, Neutron Sciences Directorate, Oak Ridge National Laboratory)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SMP33-05] **Water partitioning between upper mantle minerals and melts**

*Dmitry Bondar[1], Hongzhan Fei[1], Tony Withers[1], Tomoo Katsura[1] (1.Bayerisches Geoinstitut, University of Bayreuth, 95440 Bayreuth, Germany)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SMP33-06] Drop-solution enthalpy measurement of $MgSiO_3$ majorite

*Hiroshi Kojitani[1], Masamichi Noda[2], Toru Inoue[2,3], Masaki Akaogi[1] (1.Department of Chemistry, Faculty of Science, Gakushuin University, 2.GRC, Ehime University, 3.Dept. of Earth and Planetary systems Science, Hiroshima University)

High-temperature Raman spectroscopic study of CO_2-containing melanophlogite

*Masami Kanzaki[1]

1. Institute for Planetary Matereials, Okayama University

Introduction: Melanophlogite is one of natural silica minerals with a clathrate structure. The structure has two kinds of cages which can host small guest molecules such as CH_4, CO_2, N_2 and H_2S. These are M^{12} and M^{14} cages correspond to pentagondodecahedral [5^{12}] and tetrakaidecahedral [$5^{12}6^2$] units made of 5- and 6-membered SiO_4 rings, respectively. Previous crystal structural studies suggested that CO_2 is mostly locating in larger M^{14} cage. A few years ago, we found a very intense and broad peak below 100 cm^{-1} in CO_2-containing melanophlogite. To clarify the origin of this peak in relation with CO_2 guest molecule, heat treatment experiments and in-situ high-temperature Raman spectroscopy measurements were conducted up to 1100 ^{o}C.
Experimental: Micro-Raman spectra were obtained using a home-built Raman system made of single-monochromator, CCD detector and Ondax SureBlock filters for low frequency measurement. The heat treatment was conducted using a muffle furnace, and the in-situ study was conducted with a wire-heater cell. Natural shperical single crystals from Fortunillo, Italy were crushed and small fragments were used for the experiments.
Results and discussion (origin of low-freq. peak): For the heat treatment experiments, nearly CO_2-free melanophlogite was obtained at 950 ^{o}C for 6 h, judging from intensities of CO_2 vibrational peaks (Fermi diad). Simultaneously, the low-frequency peak nearly disappeared. For shorter time durations or lower treatment temperatures, CO_2 vibrational peaks and low-frequency peak were still visible. We found that CO_2 vibrational peaks of the heat treated samples were split.
For the in-situ study, integrated total intensity of CO_2 vibrational peaks started to drop at around 450 ^{o}C, and simultaneously the low-frequency peak intensity decreased. These peaks completely disappeared at 1100 ^{o}C, while melanophlogite itself remained intact. Thus, it was concluded that the low-frequency peak is originated from CO_2 molecules, not from melanophlogite structure. Librational and translational modes of CO_2 molecules in the cages of melanophlogite would be responsible for the low-frequency peak. Thus, degassing behavior can be studied by monitoring both the low frequency band and the vibrational peaks.
(vibrational peak splitting): At about 450 ^{o}C, we noted that the vibrational CO_2 peak started to split (or more precisely, new peak appeared at slightly higher frequency and grew with temperature while the original peak became weaker). This splitting is partly quenchable, as demonstrated in the heat treated sample mentioned above. Vibrational peak splitting has been reported for CH_4 and H_2S in melanophlogites, and has interpreted as occupancy of those molecules in both M^{14} and M^{12} cages. Thus, peak splitting observed in our study can be interpreted similarly. No splitting of CO_2 has been reported before, except one report at very low temperature. From those observations, we speculated that at above 450 ^{o}C, CO_2 molecule is able to migrate from original M^{14} cage to next M^{14} or M^{12} cages. Because M^{14} cages make an infinite chain by sharing 6-membered rings, migration of CO_2 from M^{14} to M^{14} cages through the 6-membered ring will contribute to long-range diffusion (i.e., degassing). On the other hand, migration of CO_2 from M^{14} to next M^{12} through 5-membered ring will contribute to disordered distribution of CO_2 in M^{12} and M^{14} cages, which caused vibrational peak splittings. Thus, high-temperature Raman spectroscopic study could provide us more insight of diffusion behavior of CO_2 and possibly other gas molecules in melanophlogite structure.

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Keywords: CO2-containing melanophlogite, In-situ high-temperature Raman spectroscopy, Low-frequency Raman spectroscopy, clathrasil, degassing process

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Synthesis of barium carbonate with calcite structure and rotational disorder of carbonate ions

*Hiroyuki Kagi[1], Ayaka Saito[1], Kazuki Komatsu[1], Jun Kawano[2]

1. Geochemical Research Center, Graduate School of Science, University of Tokyo, 2. Fuculty of Science, Hokkaido University

Structures of divalent metal carbonate is constrained by the ionic radii of cations. Cations larger than Ca^{2+} take the aragonite structure and cations smaller than Ca^{2+} take the aragonite structure. Barium carbonate (witherite) takes the aragonite structure and Ba2+ is incompatible to calcite. We have reported that large incompatible cations can be introduced to calcite through amorphous calcium carbonate (ACC). In this study, we synthesized $Ba_{0.7}Ca0.3CO_3$ with the calcite structure by heating treatment on ACC containing Ba^{2+}. The obtained crystal can be interpreted as Ca-containing barium carbonate with the calcite structure, which cannot be found in nature or synthesized from a direct precipitation from the supersaturated solutions.

X-ray diffraction (XRD) patterns of Ba-doped calcite measured at 300 K shows the extinction of 113 reflection with increasing Ba concentration (see Figure 1). The extinction of the 113 reflection was reported on pure calcite at temperatures higher than 1240 K (Ishizawa et al., 2013). The change was attributed to the rotational disorder of CO_3^{2-} ions. In contrast, we have observed the extinction of 113 reflection on the Ba-doped calcite at 300 K.

To investigate the behavior of CO_3^{2-} ions at an atomistic level, molecular dynamics (MD) simulation of Ba-doped calcite was conductedusing the MD program, MXDTRICL (Kawamura 1997). Intensity ratio of reflections 113 to 104 (I_{113}/I_{104}) was measured from XRD patterns obtained from experimental study and MD simulation. $I_{113}/I_{104}$from experiment dropped to 0 at Ba/(Ba + Ca) = 26.8 ±1.6 mol% while that of MD-simulated Ba-doped calcite gradually weakened and did not fall to zero. MD simulations of 25.5% and 50.9% Ba-doped calcite at high temperature were also conducted. In 25.5% Ba-doped calcite, I_{113}/I_{104} remarkably dropped at around 1050 K with the structure of rotationally disordered CO_3^{2-} ions. The transition temperature to the rotational disorder was at around 850 K for 50.9% Ba-doped calcite. These simulated temperatures are much lower than the transition temperature (1250 K) obtained from MD simulation on pure calcite (Kawano et al., 2009). The simulated results showed that the transition temperature to the rotational disordered phase dramatically decreased with increasing Ba/(Ba + Ca) in calcite.

Keywords: barium carbonate, molecular dynamics simulation, rotational disorder, calcium carbonate (calcite)

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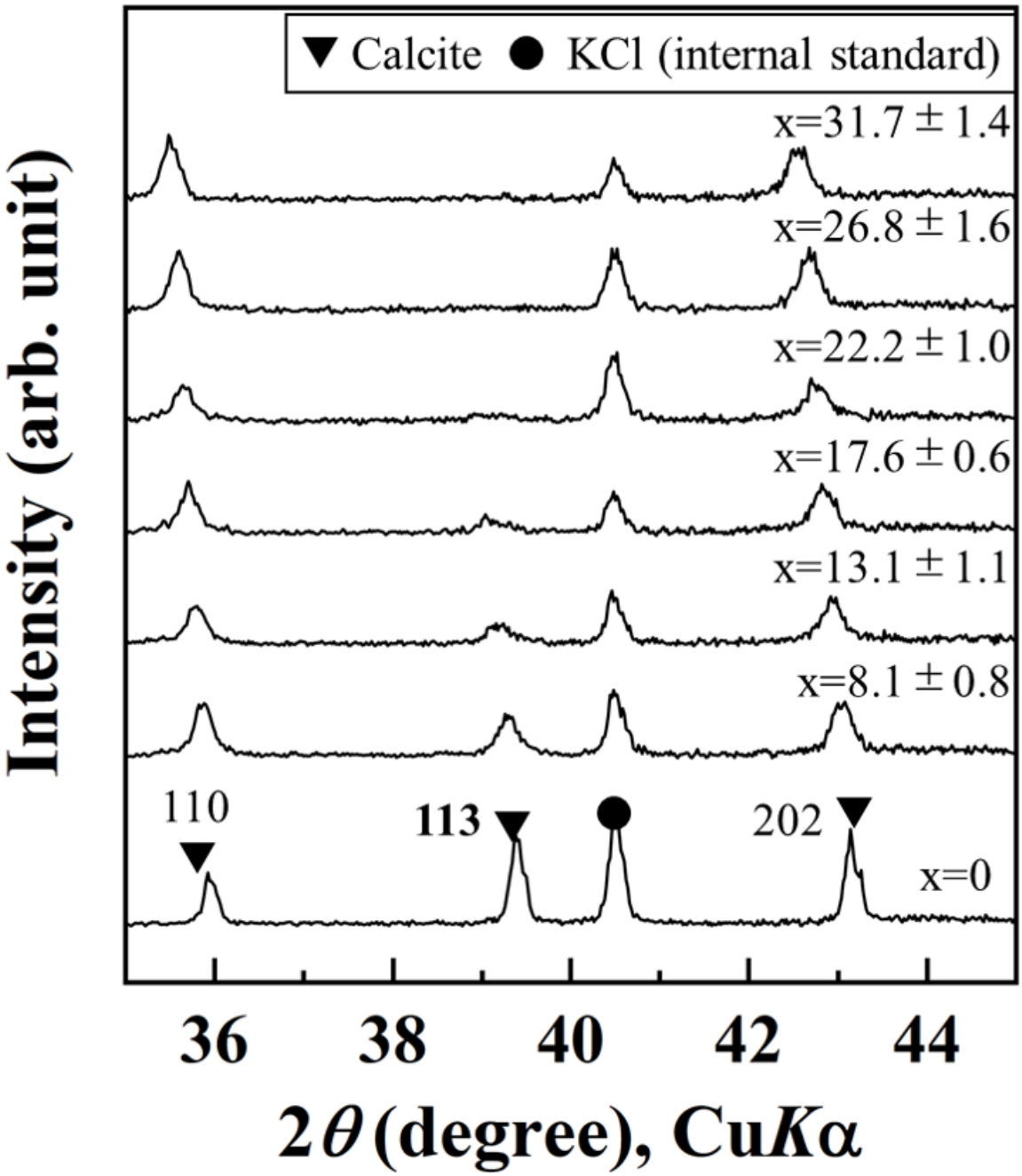


Figure 1. Broadening and disappearance of reflection 113 observed from powder X-ray patterns of Ba-doped calcite samples. x stands for Ba/(Ba+Ca) mol% in Ba-doped calcite.

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In-situ Raman spectroscopy of ε-FeOOH under high pressures

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ε-FeOOH is one of crucial high-pressure hydrous phases in the Earth's mantle, and is isostructural to δ-AlOOH. A first principles calculation (Gleason et al., 2013) has indicated pressure-induced hydrogen bond symmetrization at 43 GPa, and spin transition of iron at 65 GPa. These transitions cause changes in physical properties, and knowledge of the transition changes can help us to understand the behaviors of hydrous phases under high pressure.

We present a first study of Raman spectroscopy of ε-FeOOH at high pressure and room temperature. The measured sample was polycrystalline ε-FeOOH, which was synthesized in advance from a powder of reagent grade 99 % α-FeOOH at the pressure-temperature condition of 8 GPa and 480 ℃ for 2 hour. Micro-Raman spectrometer NRS-4100TOR (JASCO Corporation), which has a laser with the wavelength 532 nm and power 50 mW installed in Tohoku University, was used to obtain Raman spectra. Symmetric diamond anvil cell with 300 μm culet size was used to generate high pressure. The sample was loaded in the sample chamber of tungsten gasket with NaCl pressure medium. The pressure in the chamber was calculated by means of the ruby luminescence pressure scale (Dewaele et al., 2004).

Along compression, the frequencies of most of peak tops have positive pressure dependences but some peaks (298, 386, 698, and 1099 cm^{-1} at 15 GPa) changed the dependences to negative around 14 GPa. Above 15 GPa some peaks (197, 298, and 443 cm^{-1} at 15 GPa) disappeared and the others (364, 386, 549, 646, 698, and 1099 cm^{-1} at 15 GPa) jumped by frequency 10–30 cm^{-1}. This change around 15 GPa may correspond to the replacement of vibrational modes in Raman spectra of δ-AlOOH at the pressure of 5.6 GPa (Mashino et al., 2016), which indicates a hydrogen-bond related space-group transition from $P2_1nm$ to *Pnnm* (Tsuchiya et al., 2008).

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Keywords: ε-FeOOH, high pressure, Raman spectroscopy, H-bond symmetrization

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Strong hydrogen-bond generation in dense hydrous magnesium silicate phase E observed by single-crystal neutron diffraction

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Dense hydrous magnesium silicates (DHMS) are considered as the most major water transporters in cold subducting slabs, which are descending into the deep mantle. Phase E [$Mg_2SiH_4O_6$ –ideal] is one of the most important DHMS phases which is stable at conditions between 13 –17 GPa and 800 –1200 ˚C [1]. Besides its stability at such high temperatures, it stores up to 18 wt.% of water within its crystal structure, which is one of the largest among DHMS phases. Thus phase E is one of the most important carriers and transporter of water in the subducting slabs. The crystal structure of phase E was first investigated by single crystal x-ray diffraction except for its hydrogen position [2]. Its structure has brucite-like layers of MgO6 octahedra which are crosslinked by SiO4 tetrahedra [2]. The hydrogen atoms were expected to be located between these MgO6 octahedra layers like those in brucite, $Mg(OH)_2$. The previous expectation on the structure of phase E was recently confirmed by our powder neutron diffraction study [3]. In contrast, present single-crystal neutron diffraction is conducted to investigate hydrogen bonding geometry in phase E structure, including the Debye-Waller factor of the hydrogen, for which we utilize much higher spatial resolution of the single crystal method. The method has been well confirmed to be very sensitive for investigating such properties of the hydrogen atoms within a series of hydrous minerals [4, 5].
We expect that such information is helpful to understand the reason of stability of phase E at the high-temperature condition. A deuterated phase E single crystal was measured by neutron time-of-flight single-crystal Laue diffraction at Spallation Neutron Source, Oak Ridge National Laboratory. From preliminary structure refinement results, we found that the covalent bond O-D was inclined and displaced from the three-fold axis. Such O-D inclination should occur due to interlayer strong hydrogen-bond generation in the phase E structure. The details of the results will be given in the presentation.

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Keywords: hydrogen-bond, dense hydrous magnesium silicate, neutron diffraction

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Water partitioning between upper mantle minerals and melts

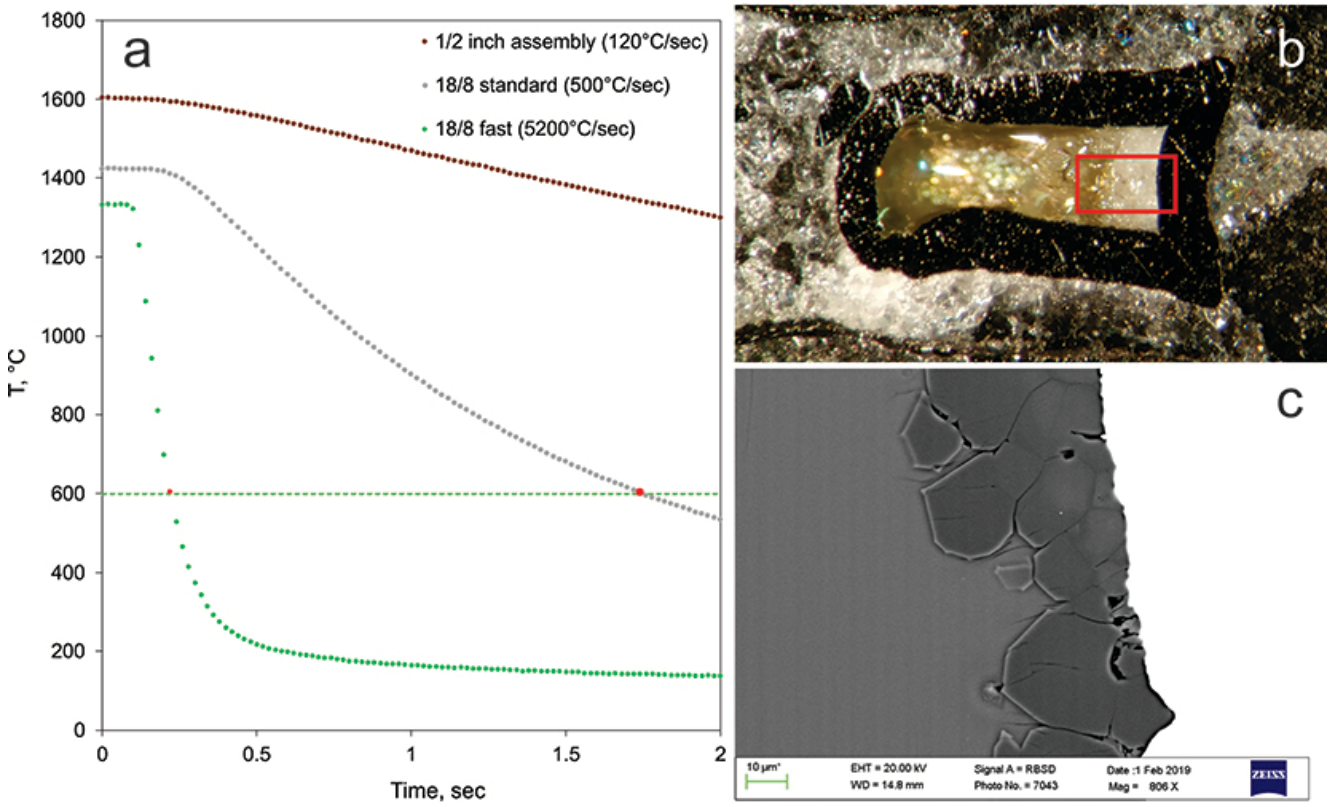
*Dmitry Bondar[1], Hongzhan Fei[1], Tony Withers[1], Tomoo Katsura[1]

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Water in the Earth's upper mantle is predominantly stored in nominally anhydrous minerals (NAMs) such as olivine, orthopyroxene, clinopyroxene and garnet. Since incorporated water has a strong influence on mantle properties, namely melting temperature, rheology, electrical conductivity and seismic velocity, it is important to know the distribution of water among phases. Knowledge of how water partitions between upper mantle minerals and melts is essential for estimation of water content in incipient melts at different depths, water transport by these melts, and total amount of water in the upper mantle.
There are quite a few studies providing data on water partitioning between NAMs and melts. The most challenging part of these studies is to quench melt coexisting with mineral phases to form glass at elevated pressures (>2 GPa), which is necessary to measure water partitioning with high accuracy. It also becomes more difficult to quench melt with higher Mg/Si ratio into glass, which is necessary in order to crystallize olivine from the melt. Previous studies produced mantle minerals coexisting with quenched melt up to only 5 GPa, namely olivine up to 3 GPa, orthopyroxene up to 4 GPa, clinopyroxene and garnet up to 5 GPa. As a result, there is no systematic pressure, temperature and water content dependence of water partitioning from the data scattered over the narrow pressure range. Many authors also reported that glasses in some run products were not transparent, which implies micro-crystals may have crystallized in those studies.
The difficulty of quenching melt into glass lies in the insufficient cooling rate. The cooling rates of regular piston-cylinder and multi-anvil experiments used for these purposes are 120˚/sec and 500˚/sec, respectively. Quenching glass at elevated pressures and at various compositions is important not only for measuring water partitioning, but also for a number of other tasks, such as melt structure studies and partitioning of other components and elements.
The purposes of the present study are (1) to develop a multi-anvil technique allowing much faster cooling rate than conventional ones and (2) to measure water partitioning between upper mantle minerals and melts for a pressure range from 1 to 13 GPa, which covers the whole upper mantle. Our design for a fast-cooling multi-anvil technique has already been shown to produce a very high quenching rate (5200˚/sec) in comparison with those of regular piston cylinder and multi-anvil apparatus (120˚C/sec and 500˚C/sec, respectively) (Fig. 1a). Using this technique, completely transparent glass coexisting with garnet was successfully quenched at 6 GPa (Fig.1b,c). We plan to improve the fast quenching technique to allow quenching melts under even wider conditions.
Fig 1. (a) Comparison of cooling rate among different assemblies. 1/2 and 18/8 are piston-cylinder and multi-anvil assemblies, respectively. Cooling rate was calculated for the temperature range between target temperature and 600˚C; (b) Glass coexisting with garnet at 6 GPa; (c) BSE image of the area in the red box from picture b.

Keywords: Water partitioning, Water distribution, Upper mantle, Nominally anhydrous minerals , Quenched melts, Basaltic glass

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Drop-solution enthalpy measurement of $MgSiO_3$ majorite

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Silicate garnet is one of the major Earth's mantle constituent minerals. With increasing depth, pyroxene components dissolve into the silicate garnet. $MgSiO_3$ majorite (Mj) is an important endmember to express such the pyroxene component dissolving in the silicate garnet solid solution. Recently, we experimentally determined isobaric heat capacity and entropy of $MgSiO_3$ Mj. The stability field of $MgSiO_3$ Mj in the $MgSiO_3$ system thermodynamically calculated using these new thermodynamic data of $MgSiO_3$ Mj together with its enthalpy data measured by Yusa et al. (1993) and Saikia (2008) is not consistent with that determined by previous high-pressure phase relation experiments. In this study, the standard enthalpy of $MgSiO_3$ Mj was determined by drop-solution enthalpy measurement and the obtained enthalpy value was applied to examine the phase stability field of $MgSiO_3$ Mj by thermodynamic calculation.

$MgSiO_3$ Mj samples for the drop-solution calorimetry was the same as those used in the heat capacity measurement, which were synthesized at 19 GPa and 2173 K using a high-pressure apparatus at Ehime University, GRC. The sintered polycrystalline samples were crushed into powder. The drop-solution calorimetry was performed using a Calvet-type high-temperature calorimeter (SETARAM, HT-1000). The powdered sample with weight of about 4 mg was compressed into a pellet and it was dropped into the lead borate solvent ($2PbO{\cdot}B_2O_3$) placed in the calorimeter which was kept at 978 K. The summation of heat content from room temperature to 978 K and solution enthalpy at 978 K, namely drop-solution enthalpy ($\Delta H_{d\text{-}s}$), was measured. To hasten the solution of the samples, the solvent was stirred by bubbling with Ar gas.

$\Delta H_{d\text{-}s}$ ($MgSiO_3$ Mj) was determined to be 69.57±0.77 kJ/mol from the average of five data. This value is the middle between 80.0±2.5 kJ/mol (Yusa et al., 1993) and 59.5±3.2 kJ/mol (Saikia, 2008). From the difference between $\Delta H_{d\text{-}s}$ (MgO) (33.74±0.99 kJ/mol, Kojitani et al. 2012) + $\Delta H_{d\text{-}s}$ (SiO_2 quartz) (40.05± 0.36 kJ/mol, Akaogi et al. 1995) and our $\Delta H_{d\text{-}s}$ ($MgSiO_3$ Mj), the formation enthalpy from the oxides was obtained as 4.2±1.3 kJ/mol. The thermodynamic calculation of the *P-T* phase diagram by adopting the present enthalpy value suggests that the stability field of $MgSiO_3$ Mj would expand to lower temperature region than that determined by previous high-pressure high-temperature experiments and thermodynamic calculations.

Keywords: garnet, majorite, enthalpy, thermodynamic stability, thermodynamic calculation

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[J] Oral | S (Solid Earth Sciences)：S-MP Mineralogy & Petrology

Wed. May 29, 2019 10:45 AM - 12:15 PM JST | Wed. May 29, 2019 1:45 AM - 3:15 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-MP33] Physics and Chemistry of Minerals

convener:Seiji Kamada(Frontier Research Institute for Interdisciplinary Sciences, Tohoku University), Masahiro KAYAMA(Department of Earth and Planetary Material Sciences, Faculty of Science, Tohoku University), Chairperson:Masahiro Kayama(東北大学)

In this session, we will discuss the physics and chemistry of the Earth and planetary materials (including amorphous and melts) based on the results obtained from various experimental methods such as X-ray diffraction, FT-IR, Raman spectroscopy, electron microscopic observations, and computer simulations.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SMP33-07] High-pressure phase transitions of minerals in the system MgO-TiO_2

*Masaki Akaogi[1], Tetsuya Fujimura[1], Shunto Arai[1], Masaki Okano[1], Hiroshi Kojitani[1] (1.Department of Chemistry, Faculty of Science, Gakushuin University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SMP33-08] Phase change process of iron sulfide nanoparticle from amorphous to crystalline with grain growth

*Yoshinari Sano[1], Atsushi Kyono[2], Yasuhiro Yoneda[3], Gen-ichiro Yamamoto[1] (1.Graduate School of Life and Environmental Sciences, University of Tsukuba, 2.Faculty of Life and Environmental Sciences, University of Tsukuba, 3.Japan Atomic Energy Agency)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SMP33-09] Texture formation in quenching of Fe-S-O micro melt spherules

*Hiroshi Isobe[1] (1.Department of Earth and Environmental Sciences, Faculty of Advanced Science and Technology, Kumamoto University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SMP33-10] Development of a software for electron diffraction simulation based on dynamical theory and its application to mineralogy

*Yusuke Seto[1], Masahiro Ohtuka[3], Akira Miyake[2] (1.Graduate School of Science, Kobe University, 2.Graduate School of Science, Kyoto University, 3.Graduate School of Technology, Nagoya University)

11:45 AM - 12:15 PM JST | 2:45 AM - 3:15 AM UTC

[SMP33-11] Site occupation analysis for cation in minerals by analytical electron microscopy: application of TEM-ALCHEMI for earth and planetary science

★Invited Papers

*Yohei Igami[1], Shunsuke Muto[1], Masahiro Ohtsuka[3], Akira Miyake[2], Takahiro Kuribayashi[4], Shoichi Toh[5] (1.Institute of Materials and Systems for Sustainability, Nagoya University, 2.Graduate School of Science, Kyoto University, 3.Graduate School of Engineering, Nagoya University, 4.Graduate School of Science, Tohoku University, 5.Faculty of Science, Fukuoka University)

High-pressure phase transitions of minerals in the system MgO-TiO_2

*Masaki Akaogi[1], Tetsuya Fujimura[1], Shunto Arai[1], Masaki Okano[1], Hiroshi Kojitani[1]

1. Department of Chemistry, Faculty of Science, Gakushuin University

Mg_2TiO_4, $MgTiO_3$ and $MgTi_2O_5$ form spinel(Sp)-, ilmenite(Ilm)-, and pseudobrookite(Pbr)-type solid solutions, respectively, with other endmembers such as Fe_2TiO_4, $FeTiO_3$ and $FeTi_2O_5$. These phases occur as minor minerals in various igneous and metamorphic rocks. Previous studies on stability relations of Mg_2TiO_4, $MgTiO_3$ and $MgTi_2O_5$ at high pressure were limited below about 3 GPa, except for that the transitions in $MgTiO_3$ were examined up to about 18 GPa. In this study, we have examined the phase transitions of these magnesium titanates up to 28 GPa and 1800 ˚C.

We have determined the high-pressure phase relations in Mg_2TiO_4, $MgTiO_3$ and $MgTi_2O_5$ at 4-28 GPa and 1000-1800 ˚C using multianvil apparatus with the quench method. $MgTiO_3$ ilm transformed to the $LiNbO_3$ (Ln)-type high-pressure phase at 16-20 GPa and 1200-1600 ˚C. The Ln phase was interpreted as the retrograde transformation product from perovskite(Pv)-type $MgTiO_3$ stable at high pressure and high temperature (Linton et al., 1999). Above 21-25 GPa, the recovered phases were MgO and a-PbO_2-type TiO_2, the latter of which was interpreted to be converted from baddeleyite(Bd)-type TiO_2. The transition boundary from Pv to MgO + TiO_2(Bd) has a positive Clapeyron slope. Mg_2TiO_4 Sp dissociates to MgO + $MgTiO_3$ Ilm at about 1 GPa, and at higher pressure they changes to MgO + $MgTiO_3$ Pv and subsequently to 2MgO + TiO_2(Bd). $MgTi_2O_5$ Pbr decomposes at 1-2 GPa to $MgTiO_3$ Ilm + TiO_2 rutile(Ru), the latter of which transforms to a-PbO_2-type TiO_2. At higher pressure, the assemblage changes to $MgTiO_3$ Pv + a-PbO_2-type TiO_2, and subsequently to MgO + 2TiO_2(Bd). These results show that the mixtures of MgO and TiO_2 (Bd) are stable above 20-25 GPa in the three magnesium titanates. We also performed Rietveld structure refinement of Ln-type $MgTiO_3$ using synchrotron powder X-ray diffraction data, and confirmed that Ti^{4+} and Mg^{2+} ions are slightly deviated from the centrosymmetric positions in the octahedra which gives polarity of the $MgTiO_3$ Ln-phase.

The high-pressure transition behaviors of Mg_2TiO_4, $MgTiO_3$ and $MgTi_2O_5$ are similar to those of Fe_2TiO_4, $FeTiO_3$ and $FeTi_2O_5$, respectively, up to moderate pressures, where the phases transform to the assemblages involving $MTiO_3$ Ilm and Pv (M = Mg, Fe). However, the transition behaviors are different at higher pressures: Fe_2TiO_4 transforms to $CaTi_2O_4$(CT)-type phase, and $FeTiO_3$ dissociates to Fe_2TiO_4 CT + a dense orthorhombic $FeTi_2O_5$ phase (Akaogi et al., 2017).

Keywords: high pressure, titanate mineral, phase transition

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Phase change process of iron sulfide nanoparticle from amorphous to crystalline with grain growth

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1. Introduction

In anaerobic marine sediments, sulfate-reducing bacteria (SRB) acquires metabolic energy by reducing sulfate ions (SO_4^{2-}) to sulfide ions (S^{2-}). Sulfide ions are, furthermore, oxidized from sulfur (S^0) to sulfate ions by the metabolic activity of sulfur bacteria (SB). These series of reaction are called geochemical sulfur cycle and considered as one of the most important elemental cycle. In the reaction, a part of the sulfide ions is readily reacted with ferrous ions (Fe^{2+}) to produce iron sulfide nanoparticle (FeS), and which grows to more stable mackinawite (FeS). In the previous study, it was reported that the crystal growth from iron sulfide nanoparticle to mackinawite occurred in hydrothermal aging experiment at 120°C (Csákberé nyi-Malasics et al., 2012). Despite its importance as a precursor of mackinawite, phase change process of the iron sulfide nanoparticle from amorphous to crystalline has not been elucidated yet. In this study, synchrotron X-ray total scattering measurement and atomic Pair Distribution Function (PDF) analysis were performed to clarify the crystal structure change of iron sulfide nanoparticle with grain growth.

2. Experimental method

At first, iron sulfide nanoparticle suspension was synthesized by the mixing 10 mL of 0.2 M $(NH_4)_2Fe(SO_4)_2 \cdot 6H_2O$ solution with 10 mL of 0.4 M $Na_2S \cdot 9H_2O$ solution in N_2 gas atmosphere. The synthesized suspensions were heated in a Teflon container at 120°C for 2, 4, 6, 8 and 12 hours, respectively. After the end of heating experiments, the solid phases were dried by blowing N_2 gas and stored in vacuum. Synchrotron X-ray total scattering measurements were performed at beamline BL14B1 in SPring-8. The incident beam was monochromatized to a wavelength of 0.20606 Å. X-ray total scattering data at 20 K and 300 K were collected in the Q range between 0 and 25 $Å^{-1}$. Atomic Pair Distribution Function (PDF) analysis was applied to X-ray total scattering data.

3. Results and discussion

The PDF pattern of iron sulfide nanoparticle synthesized in the study almost disappeared at about 2 nm. Those of samples heated for 2, 4, 6, 8, 12 h are, on the other hand, were continuously observed up to 4 nm. This result showed that the particle size of iron sulfide nanoparticle was grown to 4 nm by the heating at 120°C. The Fe-S and Fe-Fe distances obtained by the PDF analysis are 2.25 and 2.65 Å, respectively, which suggests that the local atomic structure around Fe, ie FeS_4 tetrahedra, in iron sulfide nanoparticle almost remains unchanged by particle growth. Compared with the structure model of mackinawite, the iron sulfide nanoparticle would consist of disordered arrangement of FeS_4 tetrahedra. This is consistent with the structure model of iron sulfide nanoparticle proposed by the previous study (Wolthers et al., 2003; Ohfuji and Rickard, 2006; Jeong et al., 2008). In the presentation, we will discuss structure change associated with medium-range atomic order and propose phase change process from amorphous to crystalline by particle growth.

Keywords: atomic Pair Distribution Function , iron sulfide nanoparticle, mackinawite

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Texture formation in quenching of Fe-S-O micro melt spherules

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Microtexture of minerals records physical, chemical and kinetic conditions at crystal growth. Local processes at crystal growth and migration of elements have important role in the rapid crystal growth. Especially, Fe and S-bearing systems are oxidation and evaporation sensitive. And fine particles can be quenched very quickly from high temperature, quench crystals show characteristic textures of crystals. In this study, quick heating and cooling experiments of powdered iron sulfide particles were carried out with a fine particles free falling apparatus with controlled gas flow (Isobe and Gondo, 2013). Oxygen fugacity was controlled to FMQ -0.5, +0.9 or +2.4 log unit. Particles can be heated to the maximum temperatures of approximately 1600˚C within two seconds, are kept approximately one second and quenched within a second.

Run products particles were completely melted and show rounded shape with smooth surface or characteristic texture. Spherical products were initially well homogenized from inhomogeneous starting materials by complete melting. Then, spherules are oxidized and show growth of secondary crystals with rapid cooling.

FeS dendritic crystals occur in sulfur-rich spherules with low fO2 condition. In the higher fO2 experiments, rapid growth of magnetite in Fe-O melt produces iron metal phase from an excess iron in melt phase relative to magnetite.

Compositions of iron sulfide melt in fine spherules are initially close to FeS and are losing S with oxidation following Fe-S-O phase relations depending on oxygen fugacity even in a few seconds. Crystallization of FeS crystals can reduce sulfur content in melt, then evaporation of sulfur can be suppressed. Evaporation of sulfur may be promoted by oxidation of iron sulfide melt to occur magnetite as liquidus phase.

Keywords: iron sulfide, magnetite, quench crystals, spherules, dendrite

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Development of a software for electron diffraction simulation based on dynamical theory and its application to mineralogy

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Electron diffraction technique is widely used for the phase identification and crystal structure determination of Earth and planetary materials. Electrons are scattered by the positive potential inside the electron cloud, resulting that the interaction of electrons with matter is much stronger (10^6-10^7) than that of X-rays. This has the advantage that the diffracted electron beams have a high intensity and the patterns can directly be observed on the viewing screen of the electron microscope. The strong interaction, however, easily causes multiple scattering, and thereby the intensities of the reflections are much influenced by the dynamical effects. This makes structure determinations from electron diffraction more difficult and less reliable than that from XRD data. In order to treat the dynamical effects, a lot of computer resources of Fourier transform and/or eigenvalue problem are required, and consequently, such a dynamical analysis was limited to simple structured materials. However, that situation has been changing. In recent years, many-core CPUs can make a lot of computation possible. Moreover, with the rapid spread of field emission transmission electron microscopes (TEM) and sensitive detectors (CCD or CMOS), the quantitative analyses of electron intensities become available even from nanometer-sized minerals.

In the present study, the authors developed a GUI-based software, ReciPro, that simulates electron diffraction patterns using one of the dynamical theories, called the Bethe method (or Bloch wave eigenvalue method), in which the three dimensional eigenvalues of the electron wave function in a crystalline specimen are solved with the appropriate boundary conditions on the entrance and exit face of the crystal. By this method, the diffraction patterns (SAED and CBED) can be obtained with a good accuracy and speed regardless of the specimen thickness. Moreover, ReciPro provides following features: i) Loading any crystal structure including AMCSD (American Mineralogist Crystal Structure Database) database or COD (Crystallography Open Database). ii) Changing a specimen orientation and TEM conditions freely by a mouse operation. iii) Displaying Digital Micrograph file, the de facto standard of TEM image file format developed by Gatan inc., can be read and displayed. iv) Fitting diffraction spots by two dimensional pseudo-Voigt functions. v) Quantitative comparison of simulated and experimental diffraction patterns, and many more features. In the presentation, the authors will report examples of reproducibility of simulated diffraction patterns (SAED and CBED) for several minerals, and future prospects of this approach.

Keywords: electron diffraction, dynamical theory, transmission electron microscopy

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Site occupation analysis for cation in minerals by analytical electron microscopy: application of TEM-ALCHEMI for earth and planetary science

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Cation site occupation in natural minerals is very important for earth and planetary science, because it should reflect thermal histories such as peak temperatures and cooling rates. However, natural minerals generally have various complex micro-textures. Therefore, determination of cation site occupation from micrometric regions has been required.
Spence and Taftø [1] developed the ALCHEMI (Atom Location by CHanneling-Enhanced MIcroanalysis) method in which transmission electron microscope with energy dispersive X-ray spectrometer (TEM-EDS) is used to determine the crystallographic sites of impurity elements from micrometric regions in crystals on the basis of channeling-enhanced X-ray emissions. Subsequent improvements in the ALCHEMI have led to more statistical method called HARECXS (High Angular Resolution Electron Channeling X-ray Spectroscopy) or St-ALCHEMI (statistical ALCHEMI). This method is widely applicable including minerals with low symmetric structures (reviewed by [2]). Recently, we successfully determined the order parameter of Al and Si in the tetrahedral sites in sillimanite (Al_2SiO_5) at the areas free from precipitates of mullite ($3Al_2O_3$ $2SiO_2$) and glasses [3]. In this study, we carried out the ALCHEMI/HARECXS method for major rock forming minerals to extend its applicability in earth and planetary science.
Sample minerals are olivine ($[Mg, Fe]_2SiO_4$), diopside ($Ca[Mg, Fe]Si_2O_6$) and sillimanite. The samples were prepared by a focused ion beam system (FIB, FEI Quanta 200 3DS or Helios NanoLab G3 CX), and examined by using TEM-EDS (JEOL JEM-2100F, JED-2300T). X-ray signals generated under illumination of 200 keV electrons were collected as a function of electron beam direction. The homogeneous areas free from dislocations or inclusions were selected as regions of interest.
The one-dimensional tilting ALCHEMI datasets under the condition exciting the particular systematic reflection row (HARECXS profiles) were successfully obtained from regions ~1 μm in diameter by automated control of beam tilting and X-ray detection following Muto and Ohtsuka [2]. For determination of cation site occupation, we performed theoretical calculations of HARECXS profiles using ICSC code [4] and evaluated sample thicknesses by convergent-beam electron diffraction. The experimentally obtained HARECXS profiles were fitted by linear combinations of calculated profiles, and the site occupations of constituent cations were quantitatively determined. Obtained results were almost consistent with the results determined by single crystal X-ray diffraction experiments. Moreover, the cation distributions in annealed samples showed continuous disordering with increasing temperature. This study suggests that the ALCHEMI/HARECXS method is one of the most promising candidates for accurate analysis of minerals in particular the samples having heterogeneous textures.

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Keywords: Analytical electron microscopy, ALCHEMI, HARECXS, Site occupancy, Cation ordering

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[J] Oral | S (Solid Earth Sciences)：S-MP Mineralogy & Petrology

Wed. May 29, 2019 1:45 PM - 3:15 PM JST | Wed. May 29, 2019 4:45 AM - 6:15 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-MP33] Physics and Chemistry of Minerals

convener:Seiji Kamada(Frontier Research Institute for Interdisciplinary Sciences, Tohoku University), Masahiro KAYAMA(Department of Earth and Planetary Material Sciences, Faculty of Science, Tohoku University), Chairperson:Fumiya Noritake(Materials Science, Faculty of Engineering, Graduate Faculty of Interdisciplinary Research, UNIVERSITY OF YAMANASHI), Seiji Kamada(FRIS, Tohoku Univ.)

In this session, we will discuss the physics and chemistry of the Earth and planetary materials (including amorphous and melts) based on the results obtained from various experimental methods such as X-ray diffraction, FT-IR, Raman spectroscopy, electron microscopic observations, and computer simulations.

1:45 PM - 2:15 PM JST | 4:45 AM - 5:15 AM UTC

[SMP33-12] Molecular Dynamics Study of Soret Effect in Silicate Liquids

★Invited Papers

*Fumiya Noritake[1] (1.Graduate Faculty of interdisciplinary Research, University of Yamanashi)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SMP33-13] Seebeck coefficient of olivine: Implausible Mercury's thermoelectric dynamo

*Hitoshi Gomi[1], Takashi Yoshino[1], Akira Yoneda[1] (1.Okayama University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SMP33-14] Density measurement of liquid gallium using externally heated diamond anvil cell

*Ryo Tsuruoka[1], Hidenori Terasaki[1], Seiji Kamada[2], Iori Yamada[1], Fumiya Maeda[3], Tadashi Kondo[1], Satoru Urakawa[4], Naohisa Hirao[5], Akihiko Machida[6] (1.Department of Earth and Space Science, Graduate School of Science Osaka University, 2.Frontier Research Institute for Interdisciplinary Sciences, Tohoku University, 3.Department of Earth and Planetary Materials Science, Graduate School of Science, Tohoku University, 4.Department of Earth Science, Okayama University, 5.Japan Synchrotron Radiation Research Institute, 6.National Institutes for Quantum and Radiological Science and Technology)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SMP33-15] Density measurements of crystalline Fe and amorphous materials at high pressure

*Seiji Kamada[1,2], Hidenori Terasaki[3], Yusaku Takubo[3], Ryo Tsuruoka[3], Fumiya Maeda[2], Rui Yamada[1], Saori Kawaguchi[4], Naohisa Hirao[4], Akihiko Machida[5] (1.Frontier Research Institute for Interdisciplinary Sciences, Tohoku University, 2.Department of Earth Science, Graduate School of Science, Tohoku University, 3.Department of Earth and Space Science, Graduate School of Science, Osaka University, 4.JASRI, 5.QST)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SMP33-16] DAC-GHz ultrasonic P wave velocity measurement on KCl and natural olivine

*Akira Yoneda[1], Shinichiro Kobayashi[2], Seiji Kamada[3] (1.Institute for planetary materials, Okayama University, 2.Department of Earth Science, Graduate school of Science, Tohoku Univ., 3.Frontier Research Institute for Interdisciplinary Sciences, Tohoku Univ.)

Molecular Dynamics Study of Soret Effect in Silicate Liquids

*Fumiya Noritake[1]

1. Graduate Faculty of interdisciplinary Research, University of Yamanashi

There are various transportation phenomena driven a potential gradient. The Soret effect is diffusion driven by a temperature gradient (Soret, 1879; Ludwig, 1856). The inverse effect is known as Dufour effect. The Soret effect is sometime used in explanation of fractionation phenomena in geology (Lesher, 1986; Dominguez et al., 2011). Recently Kishi et al. (2018) reports a distribution anomaly of composition in calcium aluminosilicate glass made by migration of high-temperature metal sphere induced by laser irradiation (Hidai et al., 2016). The rate of fractionation by temperature gradient is determined by both thermal diffusivity (D_T) and mass diffusivities (D) because the total net flux must be zero in a steady state. Consequently, understanding the Soret coefficient (D_T/D, or $\partial \log \rho / \partial T$) is difficult because the coefficient might be affected by not only atomic mass and inter-atomic interaction that affect activation energy but also geometric/structural factor.
I applied the molecular dynamics (MD) simulations for pseudo binary and aluminosilicate liquids to investigate the mechanism of fractionation by temperature gradient. The MD simulation appropriate method for this study because it gives trajectories of each atoms in the simulation cells and potentials of each atom at any point in simulation time. MD simulations of sodium/calcium-silicate/aluminosilicate liquids were performed using MXDORTO code (Sakuma & Kawamura, 2009). The simulation conditions are as follows: The inter-atomic potential model was taken from Feuston & Garofalini (1988). Systems of approximately 30000 particles in rod-shaped (approximately 5 x 5 x 17 nm) simulation cell in periodic boundary condition were firstly annealed for 2 ns at 2000 K from randomly generated structure. Then we started the simulations in temperature gradient. The temperatures in sliced region (approximately 0.35 nm thickness) perpendicular to the longest axis at the end and the center of simulation cell were maintained 2000 and 3500 K using the scaling procedure. After several tens nano-second simulations, we confirmed the changes in distribution of composition. The concentration of SiO_2 in the high-temperature center part slightly increases as simulation proceeds. In contrast the concentration of CaO and Na_2O in that part slightly decreases. Soret coefficients for each cation has linear relation with the half width of potential energy distribution in binary silicates. The existence of Al_2O_3 content impedes fractionation in sodium-aluminosilicate whereas it enhances in calcium-aluminosilicate. This behavior might be caused by the charge compensation of 4-fold aluminum cation.

Keywords: Silicate Liquids, Molecular Dynamics Simulation, Soret Effect

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Seebeck coefficient of olivine: Implausible Mercury's thermoelectric dynamo

*Hitoshi Gomi[1], Takashi Yoshino[1], Akira Yoneda[1]

1. Okayama University

The Mercury's magnetic fields are known to be weaker than that predicted by conventional dynamo models. In order to explain the Mercury's weak magnetic field, several models are proposed (Stanley and Glatzmaier, 2010). One of them is the thermoelectric dynamo, which drive the dynamo via the thermoelectric force (Stevenson, 1987). The field strength is proportional to the relative Seebeck coefficient between the core and the mantle. Because the Seebeck coefficient of insulators is more than one order larger than that of metals, the Seebeck coefficient of Mercury's mantle is the central parameter. Therefore, we investigated the Seebeck coefficient of mantle minerals from the first-principles calculations. The structure relaxation and band structure calculations were conducted by using the Quantum ESPRESSO package. The bandgap energy was calibrated by means of the quasiparticles self-consistent GW (QSGW) approximation adopted in the ecalj package. The Seebeck coefficient was calculated via the Boltzmann equation implemented in the BoltzTraP package. The results indicate that the Seebeck coefficient of forsterite with a small amount of dopant exhibit comparable to that previously thought (|S| ~ 1000 mV/K). This value may constrain the upper limit. The Mercury's mantle may contain ~3wt% FeO (Robinson and Taylor, 2001). The Fe substitution and O vacancy act as donor, which is predicted to reduce the Seebeck coefficient, significantly. The field strength also depends on the electrical conductivity of the mangle. Recent high pressure experiments suggest that the electrical conductivity of the Earth's mantle is ~ 10^{-2} Sm. Considering the both of the Seebeck coefficient and the electrical conductivity of mantle material, the field strength is calculated to be ~ 0.1 nT, which is significantly weaker than the observed value of 300 nT. Therefore, we conclude that the thermoelectric dynamo cannot generate the Mercury's magnetic fields.

Keywords: Seebeck coefficient, Mercury, thermoelectric dynamo

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Density measurement of liquid gallium using externally heated diamond anvil cell

*Ryo Tsuruoka[1], Hidenori Terasaki[1], Seiji Kamada[2], Iori Yamada[1], Fumiya Maeda[3], Tadashi Kondo[1], Satoru Urakawa[4], Naohisa Hirao[5], Akihiko Machida[6]

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Density of a liquid metal at high pressure and high temperature is fundamental information to determine its equation of state (EOS). Gallium (Ga) which has a low melting temperature at ambient pressure has been reported to have complex liquid structures. The densities of Ga at high pressures have been reported based on the measurement of volume changes (Lyapin et al. 2008), that of liquid structures (Yu et al. 2012), and that of sound velocity (Ayrinhac et al. 2015). However, these densities were not consistent each other. In this study, we measured densities of liquid Ga at high pressure using an X-ray absorption method with an externally heated diamond anvil cell (EHDAC).

Ga sample and reference materials (KBr, RbBr) were loaded into each hole drilled on a pre-indented Re gasket. The reference materials were used for estimation of sample thickness and for determination of experimental pressures (Takubo et al. 2018). The Re gasket was coated with Al_2O_3 to avoid a reaction between the Ga sample and the gasket. High pressure was generated using a symmetric DAC with a lever-arm frame. The culet size of the diamond anvils used was 600 μm. High temperature was generated using external heaters composed of Pt-Rh wires with a ZrO_2 insulator. X-ray absorption measurements were conducted with monochromatic X-ray of 30 keV at BL10XU and BL22XU beamlines in SPring-8. Intensities of incident and transmitted X-rays were detected using a photo-diode or ion chambers. Experimental pressures were determined based on EOSs of KBr and RbBr using their volumes from XRD patterns collected using a flat panel detector.

The densities of liquid Ga were measured up to 9.4 GPa and 500 K. The densities of liquid Ga obtained at 4–9 GPa range 6.53(7)–7.25(14) g/cm^3. The measured density at 4 GPa is consistent with the density calculated from sound velocity data reported by Ayrinhac et al. (2015).

Keywords: gallium, diamond anvil cell, X-ray absorption method

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Density measurements of crystalline Fe and amorphous materials at high pressure

*Seiji Kamada[1,2], Hidenori Terasaki[3], Yusaku Takubo[3], Ryo Tsuruoka[3], Fumiya Maeda[2], Rui Yamada[1], Saori Kawaguchi[4], Naohisa Hirao[4], Akihiko Machida[5]

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Terrestrial planets, such as Earth, Venus, Mars, and Mercury, have metallic liquid and/or solid cores. The cores consistent of mainly Fe and Ni with small amounts of light elements. Chemical compositions of solid state cores have been estimated by density measurements of crystalline core materials in a number of previous studies. On the other hand, there are a few previous studies on density measurements of liquid samples because of technical difficulties. Although Morard et al. (2008, 2013) obtained densities of liquid Fe with light elements by structure analyses from XRD patterns, accuracy of the densities was under debate because they used XRD patterns with narrow reciprocal lattice spaces. In this study, we have measured densities of crystalline Fe and amorphous materials using an X-ray absorption method in order to avoid problems of small diffraction angles due to a diamond anvil cell (DAC).
High pressure measurements were performed using a DAC with a gasket having 3 sample chambers. Fe or amorphous samples were loaded in a sample chamber for density measurements. Powders of KCl, KBr, or RbBr as references for thickness were also loaded in the other sample chambers. After XRD patterns were taken from all samples and references, absorption profiles were also measured. Experimental pressures were determined using pressure averages between KCl and KBr, or KBr and RbBr. Densities based on the X-ray absorption method were obtained using the Lambert Beer law with mass absorption coefficients from NIST data base. Densities of crystalline Fe were obtained up to 20 GPa and density differences between XRD and the absorption method were less than 2%. This technique was applied to densities of amorphous materials as well. We will report the densities based on the X-ray absorption method.

Keywords: X-ray absorption method, diamond anvil cell

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DAC-GHz ultrasonic P wave velocity measurement on KCl and natural olivine

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GHz ultrasonic velocity measurements has been developed up to 14 GPa in diamond anvil cell (DAC). In order for GHz ultrasonic measurement, both P and S wave buffer rods were manufactured through sputtering ZnO piezoelectric film on single crystal rods, such as sapphire, rutile, and YAG. Several technical breakthroughs were achieved before observing stable signals from the specimen squeezed in DAC: (1) Wiping by aqueous ammonia on the contact surfaces enhances transmissibility of GHz wave from buffer rod to diamond. (2) Cleaning by lathery detergent and water jet is effective to remove sticky staff on rear surface of diamond. (3) Steel ball supporter provides easier adjustment of contact between buffer rod and diamond. Consequently, we succeeded to demonstrate performance of DAC-GHz system through KCl and natural olivine samples.

Keywords: elasticity, DAC, GHz ultrasonics

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[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

Wed. May 29, 2019 10:45 AM - 12:15 PM JST | Wed. May 29, 2019 1:45 AM - 3:15 AM UTC | IC 2F

[S-VC38] Active Volcanism

convener:Yuta Maeda(Nagoya University), Takahiro Miwa(National research institute for earth science and disaster prevention), Takeshi Nishimura(Department of Geophysics, Graduate School of Science, Tohoku University), Chairperson:Nobukazu Seama, Tetsuo Matsuno

This session discusses various aspects of active volcanisms including, but not limited to, recent and historical eruptions, various phenomena associated with the volcanic activities, underground structures of the volcanoes, and developments of new instruments based on geophysical, geochemical, geological, and multidiscipline approaches. We also welcome studies on understanding and predicting the transitions of the eruptive activities from observational, theoretical, and experimental approaches.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SVC38-30] Summary of Kikai submarine caldera researches conducted by KOBEC (Kobe Ocean-Bottom Exploration Center)

*Nobukazu Seama[1,2], Tetsuo Matsuno[2,1], Koji Kiyosugi[3,2], Satoshi Shimizu[2], Reina Nakaoka[2], Keiko Suzuki-Kamata[2,1], Yasutomo Seto[1], Mamoru Sano[2], Yuiko Morita[4], Hikaru Iwamaru[2], Haruhisa Morozumi[2], Misaki Horiuchi[1], Kimihiro Nishimura[1], Hiroshi Ichihara[5], Kazuki Hayashi[1], Toki Hirose[1], Katsuya Kaneko[1,2], Hiroto Yamaguchi[4], Yuki Okizono[4], Hiroko Sugioka[1,2], Kazuo Nakahigashi[6,2], Yojiro Yamamoto[7], Tatsuya KODA[2], Shuichi Kodaira[7,2], Yoshiyuki Tatsumi[2,1], Scientific party of T/S Fukae-maru Kikai caldera research cruises (1.Department of Planetology, Graduate School of Science, Kobe University, 2.Kobe Ocean Bottom Exploration Center, Kobe University, 3.Organization of Advanced Science and Technology, Kobe University, 4.Department of Planetology, Faculty of Science, Kobe University, 5.Graduate school of environmental studies, Nagoya University, 6.Tokyo University of Marine Science and Technology, 7.Japan Agency for Marine-Earth Science and Technology)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SVC38-31] Distribution of submarine pyroclastic-flow deposits of Akahoya eruption, Kikai caldera

*Satoshi Shimizu[1,2], Nobukazu Seama[3,1], Reina NAKAOKA[1], Tetsuo Matsuno[1,3], Koji Kiyosugi[5], Hikaru Iwamaru[1,2], Mamoru Sano[1,2], Kimihiro Nishimura[3], Keiko Suzuki-Kamata[1,3], Katsuya Kaneko[3], hiroto yamaguchi[4], Misaki Horiuchi[3], Toki Hirose[3], Kazuki Hayashi[3], Yoshiyuki Tatsumi[1,3] (1.Ocean Bottom Exploraiton Center, Kobe University, 2.Nippon Marine Enterprises, Ltd., 3.Department of Planetology, Graduate School of Science, Kobe University, 4.Department of Planetology, Faculty of Science, Kobe University, 5.Organization of Advanced Science and Technology, Kobe University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SVC38-32] Identification of submarine volcanic ash around the Kikai caldera with the Koya pyroclastic flow deposit inferred from glass composition

*Reina NAKAOKA[1], Keiko Suzuki-Kamata[1,2], Satoshi Shimizu[1], Yoshiyuki Tatsumi[1,2], Katsuya Kaneko[2,1], Koji Kiyosugi[3,1], Nobukazu Seama[2,1], Tetsuo Matsuno[1,2], Kimihiro Nishimura[2], Kazuki Hayashi[2] (1.Kobe Ocean-Bottom Exploration Center, Kobe University, 2.Department of Planetology, Graduate School ofScience, Kobe University, 3.Organization of Advanced Science and Technology, Kobe University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SVC38-33] Preliminary report of the sea floor survey by a remotely operated vehicle (ROV) at the Kikai caldera, SW Japan

*Koji Kiyosugi[1], Keiko Suzuki-Kamata[2], Haruhisa Morozumi[2,4], Yoshiyuki Tatsumi[2], Katsuya Kaneko[3], Reina NAKAOKA[2], Mamoru Sano[2], Satoshi Shimizu[2], Hikaru Iwamaru[2], Nobukazu Seama[3], Tetsuo Matsuno[2], Kimihiro Nishimura[3], Kazuki Hayashi[3], Misaki Horiuchi[3] (1.Organization for Advanced and Integrated Research, Kobe University, 2.Kobe Ocean-Bottom Exploration Center, Kobe University,

3.Department of Planetology, Graduate School of Science, Kobe University, 4.Japan Oil, Gas and Metals National Corporation)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SVC38-34] Seismic activity beneath Kikai Caldera by using Ocean Bottom Observation

*Yasutomo Seto[1], Hiroko Sugioka[2], Yojiro Yamamoto[3], Tsutomu Takahashi[4] (1.Department of Planetology, Graduate School of Science, Kobe University, 2.Department of Planetology, Kobe University, 3.Japan Agency for Marine-Earth Science and Technology, 4.Research and Developement Center for Earthquake and Tsunami, Japan Agency for Marine-Earth Science and Technology)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SVC38-35] An investigation of three-dimensional electrical resistivity structure under Kikai Caldera

*Tetsuo Matsuno[1,2], Toki Hirose[2], Yuuki Okizono[3], Nobukazu Seama[2,1], Hiroshi Ichihara[4], Hiroko Sugioka[2,1], Yoshiyuki Tatsumi[1,2] (1.Kobe Ocean Bottom Exploration Center, Kobe University, 2.Department of Planetology, Graduate School of Science, Kobe University, 3.Department of Planetology, Faculty of Science, Kobe University, 4.Graduate school of environmental studies, Nagoya University)

Summary of Kikai submarine caldera researches conducted by KOBEC (Kobe Ocean-Bottom Exploration Center)

*Nobukazu Seama[1,2], Tetsuo Matsuno[2,1], Koji Kiyosugi[3,2], Satoshi Shimizu[2], Reina Nakaoka[2], Keiko Suzuki-Kamata[2,1], Yasutomo Seto[1], Mamoru Sano[2], Yuiko Morita[4], Hikaru Iwamaru[2], Haruhisa Morozumi[2], Misaki Horiuchi[1], Kimihiro Nishimura[1], Hiroshi Ichihara[5], Kazuki Hayashi[1], Toki Hirose[1], Katsuya Kaneko[1,2], Hiroto Yamaguchi[4], Yuki Okizono[4], Hiroko Sugioka[1,2], Kazuo Nakahigashi[6,2], Yojiro Yamamoto[7], Tatsuya KODA[2], Shuichi Kodaira[7,2], Yoshiyuki Tatsumi[2,1], Scientific party of T/S Fukae-maru Kikai caldera research cruises -

1. Department of Planetology, Graduate School of Science, Kobe University, 2. Kobe Ocean Bottom Exploration Center, Kobe University, 3. Organization of Advanced Science and Technology, Kobe University, 4. Department of Planetology, Faculty of Science, Kobe University, 5. Graduate school of environmental studies, Nagoya University, 6. Tokyo University of Marine Science and Technology, 7. Japan Agency for Marine-Earth Science and Technology

Kikai submarine caldera to the south of the Kyushu Island, SW Japan, had at least three eruptions at 140, 95 and 7.3 ka, and its collapse occurred at 7.3 ka during the latest supereruption (>500 $km^3$of magma) in the Japanese Archipelago. We have conducted series of research cruises using the T/S Fukae-maru in this caldera to understand the melt supply system for the supereruption through tracing past supereruptions, identifying current volcanic activities, and imaging current structure.

The surveys to trace past supereruptions include multi-channel seismic reflection (MCS) surveys, visual observation and sediments sampling using remotely operated vehicle (ROV; SHINDAI-2K), and land observation. The MCS surveys provide high resolution marine seismic reflection images, which are classified into seven seismic units characterized by distinctive seismic facies. We interpreted that the upper most seismic unit should be a candidate layer for Koya ignimbrite due to 7.3 ka Akahoya eruption, because the deposit from the Kagoshima mainland with regressive surface erosion on progradational HST (highstand system tract) locates beneath this seismic unit and the deposit probably corresponds to the last glacial period (18 ka) (Shimizu et al., this meeting). This interpretation is supported by the chemical composition of glass shard samples on the sea floor near the caldera wall, which were obtained by ROV divings. The chemical composition of the glass shards indicates characteristic bimodal SiO_2 contents, which consistent with unique characteristic for the Akahoya eruption (Nakaoka et al., this meeting). This seismic unit distributes around the caldera and its whole volume will be calculated to estimate reliable magma volume during the Akahoya eruption. Further, visual observation of the ocean bottom by ROV (Kiyosugi et al., this meeting) and land observation (Suzuki-Kamata et al., this meeting) suggest eruption styles of submarine volcanoes and ignimbrite deposition modes.

Current volcanic activities and structures are obtained using geophysical approaches. High volcanic activities are identified by five months of seismicity data using five ocean bottom seismometers (OBSs): 1100 volcanic tremor events with its fundamental frequency of 2 Hz, high frequency seismic events with obvious P and S arrival, and monochromatic variation events are detected beneath and/or around the caldera (Seto et al., this meeting). Imaging current structures are provided by multi-beam echosounder mapping with backscatter imaging, gravity analysis, and marine electromagnetic experiment. All these structures outside of the caldera wallshows asymmetric features between the trench side and the back-arc side. The backscatter images show rough morphological features in the back-arc side, suggesting recent local eruptions, in contrast with smooth morphology in the trench side. The gravity analysis indicates that thinner upper crust in the back-arc side than that in the trench side (Morita, 2019). The

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electromagnetic field variation data obtained by 10 ocean-bottom electro-magnetometers (OBEMs) observation allowed us to image a 3-D electrical resistivity structure, which also shows asymmetric feature at <5-10 km depths (Matsuno et al., this meeting). These asymmetric features between the trench side and the back-arc side suggest that Kikai submarine caldera formation is basically controlled by the subducting slab.

Keywords: Kikai Caldera, Supereruption, Akahoya eruption

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Distribution of submarine pyroclastic-flow deposits of Akahoya eruption, Kikai caldera

*Satoshi Shimizu[1,2], Nobukazu Seama[3,1], Reina NAKAOKA[1], Tetsuo Matsuno[1,3], Koji Kiyosugi[5], Hikaru Iwamaru[1,2], Mamoru Sano[1,2], Kimihiro Nishimura[3], Keiko Suzuki-Kamata[1,3], Katsuya Kaneko[3], hiroto yamaguchi[4], Misaki Horiuchi[3], Toki Hirose[3], Kazuki Hayashi[3], Yoshiyuki Tatsumi[1,3]

1. Ocean Bottom Exploraiton Center, Kobe University, 2. Nippon Marine Enterprises, Ltd., 3. Department of Planetology, Graduate School of Science, Kobe University, 4. Department of Planetology, Faculty of Science, Kobe University, 5. Organization of Advanced Science and Technology, Kobe University

Kikai caldera, most of which is submerged in the seawater of the south of the Kyusyu Island, southwest Japan, is the Quaternary active caldera volcano. Latest eruption accompanied by caldera collapse taken place in 7.3 ka is the biggest Holocene eruption in Japan Archipelago. The ash-fall known as Akahoya was spread to entire southwest Japan and the pyroclastic flow thought as a low-aspect ratio ignimbrite is distributed in subaerial parts of the surrounding islands 40-80 km away from the source. Such submarine caldera must supplied the products not only in air, but largely in the water which has not been identified yet.

In order to understand the distribution of the pyroclastic-flow deposits beneath the sea around Kikai caldera, we conducted high resolution marine seismic studies from 2016 to 2018 by T/V Fukae-maru. We identified the uppermost unit widely recognized around Kikai caldera as the pyroclastic-flow deposit associated with 7.3-ka Akahoya eruption from the seismic sequence stratigraphic analysis and glass composition of sediments. The uppermost unit, characterized by subparallel to hummocky configurations of high amplitude reflections, covers the slope fan and progradational deposits of shelf edge developed between the Kyusyu Island and Kikai caldera. These secondary deposits under the uppermost unit are interpreted to deposit around the last glacial by reason of the erosion structure seen on the top-lap surface of regressive clinoform at 120 m below current sea level. Since uppermost unit is deposited after the last glacial (18 ka) and shows consistent seismic facies around Kikai caldera, the unit is inferred as products of 7.3-ka eruption. This is supported by analysis of glass composition of the sediments sampled at the seafloors interpreted as the above seismic unit, which shows the bimodal geochemical characteristic of high SiO_2 glass shards and lesser amount of low SiO_2 glass shards by which Koya pyroclastic-flow deposits are characterized (Nakaoka et al., this meeting).

This uppermost seismic unit interpreted as pyroclastic-flow deposit represents Akahoya eruption is distributed with a thickness of ~50 m around Kikai caldera. It maintains a certain amount of thickness until it reaches the shelf edge of the Kyusyu and surrounding islands. At least 40 km radius circle around the caldera, this unit is recognizable in most of the area of the seismic profiles. This result shows that a large amount of volcanic materials are ejected not only in air rather in the water at 7.3-ka Akahoya eruption.

Keywords: Caldera, Pyroclastic flow deposits, Sesimic survey, Sequence stratigraphy

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Identification of submarine volcanic ash around the Kikai caldera with the Koya pyroclastic flow deposit inferred from glass composition

*Reina NAKAOKA[1], Keiko Suzuki-Kamata[1,2], Satoshi Shimizu[1], Yoshiyuki Tatsumi[1,2], Katsuya Kaneko[2,1], Koji Kiyosugi[3,1], Nobukazu Seama[2,1], Tetsuo Matsuno[1,2], Kimihiro Nishimura[2], Kazuki Hayashi[2]

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Koya pyroclastic flow deposit (PFD) is large scale ignimbrite generated during formation of the Kikai caldera in Kikai-Akahoya eruption at 7.3 ka. Kikai caldera is located ~50 km south of the Satsuma Peninsula and largely presents at the bottom of sea. Koya PFD is thickly distributed on land of Takeshima and Satsuma-Iwojima which represent subaerial part of the northern rim of the Kikai caldera. It is also thinly distributed over distal area, adjacent islands and mainland of south Kyusyu which is 40-60 km away from the source across the sea. This pyroclastic flow deposit has been suggested to exhibit rather low aspect ratio ignimbrite (Ui, 1973). However, on-land survey revealed that the maximum pumice size tends to decrease with increasing the distance across the sea. This may lead to a hypothesis that a significant amount of pyroclastics was lost during traveling over the sea and deposited on the sea floor (Yamane and Suzuki-Kamata, 2017). Our multi-channel seismic (MCS) reflection experiments around the Kikai caldera further suggested several seismic units (Shimizu et al., 2018). We have concluded that the uppermost unit should be a candidate layer for Koya PFD. This layer is recognized extensive distribution around the proximal islands (~30 m thick) and continuous to the Kagoshima bay (~10 m thick). As mentioned above, the Koya PFD is expected to be thickly distributed on the sea floor around the Kikai caldera. However, identification of submarine deposit with the subaerial Koya PFD is not sufficiently. In this study, we measured chemical composition of glass shards on the sea floor obtained by remotely operated vehicle (ROV) and compared with the subaerial Koya PFD.

The ROV conducted four dives to sea floor where MCS data indicate that uppermost unit is distributed near sea floor around the caldera wall and one dive in the south of the Satsuma Peninsula and collected volcanic ash on the sea floor using nozzle. The chemical composition of glass shards (<200 micrometers) from both subaerial and submarine were measured by Electron Probe Micro Analyzer (EPMA).
The glass shards on the sea floor around the caldera wall show bimodal geochemical characteristic which contain a high proportion of high SiO_2 glass shards (SiO_2=72-78 wt.%) and lesser amount of low SiO_2 glass shards (SiO_2=64-68 wt.%). The low SiO_2 glass was reported by Fujihara and Suzuki-Kamata (2013) and confirmed that it is unique characteristic for the Kikai-Akahoya eruption by glass and whole rock composition of other volcanics of the Kikai caldera. This indicate that the sea floor around the Kikai caldera covered by volcanic ash derived from the Koya PFD. Samples from the sea floor in the south of the Satsuma Peninsula were also confirmed that they contain small amount of glass shard corresponding the Koya PFD. These results correspond to the MCS data showing that candidate layer for the Koya PFD is thickly and widely distributed at uppermost part around the Kikai caldera. The vertical variation for contents of low SiO_2 glass on Takeshima Island, which is proximal area of the Koya PHD with a thickness of ~20 m, shows that the content of low SiO_2 glass lacks at the basal level and increases upward and reaches >10% at early stage (~10% level of the total thickness). While, the contents of low SiO_2 glass at distal areas across the sea tend to increase upward to <5%, which are lesser than value of proximal area. The contents of low SiO_2 glass of the sea floor samples around the caldera rim are >10%. Ash size grains are considered to be less under the influence of segregation by difference of density (Nakaoka and

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Suzuki-Kamata, 2018). Thus, the Koya pyroclastic flow reached distal area across the sea between the start of eruption and the beginning of containment of low SiO_2 glass and was waning to not reach distal area and deposit on sea floor after the content of low SiO_2 glass increases to >10%.

Keywords: Kikai caldera, Koya pyroclastic flow

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Preliminary report of the sea floor survey by a remotely operated vehicle (ROV) at the Kikai caldera, SW Japan

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Submarine volcanoes are one of the frontiers in volcanology: many volcanoes are located under the sea and most of them are not well studied. Since 2016, the Kobe Ocean-Bottom Exploration Center (KOBEC) at Kobe University has investigated a submarine volcano (the Kikai caldera) to understand the structure of the caldera and the style of the caldera forming eruption. The Kikai caldera is located about 45 km off southern Kyushu Island, Japan. Except two islands on the northern part of the caldera rim, most of the caldera structure is under the sea. The caldera has double caldera structure: the outer caldera has width of 19 km and length of 24 km and the inner caldera has width of 15 km and length of 17 km. The formation of, at least, the inner caldera must be related with one of the largest eruption of this volcano occurred about 7300 years ago. In the inner caldera, a giant rhyolite lava dome (~32 km^3) was created after the caldera collapse (Tatsumi et al., 2018).

A remotely operated vehicle (ROV) is a tethered underwater robot connected with a support surface vessel by a cable for power supply and signal transmission. To observe and sample sea floor material, we introduced a ROV (SHINDAI-2K) in 2016. In this presentation, we show preliminary results of 9 dives of the ROV at 8 sites in the following 3 areas in the Kikai caldera.

Outer caldera: We investigated two sites at the northeastern rim of the outer caldera. At one of the sites, we found a massive angular outcrop of dense rock in the caldera wall. This result and andesitic gravel sampled at this site confirmed the presence of igneous rock expected by our prior multi-channel seismic reflection survey. Another site had a sandy seafloor. We sampled the sediments with the ROV and identified volcanic glass fragments ejected by the caldera forming eruption.

Inner caldera: We had two dives around the inner caldera. At the northeast caldera wall of the inner caldera, basement rock appeared as a massive and angular upright outcrop of dense mudstone which had several centimeters wide horizontal banded structure. On the other hand, at the southeastern site in the inner caldera, the sea floor was covered by sandy or muddy sediments. Volcanic glass fragments ejected by the caldera forming eruption were also identified from the sediments. Furthermore, some isolated vesiculated lava blocks were observed at this site. Those blocks had fractured surface, suggesting chilling of hot ejecta due to lava/water interaction.

Lava dome: We had four dives at the lava dome. The outline of the results was already reported by Tatsumi et al (2018). The most surface of the lava dome was covered by meter-scale vesiculated lava blocks (pillow lobes; Tatsumi et al., 2018). These blocks also had water-chilled structures. Relatively dense angular chilled blocks were observed at the east flank of the lava dome where gully-like features had been determined with our prior bathymetry analysis. Furthermore, a small amount of gas emission was observed at the northern flank of the lava dome where water column was expected in our prior

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side-scan sonar acoustic images.

Visual observation and sediments sampling using ROV provides valuable information to understand the history and eruption style of submarine volcanoes. Our preliminary observations suggests that (1) the amount and size of vesiculated lava blocks decrease with distance from the lava dome, showing that they were provided from the dome, (2) basement rock of the volcano is exposed at the sea floor in, at least, some areas of the Kikai caldera, (3) as well as old volcanic edifices in the two islands, old submarine volcanic edifices were cut by the caldera collapse and some of them are exposed in the outer caldera wall. These results and further ROV survey will provide new insight into the eruption history of submarine volcanoes.

Keywords: Submarine volcanoes, Caldera volcanoes, Kikai caldera, ROV

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Seismic activity beneath Kikai Caldera by using Ocean Bottom Observation

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Kikai submarine caldera located in the southern part of Kagoshima prefecture is located on the volcanic front of the southwestern Japan arc. It was recently revealed that a giant lava dome with a volume of 32km ^{3} is created after super eruption at 7.3 K.a. (Tatsumi et al., 2018). Seismic observation with the T/S Fukae-maru of Kobe University is conducted by five short-period ocean bottom seismographs (OBSs) which were in the deepest part of the caldera from October 19, 2016 to March 14, 2017. As the result, about 1100 volcanic tremors like as swarm with a fundamental frequency of around 2Hz were detected during the period and it was occurred very frequently beneath the caldera. In addition to these low frequency tremors, about 32 high frequency earthquakes with dominant frequency of over 5Hz and many monochromatic tremors were detected, but at the onshore station of Satsuma Iwo-jima no signals corresponding to these volcanic earthquakes have been detected.

In general, volcanoes are strongly inhomogeneous regions compared with ordinary crusts. The seismic waves propagate to stations under the influence of scattering and diffraction due to random inhomogeneities along the seismic ray paths. Actually, the monochromatic tremor observed in the Kikai caldera is detected only at the stations near the place where the hydrothermal activities were observed by the high-performance camera of the remotely operated vehicle (ROV) and multi-beam echosounder mapping, suggesting strong three-dimensional inhomogeneity in the volcanic body. An amplitude envelope method is powerful tool for analyzing seismic waves propagating through such a three-dimensional inhomogeneous medium. In this study, a method based on Takahashi et al. (2007) focusing on peak delay time from direct S-wave onset to the maximum amplitude arrival of its envelope was applied to about 1100 low frequency tremors and about 32 high frequency earthquakes.

For high frequency earthquakes and some low frequency tremors, we picked up the onset times arrival of P- and S-waves recorded clearly to determine the hypocenters. The hypocenters were vertically divided into two parts at a depth of around 10 km, most of which occurred at the shallower parts were laterally expanded within the lava dome. In addition, we measured the peak delay times for S-wave seismograms filtered at four frequency bands of 2-4, 4-8, 8-16 and 16-32 Hz and calculated root mean square envelope for the sum of two components in those bands to investigate a frequency. In this presentation, we will discuss characteristics of the obtained peak delay times.

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An investigation of three-dimensional electrical resistivity structure under Kikai Caldera

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We have conducted an electromagnetic experiment to reveal a 3-D electrical resistivity (or conductivity) structure under Kikai Caldera, SW Japan. The electrical resistivity is highly sensitive to thermal structure and the presence of partial melt or magma and fluid in the crust and in the upper mantle. Imaging an electrical resistivity structure provides key constraints on the distribution of magma reservoirs in the crust and in the upper mantle and volcanic structures and activities of this submarine caldera. Our electromagnetic experiment is one part of an integrated marine investigation of Kikai Caldera since October 2016 with T/S Fukae-maru, Kobe University. By semiannual research cruises to the Kikai Caldera region, we have repeatedly deployed and recovered ocean-bottom electro-magnetometers (OBEMs) by changing their locations to obtain a data set that is useful for imaging a 3-D electrical resistivity structure. We set 13 observational sites so far, and we have 10-sites data available for analysis. The 10 sites cover an area of 13 km ×16 km within the submarine double caldera with site-distances of ~5-10 km. The OBEMs measured time variations of electromagnetic fields at sampling rates of 8 Hz and 60 s with instrumental tilts and temperature at seafloor. Data suggested instrumental vibrations during observations, likely because of strong ocean current near the Kuroshio Current or between islands, and unstable positions of OBEMs on very rugged seafloor of lavas in this volcanic area. We carefully checked the time-series data and selected available data terms. We finally obtained magnetotelluric (MT) response functions at the 10 sites at a period range from 21 s to 8192 s, using the BIRRP program [Chave and Thomson, 2004]. For imaging a 3-D electrical resistivity structure, we carried out a 3-D inversion of the MT response functions using an inversion program of Usui et al. [2018]. Undulating seafloor in the study area, which can severely distort the MT responses, was incorporated into a 3-D inversion model with tetrahedron meshes. A preliminary 3-D inversion model (RMS misfit = ~1.7) shows a shallow conductive area of 3-10 Ω-m at <5-10 km depths, which is thin to the west and is thick to the east, and an underlying deep resistive area of 30-300 Ω-m at 10-30 km depths.

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[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

Wed. May 29, 2019 1:45 PM - 3:15 PM JST | Wed. May 29, 2019 4:45 AM - 6:15 AM UTC | IC 2F

[S-VC38] Active Volcanism

convener:Yuta Maeda(Nagoya University), Takahiro Miwa(National research institute for earth science and disaster prevention), Takeshi Nishimura(Department of Geophysics, Graduate School of Science, Tohoku University), Chairperson:Takeshi Ohba, Akihiko Terada

This session discusses various aspects of active volcanisms including, but not limited to, recent and historical eruptions, various phenomena associated with the volcanic activities, underground structures of the volcanoes, and developments of new instruments based on geophysical, geochemical, geological, and multidiscipline approaches. We also welcome studies on understanding and predicting the transitions of the eruptive activities from observational, theoretical, and experimental approaches.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SVC38-36] Time variation in the chemical and isotopic composition of fumarolic gases at Hakone volcano Japan

*Takeshi Ohba[1], Muga Yaguchi[2], Kana NISHINO[1], Nozomi Numanami[1], Yasushi DAITA[3], Urumu Tsunogai[4], Masanori Ito[4], Chiho Sukigara[4] (1.Department of chemistry, School of Science, Tokia University, 2.Meteorological Research Institute, JMA, 3.Kanagawa Environmental Research Center, 4.Nagoya University Graduate School of Environmental Studies)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SVC38-37] Chemical and isotopic composition of volcanic gases at Mt Kirishima Iwoyama, Japan

*Takeshi Ohba[1], Muga Yaguchi[2], Kotaro Toyama[3], Hirochika Sumino[3], Urumu Tsunogai[4], Masanori Ito[4], Ryo Shingubara[4] (1.Department of chemistry, School of Science, Tokia University, 2.Meteorological Research Institute, 3.The University of Tokyo Graduate School of Arts and Sciences Department of Basic Science, 4.Nagoya University Graduate School of Environmental Studies)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SVC38-38] Temporal and spatial variations of helium isotope ratios in volcanic gases in Kirishima volcanic group, Japan

*Kotaro Toyama[1], Hirochika Sumino[1], Kaori Kawana[1], Takeshi Ohba[2], Muga Yaguchi[3], Yoshihide Akiyama[1], Koki Aizawa[4], Kaori Tsukamoto[4] (1.Department of Basic Science, Graduate School of Arts and Sciences, The University of Tokyo, 2.Department of chemistry, School of Science, Tokia University, 3.Meteorological Research Institute, 4.Institute of Seismology and Volcanology, Faculty of Science, Kyushu University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SVC38-39] Emission regions of gaseous elemental mercury around Yugama crater lake at Kusatsu-Shirane volcano, Japan

*Akihiko Terada[1], Noriaki Mizutani[1] (1.Volcanic Fluid Research Center, Faculty of Science, Tokyo Institute of Technology)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SVC38-40] Magnetotelluric images of Kusatsu-Shirane volcano, revisited by 3-D modeling with tetrahedral elements considered topography effect

*Kuo Hsuan Tseng[1], Yasuo Ogawa[1], Nurhassan .[2], Sabri Bulent Tank[3], Akihiko Terada[1], Wataru Kanda[1], Masato Fukai[1] (1.Tokyo Institute of Technology, 2.Bandung Institute of Technology, Indonesia, 3.Bogazici University, Turkey)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SVC38-41] Magma conduit and associated hydrothermal systems of Aso volcano as revealed by broadband magnetotelluric data

*Nobuo Matsushima[1], Mitsuru Utsugi[2], Shinichi Takakura[1], Tadashi Yamasaki[1], Maki Hata[3], Takeshi Hashimoto[4], Makoto Uyeshima[3] (1.Geological Survey of Japan,AIST, 2.Kyoto University, 3.The University of Tokyo, 4.Hokkaido University)

Time variation in the chemical and isotopic composition of fumarolic gases at Hakone volcano Japan

*Takeshi Ohba[1], Muga Yaguchi[2], Kana NISHINO[1], Nozomi Numanami[1], Yasushi DAITA[3], Urumu Tsunogai[4], Masanori Ito[4], Chiho Sukigara[4]

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A geochemical observation method that analyzes substances released from magma and hydrothermal systems such as volcanic gas, hot spring water, volcanic ash, etc. is a potentially effective means for predicting steam eruption and elucidating the structure of hydrothermal system. In Hakone volcano, an earthquake swarm began in late April 2015, and a small steam explosion occurred at the end of June. Prior to the earthquake swarm, the stable isotopic ratio of H2O in the volcanic gas declined and fluctuations in the CO2/H20 ratio synchronized with the increase and decrease in the number of earthquakes were observed. Analyzing the volcanic ash released at the end of June 2015 and using the constituent mineral species and the Cl/S ratio of the component adhered on ash surface, it was presumed that the source depth of the volcanic ash was shallower than about 350-500m. Hakone volcano repeats earthquake swarm and the associated volcanic gas anomalies every few years, and it is expected that means to predict the transition of earthquake swarm can be established by ongoing volcanic gas geochemical observation.

We collected and analyzed monthly fumarolic gases T and S, respectively, that are releasing naturally in Owakudani and Kamiyuba, which are geothermal zones developed in the central volcanic cone of Hakone volcano, and obtained the following results. The CO2/H2S ratio of T reached its maximum value around October 2017, and then showed a tendency to gradually decrease toward to January 2019. At T, a similar tendency was also observed for He/CH4 ratio. The CO2/H2S ratio of S remained nearly constant from February 2018 to February 2019, but decreased once in November 2018. The He/CH4 ratio of S showed a declining trend in 2018 like T, but the rate of decline was slower than T. CO2 and He are derived from magma that degas, H2S and CH4 are derived from hydrothermal system. Therefore the declining trend of CO2/H2S ratio and He/CH4 ratio observed in 2018 indicates that the flux of magmatic gas to shallow hydrothermal system was decreasing. The cause of the decreasing trend may be due to the development of the sealing zone surrounding the magma. The declining trend of the CO2/H2S ratio and the He/CH4 ratio in 2018 looks to disappear in 2019. The CO2/H2S ratio of T and S rose slightly from January 2019 to February. Corresponding to the rise, a minor swarm earthquake was observed on Hakone volcano on January 24, 2019 (based on Hot Springs Research Institute of Kanagawa prefecture HP). The N2/He ratio of T and S remained low from 2018 to 2019, but T was exceptionally high in January 2019. N2 is a component derived from the atmosphere, and an increase in N2 in T indicates that the fluid pressure in the shallow part hydrothermal system decreased and a part of atmospheric contamination occurred. The apparent equilibrium temperature (AETD) can be calculated by combining the hydrogen isotope ratios of H2O and H2 contained in T and S. A decline phenomenon preceding the earthquake swarm were observed in 2014 and 2017. From early 2018 to the October, AETD is declining especially for S. The decrease may be a preceding sign of earthquake swarm.

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Chemical and isotopic composition of volcanic gases at Mt Kirishima Iwoyama, Japan

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INTRODUCTION

At Mt Kirishima Iwoyama, several fumarolic gases appeared in the vicinity of the summit in December 2015, and the discharge of fumarolic gas was enhanced in May 2017. In addition, a small steam eruption occurred in April 2018. Volcanic gas contains components degassed from magma and is useful for evaluating volcanic activity. In this study, from December 2015 to January 2019, fumarolic gases were repeatedly collected and analyzed at Mt Kirishima Iwoyama. We consider the relationship between the variation of the chemical composition and stable isotope ratio of these samples and the recent volcanic activity.

SAMPLING OF FUMAROLIC GAS

Fumarolic gases a, b, c were collected near the summit of Mt. Kirishima Iwoyama. The location of fumarole-a is the place where fumarolic gas first appeared in Dec. 2015. The fumarole-b is located about 40 m south of fumarole-a. The fumarole-c is about 200 m away from the fumarole-a in the south-southwest direction. The outlet temperature of the fumaroles was all close to the boiling point of water and the discharge pressure of fumarolic gases was low.

RESULTS AND DISCUSSIONS

The SO2/H2S ratio of fumarolic gas-a fell sharply from May to October 2018, but again rose in January 2019. The ratio at fumarolic gas-b also rose from October 2018 to January 2019. The Oxygen isotope ratios of H2O rose at three fumarolic gases from October 2018 to January 2019. At all three fumarolic gases, the CO2/H2O and the H2S/H2O ratio fell from October 2018 to January 2019.

In general, CO2 is a component originating in magma, H2S is a component originating in hydrothermal system, and the CO2/H2S ratio rises as the flux of magmatic gas to a shallow hydrothermal system increases. In Mt Kusatsu Shirane and Mt Hakone, the H2S/H2O ratio of the fumaroles is stable in time, and the CO2/H2S ratio could be a good indicator of the magmatic gas flow rate for the shallow hydrothermal system. The H2S/H2O ratio of Mt Kirishima Iwoyama is variable, and the situation is different from Mt Kusatsu Shirane and Mt Hakone. For example, from January to March 2018, the H2S/H2O ratio of fumarolic gas-a changed little, but fumaroles b and c greatly decreased. From March to May 2018 the H2S/H2O ratio dropped greatly in fumarolic gas-a, but in fumarolic gas-c it increased in reverse. Thus, the change in H2S/H2O ratio was not coordinated between fumaroles, and the cause of H2S/H2O ratio change is estimtated to be local. For this reason, it is not appropriate to use the CO2/H2S ratio of fumarolic as an indicator of the flux of magmatic CO2 to the shallow hydrothermal system at Mt Kirishima Iwoyama. The reason why the H2S/H2O ratio of fumarolic gases greatly fluctuates may be

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attributed to the insufficient development of shallow hydrothermal system.

The SO2/H2S ratio of fumarolic gas gas was low in January 2018, but it rapidly rose in March 2018 just before the steam eruption. In addition, the increase in SO2/H2S ratio occurred simultaneously in three fumarolic gases. At this time, the apparent equilibrium temperature (AETD) calculated by combining the hydrogen isotopic ratios of H2O and H2 sharply increased to values close to the magmatic temperature at the fumaroles-a and b. A similar increases in SO2/H2S ratio and AETD also occurred in May 2017, when the discharge of fumarolic gas was enhanced. The H2O oxygen isotopic ratios of the three fumaroles have been similarly fluctuated. The oxygen isotopic ratio reached the maximum value in fumaroles a and b in March 2018 just before the eruption in April. Considering the SO2/H2S ratio and the high oxygen isotope ratio in May 2017, it is highly likely that so-called the attempted eruption occurred.

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Temporal and spatial variations of helium isotope ratios in volcanic gases in Kirishima volcanic group, Japan

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In Kirishima volcanic group in Kyushu, Southwest Japan, Shinmoe-dake is an active volcano and erupted in 2008, 2011, 2017 and 2018, and Iwo-yama also erupted in 2018. For the volcanic disaster preservation, forecasting the timing of the volcanic eruption is required. It is known that the temporal variations in chemical and isotopic compositions of volcanic gases are useful to evaluate the present state of volcanic activity [1]. Especially, helium isotope ratio ($^3He/^4He$) exhibits unique values corresponding to the origin (e.g., 7-8 Ra in the mantle and about 0.02 Ra in the crust, where 1 Ra denotes atmospheric $^3He/^4He$ ratio of 1.4×10^{-6} [2]). Some studies have reported pre-eruptive $^3He/^4He$ anomalies, suggesting the increase of the magmatic helium supply into the hydrothermal system preceding eruption [1, 3, 4].

We report spatial and temporal variations of $^3He/^4He$ ratios of fumaroles and hot spring gases collected from 10 sites in Kirishima volcanic group during 2016 to 2018. The measured $^3He/^4He$ ratios were corrected for atmospheric contamination based on $^4He/^{20}Ne$ ratios. The air-corrected $^3He/^4He$ ratios (6.8 to 7.7 Ra) of the central craters in the active volcanos (i.e., Iwo-yama and Shinmoe-dake) are higher than those (4.3 to 5.3 Ra) of the other sites. These $^3He/^4He$ ratios decrease with the increase of the distance from the magma reservoir, location of which is estimated as pressure source of crustal deformation associated with the 2011 Shinmoe-dake eruption, to each sampling site. This trend reflects that the contribution of radiogenic ^4He in old groundwater increases with migration distance of the gas from the magma to the site [5].

The $^3He/^4He$ ratios of fumaroles in Iwo-yama slightly increase before Shinmoe-dake eruptions, and decrease after the eruption. This variation cannot be accounted for by the contribution of the radiogenic ^4He relative to total helium in the fumaroles before and after the eruptions, because it is estimated that the amount of radiogenic ^4He which volcanic gas can acquire during its migration from magma to the surface is negligible. Alternatively, the variation results from the change in mixing ratio of gases derived from two reservoirs having high and low $^3He/^4He$ ratios. Assuming that the magma chamber has high $^3He/^4He$ ratio, the increase of $^3He/^4He$ ratios of the fumaroles before the eruption would be resulted from increase of the supply of the gas from the chamber to the Iwo-yama fumaroles. Once an eruption occurs at Shinmoe-dake, magmatic gas is effectively released through the volcanic vent, resulting in decrease of its supply to the Iwo-yama fumaroles. Thus, the temporal variation of $^3He/^4He$ ratios in volcanic gases may reflect the pressure variation of the magma chamber.

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Keywords: Kirishima volcanic group, Helium isotope ratios, Volcanic gas, Temporal and spatial variations, Volcanic eruption

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Emission regions of gaseous elemental mercury around Yugama crater lake at Kusatsu-Shirane volcano, Japan

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Kusatsu-Shirane volcano is one of the most active volcanoes in terms of release of a large amount of heat as volcanic gas and thermal hot waters. In addition to a hot crater lake, locally referred to as Yugama, the Shirane pyroclastic cone exhibits thermal features such as steaming grounds and fumaroles. Because many visitors visit around the Shirane pyroclastic cone for sightseeing, risk evaluations of phreatic eruptions are valuable. Gaseous mercury emissions from ground surface at active volcanoes suggest thermal activities such as shallow hydrothermal system. Mercury contained in geothermal hot water separated from hydrothermal reservoirs as a gas phase and is transported to the surface along relatively high permeable zones. Thus, a spacial distribution of gaseous mercury emission rates from ground surface is one of a clue used to detect fracture zones. Such fracture zones may correspond to areas where explosion vents are formed in future. Furthermore, changes in flux of gaseous mercury may reflect temperature changes in a hydrothermal reservoir although mercury flux from ground surface is affected by environmental factors including air temperature, soil moisture content and organic carbon. Recently, portable apparatuses enabling to measure concentrations of gaseous elementary mercury (GEM) have been developed. To detect fracture zones around the Shirane pyroclastic cone, we applied the portable GEM analyzer which is low power consumption and light weight. On the basis of a simple numerical model which we have developed, we calculated GEM flux from GEM density measured around the soil. As a result, two GEM emission zones, A and B were found at the southern flank of the Shirane pyroclastic cone. The zone A corresponds to a locality of fissure vents formed by phreatic eruptions occurred at the beginning of 20 century. No volcanic vents are observed at ground surface at the zone B while its direction is parallel to an orientation of past fissure vents at the bottom of Yugama crater lake. We believe the zone B is fracture zone which was buried by thick ejecta emitted by following eruptions.

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Keywords: Gaseous elemental mercury, Kusatsu-Shirane volcano, Hydrothermal system, Phreatic eruption

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Magnetotelluric images of Kusatsu-Shirane volcano, revisited by 3-D modeling with tetrahedral elements considered topography effect

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Mount Kusatsu-Shirane, Japan, is an active volcano with temporary phreatic eruptions. The distribution of subsurface conductor was previously inferred with 2-D inversion of magnetotelluric data which considered the topography effect. We combine the magnetotelluric data from 94 stations which were investigated in 2001-2002 and 8 stations which were investigated in 2017-2018 for inverse modeling. The stations were located on the volcano, mostly around Yugama crater. We selected the data by 15 frequencies for the 3-D inverse modeling. The model was calculated by FEMTIC (Usui, 2015; Usui et al., 2017), considering the topographic effect.

The final model presents two major electric conductive structures. A 0.5-3 ohm-m conductive structure with 500-1000 meters thickness is located at 300 meters depth, beneath Yugama crater and extend to the east slope of Kusatsu-Shirane volcano until Sesshogahara fumarole field. Another conductor at the west of Yugama crater has 600-1000 meters thickness at 1500-2000 meters depth.

Comparing the final model with microseismic data, most of the hypocenters are under a low conductive (<2 ohm-m) structure beneath Yugama crater. This conductive structure infers a hydrothermal deposit of volcano, which cut-off the seismicity as a cap rock. At the north of Mizugama crater, a high resistivity structure at the edge of conductor infers the path of fumarole. The deep conductor between Kusatsu-Shirane volcano and Manza geothermal field infers the geothermal source of Kusatsu-Shirane volcano system.

Keywords: data inversion, geothermal field, clay, fumerole

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Magma conduit and associated hydrothermal systems of Aso volcano as revealed by broadband magnetotelluric data

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1. Geological Survey of Japan,AIST, 2. Kyoto University, 3. The University of Tokyo, 4. Hokkaido University

Aso volcano is one of the most active volcanoes in Japan. The caldera forming eruptions occurred from 210 ka to 90 ka, emitting the volcanic product of 600 m^3 in total. The caldera has a dimension of 25 ×18 km^2. After the caldera forming eruptions, post-caldera cones more than 17 were formed at the center of the caldera. Resent eruptions occurred repeatedly at Naka-dake cone. The count of the eruption events from Naka-dake crater was 73 times from 1901 to 2015. These volcanic activities suggest the stable magma supply from deep seated magma source to the surface. To investigate the magma plumbing system, the resistivity structure under Aso volcano was analyzed using the broadband magnetotelluric (MT) data. The four components of MT impedance and two components of tipper vector were used to obtain the resistivity structure by three-dimension inversion (Siripunvaraporn and Egbert, 2009). Overall structure was obtained using 55 measurement sites in and around of Aso caldera (Hata et al., 2016). We observed additional 9 sites near Naka-dake crater and revised the previous model to examine mainly the shallow structure near the active crater. The resistivity structure represents the low resistivity (< a few Ω•m) body which extends from near surface to a depth of 15 km (bsl) with a columnar shape, dipping northward and roughly directs to the epicenter of deep low-frequency earthquakes. The top of the low resistivity body is just located below the Naka-dake crater at sea level, which corresponds to the upper bound of magma depth estimated by melt inclusion analysis (Saito et al., 2018). From these results, we conclude that the low resistivity body indicates the upper part of the magma plumbing system of Aso volcano from deep seated magma source to the present active crater.

Keywords: Aso volcano, resistivity structure, magma plumbing system

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Wed. May 29, 2019 9:00 AM - 10:30 AM JST | Wed. May 29, 2019 12:00 AM - 1:30 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-CG57] Structure and evolution of Japanese islands - Formation of island arc systems and earthquake cycles

convener:Hiroshi Sato(Earthquake Prediction Research Center, Earthquake Research Institute, The University of Tokyo), Masanao Shinohara(Earthquake Research Institute, University of Tokyo), Masahiro Ishikawa(Graduate School of Environment and Information Sciences Yokohama National University), Makoto MATSUBARA(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Masanao Shinohara(Earthquake Research Institute, The University of Tokyo), Tatsuya Ishiyama(Earthquake Research Institute, University of Tokyo)

Subduction processes such as accretion, back-arc-spreading, and arc-arc collisions have shaped the Japanese island arc. Recent advances in seismic imaging, both passive and controlled source, have produced new images of the crust-mantle structure under Japan and surrounding regions. Through the influence of pre-existing faults and rheological structures, these crust and mantle structures are exerting strong control on active tectonic processes like seismic activity and crustal deformation in the overriding plate. We seek contributions that document and/or model the deformation of the Japanese islands over a variety of time scales from the earthquake cycle to the tectonic evolution of the Japanese island arc, and from a range of research fields including seismology, geology, geochemistry, tectonic geomorphology, and geodynamics. Multidisciplinary studies are encouraged. We also welcome contributions in numerical or analogue geodynamical modeling that explore deformation processes.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SCG57-01] Recent Earthquake Activity in Northern Hokkaido, Japan

Cancelled

*Tetsuo Takanami[1,2] (1.Carnegie Institution for Science, 2.Hokkaido Research Center of Geology)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SCG57-02] Seismic constraints on the crustal structure off the southwestern coast of Hokkaido, Japan Sea

*Tetsuo No[1], Takeshi Sato[1], Shuichi Kodaira[1], Hiroshi Sato[2], Tatsuya Ishiyama[2] (1.JAMSTEC, 2.ERI, University of Tokyo)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SCG57-03] Deep seismic reflection profiling across the Oshima Peninsula, SW Hokkaido, Japan

*Hiroshi Sato[1], Tatsuya Ishiyama[1], Naoko Kato[1], Hidehiko Shimizu[2], Takeshi Sato[3], Shinji Kawasaki[2], Tetsuo No[3], Shuichi Kodaira[3], Seiichi Miura[3] (1.Earthquake Research Institute, The University of Tokyo, 2.JGI Inc, 3.Japan Agency for Marine-Earth Acience and Technology)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SCG57-04] Crustal deformation and stress accumulation on source faults around Hokkaido, Japan, due to coupling at the Kuril trench

*Akinori Hashima[1], Hiroshi Sato[1], Tatsuya Ishiyama[1], Andrew M. Freed[2] (1.Earthquake Research Institute, The University of Tokyo, 2.Purdue University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SCG57-05] Structural Heterogeneity in and around the Source Region of the 2018 Hokkaido Eastern Iburi Earthquake, Central Hokkaido, Japan

*Takaya Iwasaki[1], Noriko Tsumura[2], Tanio Ito[3], Kazunori Arita[4], Makoto Matsubara[5], Hiroshi Sato[1], Eiji Kurashimo[1], Naoshi Hirata[1], Susumu Abe[6], Katsuya Noda[7], Akira Fujiwara[8], Shinsuke Kikuchi[9], Kazuko Suzuki[10] (1.Eathquake Research Institute, the University of Tokyo, 2.Graduate School of Science, Chiba

University, 3.Association for the Development of Earthquake Prediction, 4.Hokkaido Research Center of Geology, 5.National Research Institute for Earth Science and Disaster Resilience, 6.JAPEX, 7.GEOSYS Inc., 8.JOGMEC, 9.JGI Inc., 10.Schlumberger Ltd.)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SCG57-06] Electrical resistivity distribution around the middle axis of Hokkaido Island: constraint for tectonics of ultra-mafic rocks

*Hiroshi Ichihara[1], Toru Mogi[1], Yusuke Yamaya[2] (1.Earthquake and Volcano Research Center, Nagoya University, 2.AIST)

Recent Earthquake Activity in Northern Hokkaido, Japan

*Tetsuo Takanami[1,2]

1. Carnegie Institution for Science, 2. Hokkaido Research Center of Geology

In order to understand the future earthquake potential damage in northern Hokkaido, we examined the current seismic activity from the perspective of plate tectonics. An earthquake swarm, with largest earthquake of M_{JMA} 4.3, starting on July 15, 2012 in the town of Nakagawa in northern Hokkaido, Japan, where residents felt the earthquakes of seismic intensity IV three times in 3 days (The Seismological Bulletin of Japan, JMA, 2012). At the same time, a slow earthquake was also detected nearby during the swarm (M. Ohzono et al., 2015; S. Ikeda, 2016). It is inferred from the results that the source area is associated with almost horizontal E-W compressional tectonics. Den and Hotta (1973) first proposed the paleo-tectonic movement of the Okhotsk plate in the Mesozoic to Paleogene time along western Hokkaido and the island of Sakhalin to the north. Nakagawa is located at the western margin of the Okhotsk paleo-plate. The present tectonic movement of the island of Hokkaido is controlled by the triple interaction among the Pacific, the North American and the Eurasian plates. The current activity of an earthquake swarm and slow earthquake near Nakagawa suggests that the tectonic movement on the remnant boundary zone has not completely vanished. Further, according to the geodetic imaging by Loveless and Meade (2010), the slip rates across the corresponding area were estimated as 13.0±2.1 mm/y ~ 8.4±2.1 mm/y of E-W closing or shortening. In order to shed light on the current earthquake behavior in the western boundary of the Okhotsk paleo-plate, we study seismic activity in northern Hokkaido centered on Nakagawa using earthquakes of magnitude 2 or more in the JMA unified catalog from January 1, 1996 to October 30, 2018. The map of epicenters indicates that almost all are inland earthquakes within a western coastal zone extending 40km east-west and 200km north-south with very few earthquakes located in the east side of the Sea of Okhotsk. Here we focus on the earthquake activity in the northern half of the zone (44.2˚N - 45.5˚N; 141.5˚E - 142.5˚E). The topical earthquake swarm and slow earthquake near Nakagawa occurred when the general earthquake activity was at its highest. We apply the Gutenberg-Richter frequency-magnitude formula (G-R law) to our earthquakes set and obtain a b-value of 0.87 that is somewhat small but almost normal. This current seismic activity is also useful in considering future potential damages in northern Hokkaido. The largest earthquake magnitude from the G-R relation is estimated to be about $M_{JMA}5$ consistent with the fact that few moderate to larger earthquakes with magnitude (M_{JMA}) greater than 5 have occurred in the research region. Our results are limited by the number of earthquakes in the region since the installation of the high density network in late 1990. In 2007, the Headquarters for Earthquake Research Promotion, an office of Japanese government estimated the magnitude of the biggest earthquake of $M_{JMA =}$ 7.6 if the Sarobetsu fault zone in northern Hokkaido fails over its entire zone. Since we have a catalog for a certain time interval (2.7 years) the straight line projection to higher magnitudes gives an estimate of the probability of having a larger earthquake. Projecting the line to say M_{max} =7.6 expected gives a value of 0.0055, implying that we could expect one M_{max} =7.6 in 183 years. We are aware that such a long term projection based on a relatively short data interval is subject to significant error. As earthquake data are added in the future, this aspect should be reexamined.

Keywords: Earthquake activity in northern Hokkaido, Earthquake zone in the western margin of Okhotsk sea plate, Earthquake swarm, Slow earthquake, Gutenberg-Richter law, b-value

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Seismic constraints on the crustal structure off the southwestern coast of Hokkaido, Japan Sea

*Tetsuo No[1], Takeshi Sato[1], Shuichi Kodaira[1], Hiroshi Sato[2], Tatsuya Ishiyama[2]

1. JAMSTEC, 2. ERI, University of Tokyo

Offshore crustal structure studies have been conducted around Japan, with a primary focus on the Pacific side such as the Nankai Trough and Japan Trench via multichannel seismic reflection (MCS) and ocean bottom seismograph (OBS) surveying since the 1990s (e.g. Kodaira, 2009); moreover, seismic surveys have been conducted in the Japan Sea since the 2000s (e.g. Sato et al., 2018a). In 2018, we conducted a MCS and OBS survey off the southwestern coast of Hokkaido, which was one of the unsurveyed areas in the Japan Sea. Our survey area included the source region of the 1993 Hokkaido Nansei-Oki Earthquake, which is the largest earthquake among the shallow earthquakes that occurred in the Japan Sea since the Meiji period. Therefore, as our survey lines were oriented traverse the source region of the 1993 Hokkaido Nansei-Oki earthquake to the east and west, our data provided very important information for studying the relation between this earthquake source fault and its surrounding crustal structure. Furthermore, we targeted the Japan Basin, which is located to the west of the Hokkaido Nansei-Oki Earthquake source region. The Japan Basin is the widest basin in the Japan Sea, with previous studies estimating that it possesses a standard oceanic crustal structure and thickness (e.g. No et al., 2014; Sato et al., 2018b). Our survey area provides another key piece of information for comparison with a previous geomagnetic study because it overlaps with an area that has been defined by a striped pattern of geomagnetic anomalies (e.g. Kinoshita et al., 1995).

We conducted the seismic survey using the JAMSTEC R/V *KAIREI*. The survey area extends from the Okushiri Basin and Shiribeshi Trough to the Okushiri Ridge, the Japan Basin, and comprises nine MCS lines and one seismic refraction line using OBSs. Furthermore, the seismic refraction survey line was extended onshore to link with a land seismic survey in Oshima Peninsula, which was simultaneously conducted by the Earthquake Research Institute, University of Tokyo.

According to the provisional data processing results, clear shortening structures are imaged in the MCS data that cover the Okushiri Basin, Shiribeshi Trough, and the source region of the Hokkaido Nansei-Oki earthquake. However, a sedimentary layer with a thickness of approximately 2 km is observed in the Japan Basin, and clear reflectors, dense normal faults are observed throughout this sedimentary layer. Furthermore, a strong reflector is identified at approximately 7 km under the sedimentary layer, which we presumed to be the Moho. We image clear reflectors in the crust and uppermost mantle. Furthermore, the Moho reflector is poorly defined in the eastern margin of the Japan Basin, with a shortened structure and clear east-dipping crustal reflector imaged in this region.

The results of data analysis of seismic survey using OBSs indicate that the Japan Basin is a relatively homogeneous structure that possesses a standard oceanic crustal structure. However, the P-wave velocity structure indicates a thicker crust to the east of the region where the MCS data confirmed a shortened structure. Additionally, it is suggested that the crust thickens rapidly across the Okushiri Ridge.

Keywords: Japan Sea, 1993 Hokkaido Nansei-Oki Earthquake, Japan Basin, Okushiri Ridge, Seismic survey

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Deep seismic reflection profiling across the Oshima Peninsula, SW Hokkaido, Japan

*Hiroshi Sato[1], Tatsuya Ishiyama[1], Naoko Kato[1], Hidehiko Shimizu[2], Takeshi Sato[3], Shinji Kawasaki[2], Tetsuo No[3], Shuichi Kodaira[3], Seiichi Miura[3]

1. Earthquake Research Institute, The University of Tokyo, 2. JGI Inc, 3. Japan Agency for Marine-Earth Acience and Technology

An onshore-offshore seismic data set was collected across the Oshima peninsula, SW Hokkaido to the Japan basin, off SW-Hokkaido to determine the geometry of seismogenic source faults and basic structure of backarc of NE Honshu arc (Sato, T. et al., 2019 JpGU; No et al., 2019, JpGU). Here, we present the result of deep seismic reflection profiling across the Oshima peninsula, high-reslolution seismic reflection survey across the western boundary fault of Hakodate plain and P-wave velocity structure obtained from onshore-offshore integrated seismic processing.

The deep seismic data set was collected across the Oshima peninsula in May, 2018. Vertical land seismometers (GSR) were deployed with a spacing 50 to 200 m along the 54-km-long seismic line using fixed 1119 channel. The seismic source was four to five vibroseis trucks with standard 150 m shot spacing. As high energy shot, 50 stationary sweep were carried out every 5 km along the seismic line. Sweep frequency was 6 to 60 Hz and sweep length was 16 to 20 sec. The obtained seismic data were processed according to a standard common-midpoint (CMP) stacking and a post stack time migration. We used refraction tomography to determine the P-wave velocity structure, that revealed down to 8 km in depth beneath the western part of the seismic line. Obtained P-wave velocity profile demonstrates the geometry of the top surface of pre-Tertiary rocks. The Kamiiso massif and Esashi range marked by high Vp (> 5 km/s) and 2 km of sediment cover are distributed in the Tate and Hakodate Basins. With a pattern of seismic reflection, main geologic structure is interpreted a series of westward dipping Miocene normal faults. The NS-trending Kamiiso massif is an uplifted zone bounded by a high-angle reverse fault, which formed as a normal fault. The high-resolution seismic reflection profiling was performed across the western boundary fault of the Hakodate plain. Seismic source was a viborseis truck and the seismic signal was recorded fixed 845 channel offline recorders (GSR). Shot and receiver intervals are 10 m. The 8-km-long seismic section portrays the geometry of active fault down to 2 km in depth. The fault dips 45 degrees westward in more than one km depth. Judging from the stratigraphy, it is interpreted as a reactivation of normal fault as reverse fault. On the contrary, the shallower part of active fault forms thin-skinned type of deformation associated with wedge-thrust, fault-related fold and flat-ramp structure. The obtained shallow structure is very concordant with the feature of tectonic geomorphology and frontal part of active thrust is presented as a blind thrust. The air-gun shots along the offshore of Oshima peninsula were recorded by fixed recorders on land and integrated P-wave velocity was obtained covering 310 km seismic line. The basic feature is very similar to the velocity model proposed by Sato, T. et al. (2019) JpGU. The velocity structure portrays the detailed structure produced by Miocene backarc extension and formation of the Sea of Japan crust. In spite of the later shortening deformation, basic structure has extensional tectonic features. There no evidence of the subduction of the Sea of Japan crust beneath the Hokkaido continental crust.

Keywords: Deep seismic reflection profiling, Seismic source fault, SW Hokkaido

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Crustal deformation and stress accumulation on source faults around Hokkaido, Japan, due to coupling at the Kuril trench

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1. Earthquake Research Institute, The University of Tokyo, 2. Purdue University

2018 Mw6.7 Hokkaido-Iburi earthquake, Japan, brought about disastrous landslides near epicenter, and a power blackout on the whole Hokkaido island. In order to assess activity of such an intra-plate earthquake, we need to know not only the geometry of local source faults but also stress on them. The geometry model for the source faults over Japan was already published by the Headquarters for Earthquake Research Promotion of the Japanese government. We are now revising the model and adding new source faults in the offshore areas. Stress in the plate interior is essentially formed due to the interplate interaction at plate boundaries. The Kuril trench near Hokkaido has hosted a massive megathrust rupture. GPS observation shows widespread locking region southeast off Hokkaido. Similarities to the preseismic state around the 2011 Mw9.0 Tohoku-oki earthquakes along the Japan trench are pointed out such as decades of subsidence along the southeast Hokkaido and decrease in seismicity in recent years in this region. In order to quantitatively estimate the effect of these plate boundary process, we construct a finite element model (FEM) to estimate regional deformation and stress accumulation rate on source fault around Hokkaido due to the locking along the Kuril trench.

Our model contains the region of 3700 km x 4600 km including the Kuril–Japan trench. The bottom of the model is taken at the depth of 700 km to consider the whole upper mantle. The geometries of the Pacific and Philippine sea slabs under the Northeast Japan –Izu Bonin arcs, and the Southwest Japan –Ryukyu arcs, respectively, are incorporated following the previous studies. The model region is divided into 1000,000 tetrahedral elements. The size of the elements is set 5 km around the slip region and gradually larger close to the boundaries. Fault slip can be modeled by giving constraint equation of displacement discontinuity. Slip region is taken on the upper surface of the Pacific plate shallower than the depth of 80 km. We simply set the Pacific and Philippine sea slabs as the 70-km thick elastic plates over viscoelastic asthenosphere. The continental side is assumed to be elastic-viscoelastic stratified structure. Elastic thickness is tested for the case of 30 and 50 km. Since the interseismic deformation includes the effect of the concurrent viscous relaxation in the asthenosphere, we used response after complete relaxation.

In order to understand the basic feature of crustal deformation around Hokkaido, we compute response to locking of two offshore regions inferred from the past earthquake occurrence: Tokachi and Nemuro. Crustal deformation in Hokkaido obtained from GPS observation shows ~5 cm/yr northwestward movements on the Southeast coast, which decay toward the North and West, except the effect of the 2003 Mw8.0 Tokachi-oki and 2011 Mw9.0 Tohoku-oki earthquakes. This basic feature can be realized in the case of elastic thickness of 50 km and locking rate of 4 cm/yr in Tokachi and 8 cm/yr in Nemuro, respectively. These locking rates form compressive stress fields over the Hokkaido region. The compressive axes are NW-SE in the eastern Hokkaido and E-W in the western Hokkaido. The calculated stress field in the western Hokkaido is consistent with the occurrence of the 2018 Hokkaido-Iburi earthquake. In this study, we also apply the calculated stress field to source fault model around Hokkaido and calculate Coulomb stress to examine the earthquake activities.

Keywords: Kuril trench, Crustal deformation, Finite element method, Viscoelasticity, Coulomb stress

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Structural Heterogeneity in and around the Source Region of the 2018 Hokkaido Eastern Iburi Earthquake, Central Hokkaido, Japan

*Takaya Iwasaki[1], Noriko Tsumura[2], Tanio Ito[3], Kazunori Arita[4], Makoto Matsubara[5], Hiroshi Sato[1], Eiji Kurashimo[1], Naoshi Hirata[1], Susumu Abe[6], Katsuya Noda[7], Akira Fujiwara[8], Shinsuke Kikuchi[9], Kazuko Suzuki[10]

1. Eathquake Research Institute, the University of Tokyo, 2. Graduate School of Science, Chiba University, 3. Association for the Development of Earthquake Prediction, 4. Hokkaido Research Center of Geology, 5. National Research Institute for Earth Science and Disaster Resilience, 6. JAPEX, 7. GEOSYS Inc., 8. JOGMEC, 9. JGI Inc., 10. Schlumberger Ltd.

Central Hokkaido, Japan, has complicated tectonic history of subduction, accretion and collision processes from Late Jurassic to the present. Since Paleogene or Early Miocene, compressional stress regime has been dominated by the dextral oblique collision between the Eurasia and North America (Okhotsk) Plates and the subsequent westward movement of the Kuril Arc due to the oblique subduction of the Pacific Plate. The latter event was responsible for the formation of the Hidaka Collision Zone (HCZ) and the foreland fold-and-thrust belt with a very thick (>10 km) sedimentary package. The 2018 Hokkaido Eastern Iburi Earthquake (M=6.7) took place at a very deep depth of 37 km under this foreland fold-and thrust belt. To understand the mechanism on the occurrence of such a deep earthquake from the surrounding structural heterogeneity, we reanalyzed controlled source seismic data from the 1998-2000 Hokkaido Transect Project by applying advanced processing techniques including CRS/MDRS stacking methods and integrated refraction/wide-angle reflection analyses.

The seismic reflection processing imaged for the first time the NE Japan Arc underthrust eastward beneath the thick sedimentary package. The refraction/wide-angle reflection data were re-interpreted by tomography and ray-tracing methods. The latter analysis with aid of the new structural information from the reflection processing indicate that the crust is very thin (15-23 km) and the Moho depth is 22-30 km. The Pn velocity is a normal value of around 8 km/s. These structural features are well consistent with those in the offshore area of NE Japan, which belongs to the same geological unit. Based on the structural information mentioned above, the aftershock distribution was carefully investigated. Aftershocks relocated by the 3D structure model (Matsubara, 2017) with appropriate station corrections are distributed in a depth range of 7-45 km showing a steep geometry facing to the east. We cannot find any evidence that the aftershock distribution is related with shallow west-verging active faults developed in the fold-and-thrust belt. We think that the high-angle fault of this earthquake was formed by a certain tectonic event before the collision, maybe in Late Oligocene to Middle Miocene. The relocated aftershocks are separated into the upper (7-20 km) and lower (22-45 km) groups. The seismicity gap between them corresponds to the lower crust of our velocity model, probably representing its ductile property. According to our results, more than 80 % of relocated events occurred within the uppermost mantle of our structure model. Possible explanation for this high seismic activity is the cold crust delaminated from the Kuril Arc side, whose existence was is confirmed by a series of seismic reflection profiling in the southern part of the HCZ (Arita et al., 1998; Tsumura et al., 1999; Ito, 2000, 2002) and seismic tomography by Matsubara et al. (2017). This delaminated crustal body prevents the thermal circulation and upward migration of dehydrated fluid to cool the forearc mantle and generate more favorable environment for the brittle failure.

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Keywords: Hokkaido Island, Hokkaido Eastern Iburi Earthquake, Crust and upper mantle structure, Controlled-source seismic expeditions, Seismic tomography, Fold-and-thrust belt

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Electrical resistivity distribution around the middle axis of Hokkaido Island: constraint for tectonics of ultra-mafic rocks

*Hiroshi Ichihara[1], Toru Mogi[1], Yusuke Yamaya[2]

1. Earthquake and Volcano Research Center, Nagoya University, 2. AIST

Middle axis of Hokkaido Island is located on a tectonic boundaries between NE Japan arc and Kurile arc. In the south part of the boundary, collision due to migration of fore-arc aliver is known (Hidaka Collision zone). Huge serpentine rock bodies are exposed in the high P/T metamorphic belt (kamui-kotan belt) located on the NE Japan arc side near the boundary. In addition, a fresh peridotite rock body (Horoman periodotite) is also distributed in the south part around the boundary. However, tectonic process to bring the surface has not been understood although it is the key to understand the tectonics. In this study, we discuss the crustal structure beneath the arc-arc boundary especially for ultra-mafic rock area based on electrical resistivity distribution obtained in following three areas: (1) middle part of Hidaka collision zone where serpentine is exposed, (2) north part of Kamui-kotan belt where serpentine is exposed but the collision is not occurred, and (3) south part of Hidaka collision zone where the Horoman peridotite is distributed. In the area (1) and (2), very low resistivity (1-10 ohm-m) anomalies area found in the depth around 10-40 km beneath the surface serpentine body but they are not significant beneath out of the serpentine area. We interpreted them as high fraction of aqueous fluid area related to serpentine forming and bring them to the surface. In the area (3), we found thin sheet-like high resistivity body near the surface embedded to low resistivity body (Ichihara et al., G3). The surface high resistivity correspond to the peridotite because unaltered igneous rocks are basically resistive. The underlying conductive area possibly reflect cretaceous sedimentary rock based on integrated interpretation of geomagnetic anomaly, gravity anomaly and the resistivity distribution. If these interpretations in the area (3) are true, the Horoman peridotite covers over the sedimentary rock, implying the unknown tectonics processes occurred on the south part of Hidaka collision zone.

Keywords: Hidaka collision zone, serpentine, peridotite, magnetotelluric, kamui-kotan belt, 2018 eastern Iburi earthquake

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Wed. May 29, 2019 10:45 AM - 12:15 PM JST | Wed. May 29, 2019 1:45 AM - 3:15 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-CG57] Structure and evolution of Japanese islands - Formation of island arc systems and earthquake cycles

convener:Hiroshi Sato(Earthquake Prediction Research Center, Earthquake Research Institute, The University of Tokyo), Masanao Shinohara(Earthquake Research Institute, University of Tokyo), Masahiro Ishikawa(Graduate School of Environment and Information Sciences Yokohama National University), Makoto MATSUBARA(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Hiroshi Sato(Earthquake Research Institute, Tokyo University), Masahiro Ishikawa(Yokohama National University)

Subduction processes such as accretion, back-arc-spreading, and arc-arc collisions have shaped the Japanese island arc. Recent advances in seismic imaging, both passive and controlled source, have produced new images of the crust-mantle structure under Japan and surrounding regions. Through the influence of pre-existing faults and rheological structures, these crust and mantle structures are exerting strong control on active tectonic processes like seismic activity and crustal deformation in the overriding plate. We seek contributions that document and/or model the deformation of the Japanese islands over a variety of time scales from the earthquake cycle to the tectonic evolution of the Japanese island arc, and from a range of research fields including seismology, geology, geochemistry, tectonic geomorphology, and geodynamics. Multidisciplinary studies are encouraged. We also welcome contributions in numerical or analogue geodynamical modeling that explore deformation processes.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SCG57-07] Three-dimensional seismic velocity structure beneath and around Japanese Islands including beneath the Pacific Ocean using NIED S-net data

*Makoto MATSUBARA[1], Hiroshi Sato[2], Kenji Uehira[1], Masashi Mochizuki[4], Toshihiko Kanazawa[5], Narumi Takahashi[1], Kensuke Suzuki[3], Shinichiro Kamiya[1] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Earthquake Research Institute, the University of Tokyo, 3.Japan Agency for Marine-Earth Science and Technology, 4.Ministry of Education, Culture, Sports, Science and Technology, Japan , 5.Association for the Development of Earthquake Prediction)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SCG57-08] Spatio-temporal extent of Cretaceous fore-arc basin in Japan

*Yukio Isozaki[1], Ryo Hasegawa[1], Yukiyasu Tsutsumi[1] (1.Department of Earth Science and Astronomy, Multi-disciplinary Sciences - General Systems Studies, Graduate School of Arts and Sciences, The University of Tokyo)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SCG57-09] Geotectonic identities of dismembered ancient fore-arc clastics: U-Pb dating of detrital zircons in Cretaceous-Paleogene shallow marine/fluvial sandstones sporadically found in Kanto, central Japan

*Ryo Hasegawa[1], Yukio Isozaki[1], Yukiyasu Tsutsumi[2] (1.Department of Earth Science and Astronomy, The University of Tokyo, 2.Department of Geology and Paleontology, National Museum of Nature and Science)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SCG57-10] Laboratory Measurements of Vp, Vs and Vp/Vs for polycrystalline labradorite up to 800°C and 1GPa

*Satoko Honda[1], Masahiro Ishikawa[1] (1.Graduate School of Environment and Information Sciences, Yokohama National University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SCG57-11] Shallow to deeper structures of the Median Tectonic Line active fault system in Shikoku illuminated by new hi-resolution seismic reflection profiling, southwest Japan

*Tatsuya Ishiyama[1], Naoko Kato[1], Shin Koshiya[2], Hiroshi Sato[1], Makoto MATSUBARA[3], Tomoko Elizabeth Yano[3], Taro Koike[4], Katsuya Noda[4] (1.Earthquake Research Institute, University of Tokyo, 2.Department of Civil and Environmental Engineering, Faculty of Science and Engineering, Iwate University, 3.National Research Institute for Earth Science and Disaster Resilience, 4.Geosys, Inc.)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SCG57-12] **Cenozoic evolution of the Tsushima Strait and the Fukue Basin, southern Sea of Japan: an interplay of tectonics, palaeo-environment, and volcanism**

*Johan S. Claringbould[1], Hiroshi Sato[1], Tatsuya Ishiyama[1], Anne Van Horne[1,2], Shinji Kawasaki[3], Susume Abe[4] (1.Earthquake Research Institute, The University of Tokyo, 2.Department of Geology and Geophysics, University of Wyoming, 3.JGI, Inc., 4.JAPEX)

Three-dimensional seismic velocity structure beneath and around Japanese Islands including beneath the Pacific Ocean using NIED S-net data

*Makoto MATSUBARA[1], Hiroshi Sato[2], Kenji Uehira[1], Masashi Mochizuki[4], Toshihiko Kanazawa[5], Narumi Takahashi[1], Kensuke Suzuki[3], Shinichiro Kamiya[1]

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1. Introduction
We investigate the 3D seismic velocity structure beneath and around Japanese Islands including beneath the Sea of Japan and Pacific Ocean with seismic tomographic method. National Research Institute for Earth Science and Disaster Resilience (NIED) constructed the High-sensitivity seismograph network (Hi-net) after the 1995 Kobe earthquake, the Seafloor observation network for earthquake and tsunamis along the Japan Trench (S-net) after the 2011 Tohoku-oki earthquake on March 11, and the Dense Oceanfloor Network System for Earthquakes and Tsunamis (DONET) constructed by Japan Agency for Marine-earth Science and Technology (JAMSTEC) was transfered to NIED on April 1, 2016. We used arrival time data detected by these networks operated by NIED as well as other organizations and apply the seismic tomography for these data.

2. Data and method
The target region, 20–48°N and 120–148°E, covers the Japanese Islands. In addition to the arrival time data used by Matsubara et al. (2017), we used P- and S-wave arrival times for 32952 earthquakes recorded at approximately 1500 stations including the NIED S-net and DONET from April 2016 to June 2018. We also added the arrival time data detected at the stations operated by universities near the coast of the Sea of Japan from 2000 to 2004. Totally 6356481 P arrival data and 3534482 S arrival data from 112631 events are available. The inversion reduces the RMS of the P-wave traveltime residual from 0.245 s to 0.189 s and that of the S-wave data from 0.287 s to 0.236 s after 11 iterations.

3. Result and discussion
We clarified the seismic velocity structure beneath the Sea of Japan at depths of 10-20 km from off Hokkaido to Wakasa Bay. Vp beneath the Okushiri and Sado Islands is low at a depth of 10 km however, Vp beneath the Sea of Japan is high at depths of 10-35 km. Vp along the coast of Sea of Japan in western Japan is moderate. The lithospheric velocity structure in this region is strongly affected by the mid-Tertiary break up and formation of the Sea of Japan. Through the reactivation of the younger compression, tsunamigenic source faults has been developed. The information of the lithospheric structure provides the essential information to the structure of faults.
Due to the contribution of S-net, the velocity structure of the overlying plate beneath Pacific Ocean has been improved. One important feature is the probable Mesozoic rift structure trending NS from the coast of Tohoku to the west of Hidaka collision zone. Recent the 2018 Hokkaido Eastern Iburi Earthquake (M6.7) may related to the reactivation of the rift related structure in the upper mantle to the lower crust, where marked by high-Vp.

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Keywords: seismic tomography, NIED S-net, rift

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Spatio-temporal extent of Cretaceous fore-arc basin in Japan

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Recent analyses on detrital zircon ages in sandstones calrified various new aspects on characteristics and secular changes in provenance for the fore-arc domain of Cretaceous Japan. The shallow marine to fluvial Cretaceous strata are disrtibuted in multiple zones running almost parallel to the coeval arc-trench system in SW Japan, which is represented by the paired granitoid (Ryoke) and blueschist (Sanbagawa) belts. For example, the Upper Cretaceous Izumi Group in Shikoku and Kii peninsula has been regarded as a typical fore-arc sedimentary package deposited between the coeval grnaitoid and blueschist belts. Much emphasis was given to its origin in a pull-apart setting along an imaginary large strike-slip movement of the Median Textonic Line. Nonetheless, the lastest zircon analyses documented that its spatio-temporal dimentsion was much greater than previously believed, e.g., more than 1000 km along-arc, and nearly 100 km wide across-arc in sapce, and extended up into the Paleocene in age. The Izumi Group likely represnt a remnant of much large sedimentary basin, and its current restircted occurrence, ca. ca. 300 km along arc and ca. 20 km across-arc, was made by large-scale removal of fore-arc crust, probably relevant to the back-arc rifting to open the Japan Sea. The missing fore-arc crust can be properly reconstructed by checking ancient provenance through zircon dating in Kyushu and southern Tohoku district.

Keywords: fore-arc basin, detrital zircon, U-Pb dating

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Geotectonic identities of dismembered ancient fore-arc clastics: U-Pb dating of detrital zircons in Cretaceous-Paleogene shallow marine/fluvial sandstones sporadically found in Kanto, central Japan

*Ryo Hasegawa[1], Yukio Isozaki[1], Yukiyasu Tsutsumi[2]

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For reconstructing the fore-arc basin of Cretaceous arc-trench system in Japan, provenance analysis for sandstones has been carried out by U-Pb dating of detrital zircons, particularly for the “Cretaceous-Paleogene” sandstone-bearing units sporadically occurred in 5 distinct areas in the Kanto Mountains and northern Kanto/southern Tohoku region, i.e. the Shoya Formation in Saku, the Kanohara conglomerate in Shimonita, the Yorii Formation in Yorii (Kanto Mountains), the Nakaminato Group (northern Kanto), and the Futaba Group (southern Tohoku), of which geotectonic identities are ambiguous. The U-Pb dating of detrital zircons from these units constrained the depositional ages of 10 sandstone samples to the Late Cretaceous and early Paleocene, and also their provenance. These results confirmed that 1) the Shoya Fm and the lower-middle Nakaminato Gr are of the Maastrichtian age, which are correlated with the Izumi Group on the Late Cretaceous Ryoke ganitoids in SW Japan, 2) the Kanohara conglomerate, Yorii Fm, and Oarai Fm are of the Danian (early Paleogene) age, which were deposited on the Ryoke belt as well as the Izumi Gr., 3) the Futaba Gr is of the Coniasian age, which is correlated not with the Izumi Gr. but with the coeval units in western Kyushu, i.e., basal Himenoura Group, Kumamoto Gr, and upper Mifune Gr, which were deposited unconformably on a slightly older (Early Cretaceous) granitoids in the same fore-arc domain. These new age data provide new clues in reconstructing paleogegraphy of Cretaceous arc-trench system in Japan, before the Miocene opening of the Japan Sea. The expected discontinutity between pre-Miocene SW and NE Japan crusts in central Japan is currently buried beneath thick Quaternary sediments of the Kanto plain; nonetheless, the present data suggests two candidates, i.e., the seismologically detected major break of the pre-Cenozoic basement along the River Tone and the conventional Tanagura tectonic line to the north.

Keywords: fore-arc basin, detrital zircon, U-Pb age, Cretaceous, Paleocene, Kanto

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Laboratory Measurements of Vp, Vs and Vp/Vs for polycrystalline labradorite up to 800˚C and 1GPa

*Satoko Honda[1], Masahiro Ishikawa[1]

1. Graduate School of Environment and Information Sciences, Yokohama National University

In order to estimate the elastic properties of crustal rock-forming minerals at mid-to-lower crustal P-T conditions, we performed simultaneous measurements of compressional-wave (Vp) and shear-wave (Vs) velocities of the labradorite. In this presentation, we report temperature-pressure dependence of the elastic wave velocity for labradorite, intermediate member of plagioclase feldspars, at crustal P-T condition.

The fine-grained pollycrystalline labradorite was fabricated from the nano-sized powders of crushed natural labradorite crystal ($An_{61}Ab_{37}Or_2$, $An_{65}Ab_{34}Or_1$), and was used for the measurements. After milling and forming mineral powders, sintering was carried out at a temperature of 1180–1210˚C with controlled time. Ultrasonic measurements on these samples were conducted up to 1.0 GPa in a temperature range of 25-800˚C with a piston cylinder high pressure apparatus.

The Vp increase rapidly with pressure increase up to 0.40 GPa at room temperature, while it is moderately increasing between 0.40 and 1.00 GPa. At 1.00GPa up to 800 ˚C, the elastic wave velocities decrease with increasing temperature blow 600 ˚C, δVp/δT and δVs/δT of the labradorite sample (An65Ab34Or1) is -1.6×10^{-4} km/s/˚C, -1.0×10^{-4}km/s/˚C . In contrast, above 600 ˚C , the elastic wave velocities show an increasing trend in the range of 600–800 ˚C . At cooling stage, Vp and Vs show an decreasing trend with decreasing temperature above 400˚C.
Previous studies report that elastic wave velocities of polycrystalline anorthite show an increasing trend in the range of 240–640 ˚C (Matsukage et al 2015) and that a polycrystalline plagioclase ($An_{51\pm1}$) at 1.0 GPa show marked increase in Vp and Vs between 700 and 800 ˚C (Kono et al 2008). They suggest that these discontinuous velocity changes in temperature dependence of Vp and Vs would be associated with phase transformation in plagioclase. However, it is unclear whether our measurements results between 650 and 800˚C is phase transformation, because the phase transformation was not determined on our sample using X-ray diffraction analisys. In addition, the temperature conditions of the discontinuous in Vp and Vs at high temperature is not consistent with the phase boundary previously reported. Phase transformation, therefore, would have been only temporary during the experiment.

Keywords: elastic wave velocity, polycrystalline labradorite, sintering

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Shallow to deeper structures of the Median Tectonic Line active fault system in Shikoku illuminated by new hi-resolution seismic reflection profiling, southwest Japan

*Tatsuya Ishiyama[1], Naoko Kato[1], Shin Koshiya[2], Hiroshi Sato[1], Makoto MATSUBARA[3], Tomoko Elizabeth Yano[3], Taro Koike[4], Katsuya Noda[4]

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Median Tectonic Line (MTL) active fault system is one of the most pronounced, trench-parallel active dextral slip faults in SWJapan, extending for approx. 300 km (Okada, 1992). With ubiquitous proximity to the north dipping terrane boundary MTL between Samgawa metamorphic rocks (Sm) and Ryoke granitic rocks to the north, their structural links with active strands of the MTL have been widely discussed. Seismic experiments in Kinki (Wakayama) clearly illuminate that near-surface steeply dipping fault plane appears merge into underlying more shallowly dipping reflectors correlated with top Sm (Sato et al., 2015). In Shikoku, however, previous seismic sections have not fully resolved such structural linkages of the major fault strands of the MTL, whereas pioneering deep seismic experiments successfully imaged northerly dipping MTL (Ito et al., 1995). To define structural characters of the shallow to deeper subsurface geometry, we collected new seismic reflection profiles across MTL active fault system in Shikoku island. Our new, processed seismic profile across the Okamura Fault, Komatsu Fault (Goto and Nakata, 1998), and the MTL and its preliminary interpretation suggest northerly dipping Sambagawa metamorphic rocks beneath the northern flank of the Ishizuchi Mountains and Niihama plain to the north. As is the case with previous seismic results, downward extensions of the MTL apparently dips northward, in contrast to near-surface steep fault planes identified in outcrop and trench exposures. In addition, northerly dipping clouds of microseismicity also suggest its deeper extension. Similarly, in our new seismic profile in Wakimachi, Tokushima, Chichio fault (Okada and Tsutsumi, 1997), active dextral slip fault that dips vertically at ground surface, is apparently underlain by very strong and continuous north dipping reflectors from the top of Sm. This observation also suggests that the Chichio fault may merge into, rather than cut across these Sm reflectors. We will mainly discuss on (1) detailed structural characters identified in the new seismic data, (2) their structural linkages with near-surface structures of the active strands, and (3) implications for overall shallow to deeper geometry of the MTL based on both new and previous seismic data, regional seismicity based on JUICE catalogue (Yano et al., 2017), and crustal structures estimated from seismic tomography (Matsubara et al., 2017).

Keywords: Active fault , Median Tectonic Line active fault system, Seismic reflection profile, Seismicity, Shikoku

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Cenozoic evolution of the Tsushima Strait and the Fukue Basin, southern Sea of Japan: an interplay of tectonics, palaeo-environment, and volcanism

*Johan S. Claringbould[1], Hiroshi Sato[1], Tatsuya Ishiyama[1], Anne Van Horne[1,2], Shinji Kawasaki[3], Susume Abe[4]

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The Japanese island arc is tectonically active with earthquake and tsunami hazard along both the Pacific and Sea of Japan coasts. Following the tsunami disaster from the 2001 Off-Tohoku (M9) earthquake, the Japanese government initiated an extensive evaluation of tsunami hazard around Japan. Since records of prior tsunamis along the southern Japan Sea margin are rare, we here investigate the geologic evolution of the SW Japan back-arc basin to identify and analyse potential tsunami source-faults.

Located between SW Japan and the Korean Peninsula, and connecting the Japan Sea and East China Sea, the Tsushima Strait and the Fukue Basin represent a structurally complex region that formed over the last ~25 Ma as a result of several tectonic phases: (i) back-arc rifting and rotation, (ii) post-rift compression, (iii) weak thrusting, and (iv) subsidence and strike-slip deformation. Syn-depositional volcanism and changes in regional palaeo-environment are known from previous studies surrounding this connecting region, but how these factors fit together in the regional tectonic framework is not well understood. In addition to analysing recent seismic reflection data and detailed gravity data, we here re-evaluate extensive seismic reflection profiles and well data of ten boreholes offshore the SW Japan arc. We observe large basement blocks and igneous bodies, and inverted and cross-cut half grabens filled with syn-kinematic deposits. Clear stratal terminations suggest multiple transitions in regional stress regime. The gravity data allow us to link the syn-depositional igneous bodies to previously-dated volcanism onshore. Additionally, planktonic and calcareous nanno-fossils from the well data provide control on absolute timing of different kinematic stages, while benthic foraminifers and pollen show changes in palaeo-water depth, coeval with local, relative palaeo-climate reversals, respectively.

From ~25 Ma pollen data show warming of the local climate in southern Japan Sea side of the Tsushima Strait, while on the East China Sea side in the Fukue Basin relative cooling is observed. This is related to initial rifting, opening up back-arc basin allowing relative warm water to flow through the Tsushima Strait into the Japan Sea warming the local climate, and relative cold water flowing back cooling the local environment in the Fukue Basin on the opposite side of the Tsushima Strait. Subsequently, negative flower structures and large half-grabens filled with over 5400 m of synrift sediments developed between ~18-16 Ma, containing benthic foraminifera suggesting a deepening marine environment. This is linked to the rapid, clock-wise rotation of SW Japan, which pivot point migrates along a dextral oblique normal fault west of Tsushima. At ~15 Ma rift structures are abruptly inverted or cross-cut by thrust faults and wedge thrusts, with microfossils and pollen on the Japan Sea side suggesting shallowing of the palaeo-waterdepth and cooling of the local climate, respectively. Contrary, in the Fukue Basin, the local climate shows relative warming. We suggest that during this compressional tectonic event a topographic sill developed in the Tsushima Strait that cut off water flow between the cooler Japan Sea and the subtropic East China Sea. From ~6 Ma, the local climate on the Japan Sea side warms again contemporarily with deepening of the marine palaeo-environment and deposition of sub-horizontal

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Pliocene sediments, implying a weakening of the compressional stress and renewed water flow through the Tsushima Strait. These observations along with previously published data of the surrounding areas enable us to better understand the connection between the Cenozoic structural development of the SW Japan arc, and the related the palaeo-environment changes and volcanism. As a result, we are better able to identify potential tsunami-source faults along the southern Japan Sea margin based on our understanding of the structural evolution.

Keywords: Structural evolution, Tsushima Strait, Fukue Basin, Palaeo-environment, Back-arc rift basin, Inversion

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[J] Oral | B (Biogeosciences)：B-CG Complex & General

Wed. May 29, 2019 9:00 AM - 10:30 AM JST | Wed. May 29, 2019 12:00 AM - 1:30 AM UTC | 201A 2F

[B-CG07] Decoding the history of Earth: From Hadean to the present

convener:Tsuyoshi Komiya(Department of Earth Science & Astronomy Graduate School of Arts and Sciences The University of Tokyo), Yasuhiro Kato(Department of Systems Innovation, Graduate School of Engineering, University of Tokyo), Katsuhiko Suzuki(Research and Development Center for Submarine Resources, Japan Agency for Marine-Earth Science and Technology), Chairperson:Tomohiko Sato(Earth-Life Science Institute, Tokyo Institute of Technology)

The latest results of Earth's evolution and geological processes through 4.6 billion year
s from Hadean to Modern, based on various approaches including fieldworks, chemical
analyses, experiments and computer simulation, will be presented. In this session, we ai
m to discuss and understand causal relationships and interplay among the evolution of
Earth's deep interior, changes in the surface environments, and development and evolut
ion of life. Wide-ranging topics are accepted.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[BCG07-01] Iron-oxidizing bacteria and stromatolites in the Ediacaran hydrothermal carbonate

*Akihiro Kano[1], Aya Miyazaki[1], Jumpei Yoshioka[1], Ibtissam Chraiki[2], Abdelhafed Barzouk[2], Nasrrddine Youbi[2,3], Hassan Admou[2], Moulay Ahmed Boumehdi[2,3], Lhou Maacha[4], Hsaine Baoutoul[4], Ismail Bouskri[4] (1.Graduate School of Science, The University of Tokyo, 2.Department of Geology, Faculty of Sciences-Semlalia, Cadi Ayyad University, 3.Instituto Dom Luiz, Faculdade de Ciências, Universidade de Lisboa, 4.Managem-ONA Group)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[BCG07-02] Carbonate carbon isotope stratigraphy of the Paleoproterozoic Francevillian Group in Gabon

★Invited Papers

*Tomohiko Sato[1], Yusuke Sawaki[2], Hisashi Asanuma[2], Hisahiro Ueda[1], Shigenori Maruyama[1] (1.Tokyo Institute of Technology, 2.The University of Tokyo)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[BCG07-03] The redox condition of late Paleoproterozoic shallow marine environment: The Cape Smith Belt, Canada

*Kento Motomura[1], Shoichi Kiyokawa[1], Minoru Ikehara[2], Takashi Sano[4], Kentaro Tanaka[3], Tsubasa Miki[3], Yuji Sano[3] (1.Kyushu University, 2.Kochi University, 3.University of Tokyo, 4.National Museum of Nature and Science)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[BCG07-04] Paleovegetation changes reconstructed by terrestrial plant biomarker analyses in the sediments deposited across the Cenomanian/Turonian boundary in the Tomamae area, Hokkaido, Japan

*Masashi A. Ikeda[1], Ken Sawada[2], Takuto Ando[3], Hideto Nakamura[4], Reishi Takashima[5], Hiroshi Nishi[5] (1.Graduate School of Science, Hokkaido University, 2.Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University, 3.Arctic Research Center, Hokkaido University, 4.Faculty of Science, Osaka City University, 5.The Center for Academic Resources and Archives, The Tohoku University Museum, Tohoku University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[BCG07-05] A general overview of the research progress on REY-rich mud

*Yasuhiro Kato[1,2], Kentaro Nakamura[1], Koichiro Fujinaga[2,1], Kazutaka Yasukawa[1,2], Yutaro Takaya[3,1,2], Junichiro Ohta[2,1], Erika Tanaka[1], Kazuhide Mimura[1], Koichi Iijima[4,1], Shiki Machida[2,1], Tatsuo

Nozaki[4,1,2,5], Jun-Ichi Kimura[4], Hikaru Iwamori[1,4,6] (1.The University of Tokyo, 2.ORCeNG, Chiba Institute of Technology, 3.Waseda University, 4.JAMSTEC, 5.Kobe University, 6.Tokyo Institute of Technology)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[BCG07-06] A cold and alkaline Hadean ocean caused by impact ejecta weathering

*Shintaro Kadoya[1], David C Catling[1] (1.University of Washington)

Iron-oxidizing bacteria and stromatolites in the Ediacaran hydrothermal carbonate

*Akihiro Kano[1], Aya Miyazaki[1], Jumpei Yoshioka[1], Ibtissam Chraiki[2], Abdelhafed Barzouk[2], Nasrrddine Youbi[2,3], Hassan Admou[2], Moulay Ahmed Boumehdi[2,3], Lhou Maacha[4], Hsaine Baoutoul[4], Ismail Bouskri[4]

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Association of drastic climate change and biological evolution during Neoproterozoic is one of the most enigmatic features of the Earth history. The If the Earth’ s surface has been hardly covered with thick ice-cover during the 58-myr-long Sturtian glaciation, the evolution of organisms was mostly reset. However, there is glowing evidence of protozoan fossils immediately after the Sturtian and Marinoan glaciations. This requires the argument that liquid environments as refugia for protozoans must have occurred in tropical zones or around volcanos.
Moroccan Anti-Atlas exposes several Proterozoic inliers surrounded with Ediacaran, Paleeozoic and Mesozoic strata. Accumulated age data of zircon U-Pb indicate that active tectonics had been sustained here during Cryogenian and Ediacaran. Paleogeographic interpretation based on paleomagnetism reconstructed a high latitude of Anti-Atlas. Neoproterozoic sedimentary sequence here is dominated by volcanics and siliciclastics, and carbonate is developed as lentic bodies on granodiorite rock.
This study focuses on two carbonate bodies near Bleida and Ouarzazate in Anti-Atlas. The Blida section exposes a 25-m-thick sequence of bedded and fine-grained dolostone of red color. This overlies 586Ma volcanic rock, and apparently underlies possible diamictite with a fault contact. Dolostone of the lower part of the section contains relics of iron-oxidizing bacteria. Carbon isotope of the dolostone is low as -6‰, but the stratigraphic position negates the correlation to the Shuram negative excursion of late Ediacaran. The low d13C value likely inherited endogenic carbon, and this interpretation is supported by low d18O indicating high water temperature (around 40-50ºC). While, the 30-m-thick carbonate sequence near Ouarzazate consists of red-colored limestone alternated with volcanoclastic sandstone and siltstone. It rests on 580Ma volcanics. The carbonate sequence exhibit stromatolites at least four stratigraphic levels. The higher d13C value (around -1.5‰) was likely reflected from CO2 degassing or gas exchange with the atmosphere. These stromatolites show regular lamination of ~1 mm interval and appears color changes reflected from a redox gradient within a biofilm.
These carbonate sequences in Anti-Atlas are not directly associated with the Snowball glaciations. However, active volcanism that had sustained latest Neoproterozoic might had provided liquid water environments, as biologic refugia during the Marinoan Snowball Earth.
N.B.Funding was provided by the Academy Hassan II of Science and Technology of Morocco AcadHIIST/SDU/2016-02 (grant to Abderrazzak El Albani and Nasrrddine Youbi and others)and Managem-ONA Group.

Keywords: Neoproterozoic, carbonate rock, Microbe, stromatolite

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Carbonate carbon isotope stratigraphy of the Paleoproterozoic Francevillian Group in Gabon

*Tomohiko Sato[1], Yusuke Sawaki[2], Hisashi Asanuma[2], Hisahiro Ueda[1], Shigenori Maruyama[1]

1. Tokyo Institute of Technology, 2. The University of Tokyo

The large fluctuations of δ13C_carb in the Paleoproterozoic are important in terms of the speculation on the atmospheric oxygen level and the global stratigraphic correlations. The interval characterized by the generally high values of δ13C_carb up to +10 ‰is called Lomagundi-Jatuli Event (LJE; ca. 2.2-2.0 Ga) and interpreted as reflecting high rates of oxygen production (e.g. Karhu & Holland, 1996; Martin et al., 2011). The drop of δ13C_carb and δ13C_org at the end of LJE are reported from Shunga in Fennoscandia, and the negative shift of δ13C_org is correlated with that of Franceville in Gabon (Kump et al., 2011); however, the δ13C_carb data in Gabon is still missing because of the scarcity of the carbonate rocks. The Paleoproterozoic Francevillian Group in Gabon consists of FA (fluvial sandstones), FB (black shales/carbonates), FC (cherts), FD (black shales), and FE (sandstones) in ascending order. The lithostratigraphic correlation between the Franceville, Lastoursville, and Okondja basins suggests that the FA-FB-FC units are in different depositional settings and the FD-FE units are in common facies, which indicates the final opening of the intracratonic basins. In order to explore the global correlation of δ13C_carb, the analyses in the FD-FE units are required. In this study, we conducted two drillings in the Lastoursville and Okondja basins to obtain the fresh core-samples of FD. The lithological observations clarified that numbers of carbonate layers are intercalated in black shales in the FD unit in the both areas. We analyzed δ13C_carb of these carbonate layers, and filled in the stratigraphic blanks in the FD unit. In this presentation, we will discuss the propriety of the δ13C_carb stratigraphic correlations.

Keywords: Paleoproterozoic, carbon isotope, Gabon

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The redox condition of late Paleoproterozoic shallow marine environment: The Cape Smith Belt, Canada

*Kento Motomura[1], Shoichi Kiyokawa[1], Minoru Ikehara[2], Takashi Sano[4], Kentaro Tanaka[3], Tsubasa Miki[3], Yuji Sano[3]

1. Kyushu University, 2. Kochi University, 3. University of Tokyo, 4. National Museum of Nature and Science

The oceanic redox condition strongly affects the chemical compositions of seawater, especially, redox-sensitive elements such as Fe and Mo. Although it is suggested that bio availability of these bio-essential elements have restricted the biological development through Precambrian ocean, the redox conditions and the trigger of its transition at late Paleoproterozoic era are poorly constrained.

In this study, we reconstructed 50 m lithostratigraphy and chemostratigraphy including major and trace element compositions and C-N-S isotopes ($\delta^{13}C_{org}$, $\delta^{15}N$, $\delta^{34}S$) in order to clarify the sedimentary environment and the trigger of its change.

A part of the drilled hole from the Northern Povungnituk Group, Cape Smith belt of Canada is used for geochemical analyses. The sequence consists of the alteration of sandstone and black shale deposited at northern margin of the Superior province at ~1.9 Ga. Two lithological units, lower and upper units, are identified based on sedimentary sequence. The lower unit is characterized by the transition from coarse sandstone dominant to black shale dominant sequence, while, the upper is fine sandstone dominant sequence.

Vanadium concentrations normalized by total organic carbon (TOC) shows clear evidence for the transition of the redox condition. Although V/TOC at the bottom of the sequence (<~50 ppm/%) is lower than that of black shale from the Bravo Lake Formation of Buffin island in which a previous work cleared the black shale deposited under euxinic condition (H_2S-rich), the value increased and reaches the mean of the black shale (~105ppm/%) from the Formation at lower coarse sandstone dominant portion. These increase of V/TOC suggests ocean redox conditions changed from anoxic (weak-reducing) to euxinic (strongly-reducing). This inference is consistent with redox-sensitive element behavior confirmed from the correlation between the V concentration and TOC.

$\delta^{15}N$ of the sequences (~+7 –+9 ‰) are comparable with that of the modern ocean and that indicates nitrification, denitrification and NH_3assimilation keep $\delta^{15}N$ of dissolved N species high. $\delta^{13}C_{org}$and $\delta^{34}S$ change at the same interval ($\delta^{13}C_{org}$: -30.6 –-33.2 ‰, $\delta^{34}S$: +11.9 –-4.1 ‰) and that suggests some trigger which affects $\delta^{13}C_{org}$and $\delta^{34}S$ caused development of strongly-reducing condition. $\delta^{13}C_{org}$and $\delta^{34}S$ transition are likely to represent input of isotopically light $HCO_3^-$and SO_4^{2-}. The activity of large igneous provinces and oxidative weathering of black shale which relates regression suggested by the change of lithofacies are plausible for these isotope change.

Keywords: Late Paleoproterozoic, Redox condition

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Paleovegetation changes reconstructed by terrestrial plant biomarker analyses in the sediments deposited across the Cenomanian/Turonian boundary in the Tomamae area, Hokkaido, Japan

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The Cretaceous is known as the extreme greenhouse period attributed to the elevated atmospheric CO_2 concentration triggered by the superplume activity. In particular, the Oceanic Anoxic Events (OAEs) caused by the occurrences of the Large Igneous Plateaus (LIPs) in several times during the mid-Cretaceous. Global environmental disturbance events have been extensively investigated in the ocean, but there have been few reports for terrestrial environmental variation during the OAE periods (e.g. Kuypers et al., 2002). In the present study, we analyzed biomarkers of terrestrial plants including lichen and fungi in the sediments deposited across the Cenomanian/Turonian boundary (CTB) from the northern Hokkaido, Japan to reconstruct paleovegetation changes and to evaluate paleoecology of individual plants during environmental disturbance event.

We analyzed sedimentary rocks across the CTB in the Saku Formation,Yezo Group, were collected from the Omagari-zawa sections of the Tomamae area, northern Hokkaido, Japan. The sediments used correspond to the OAE2 intervals (1st build-up, Trough, 2nd build-up and Plateau phases), determined by $\delta^{13}C$ stratigraphy (Omatsu et al., 2014). For the biomarker analysis, the extractions of freeze-dried sediments were fractionated using silica-gel column and analyzed by GC-MS.

By sterane and hopane ratios, we confirmed the high contribution of terrigenous matter input and low maturity of organic matter (vitrinite reflectance ca. 0.4% level; lignite to subbituminous coal rank) in the Omagari-zawa section. These results agree with those reported by Ando et al. (2017). Higher Plant Parameter (HPP) as the vegetation index of higher plants increased in the 1st build-up and 2nd build-up stages, and declined in the Trough and Plateau stages. We interpret that the coniferous vegetation has expanded under arid condition. Moreover, we analyzed the proportion of 1-methyl dibenzofuran in total methyl dibenzofurans as a lichen indicator (1- MDBF ratio), and perylene/ pyrene ratio as a fungal assemblage index. Variations in lichen and fungi vegetation tend to decrease from the 1st build-up to the 2nd build-up stage, which are resemble to those of coniferous vegetation. Thus, it is considered that the vegetation overall declined against the mid-Cretaceous environmental disturbance, especially affected by arid/humid fluctuation.

Keywords: Paleovegetation, lichen, biomarker, Yezo Group, C/T boundary, Cretaceous

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A general overview of the research progress on REY-rich mud

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Deep-sea mud enriched in rare-earth elements and yttrium (REY), termed as REY-rich mud, has been expected as a novel mineral resource for the industrially critical elements [1]. Targeting the Japanese exclusive economic zone around Minamitorishima Island, where highly promising REY-rich mud (total REY content > 5,000 ppm) lies at very shallow depth (2 to 4 m) below the seafloor [2], we have conducted a variety of researches on the mud from both scientific and engineering perspectives.

In the presentation, we report a general overview of the research progress on REY-rich mud, and discuss the importance of the mud from viewpoints of the Japan’s resource security and a new strategy for economic growth.

[1] Kato, Y. et al. (2011) Nature Geoscience 4, 535-539, [2] Iijima, K. et al. (2016) Geochemical Journal 50, 557-573.

Keywords: seafloor mineral resources, rare-earth elements, REY-rich mud, Minamitorishima Island, Pacific Ocean, deep-sea sediment

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A cold and alkaline Hadean ocean caused by impact ejecta weathering

*Shintaro Kadoya[1], David C Catling[1]

1. University of Washington

Life probably arose in the Hadean (either on land or in the sea) and then would have spread through the early ocean. Hence, determining constraints on the early marine environment is essential for understanding conditions for the spread of early life, in addition to the history of the Earth itself. In this study, we modelled the evolution of the surface environment of the Earth, including the surface temperature, pCO_2, and oceanic pH.

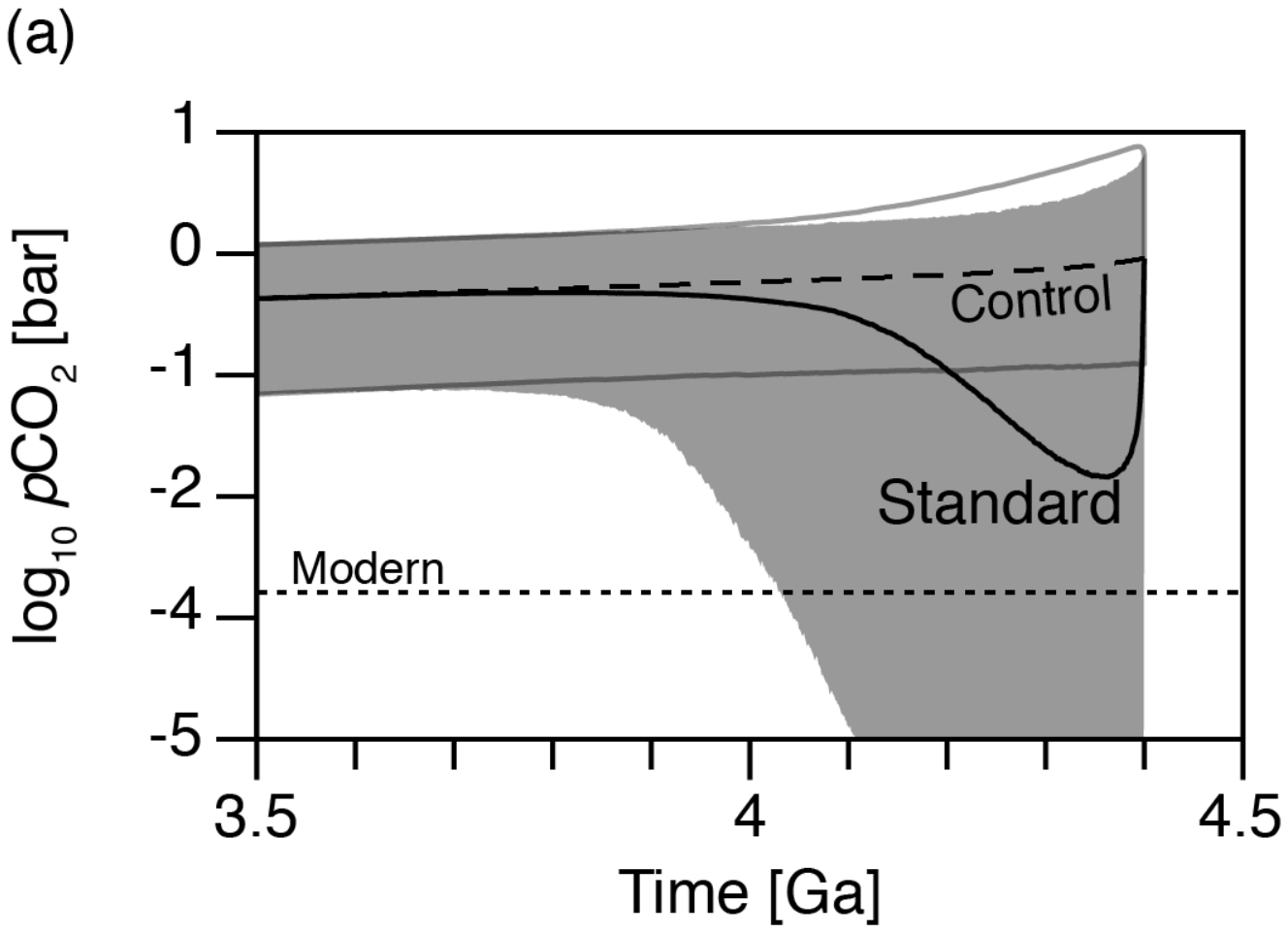
As revealed by previous works (e.g., Krissansen-Totton et al., 2018, PNAS), Earth's long-term surface environment is controlled by the carbonate-silicate geochemical cycle. This negative feedback has moderated the surface temperature, resulting in the continuous existence of surface liquid water, even when the solar luminosity was smaller in the past than today. To compensate for the faint Sun, the feedback sets a high pCO_2 in the past, which would result in a more acidic ocean. The same mechanism can be applied for modelling the Hadean eon. However, we have to add another factor: impact ejecta weathering. As indicated by impact craters on the Moon, the Earth would also undergo intense meteorite impacts during the Hadean. Since the impact ejecta are easily weathered, they provided an additional sink of CO_2. Hence, previous works (e.g., Sleep & Zahnle et al., 2001, JGR) suggested that the surface temperature and pCO_2 would actually be low, i.e., a cold Hadean Earth –an idea that has been controversial.

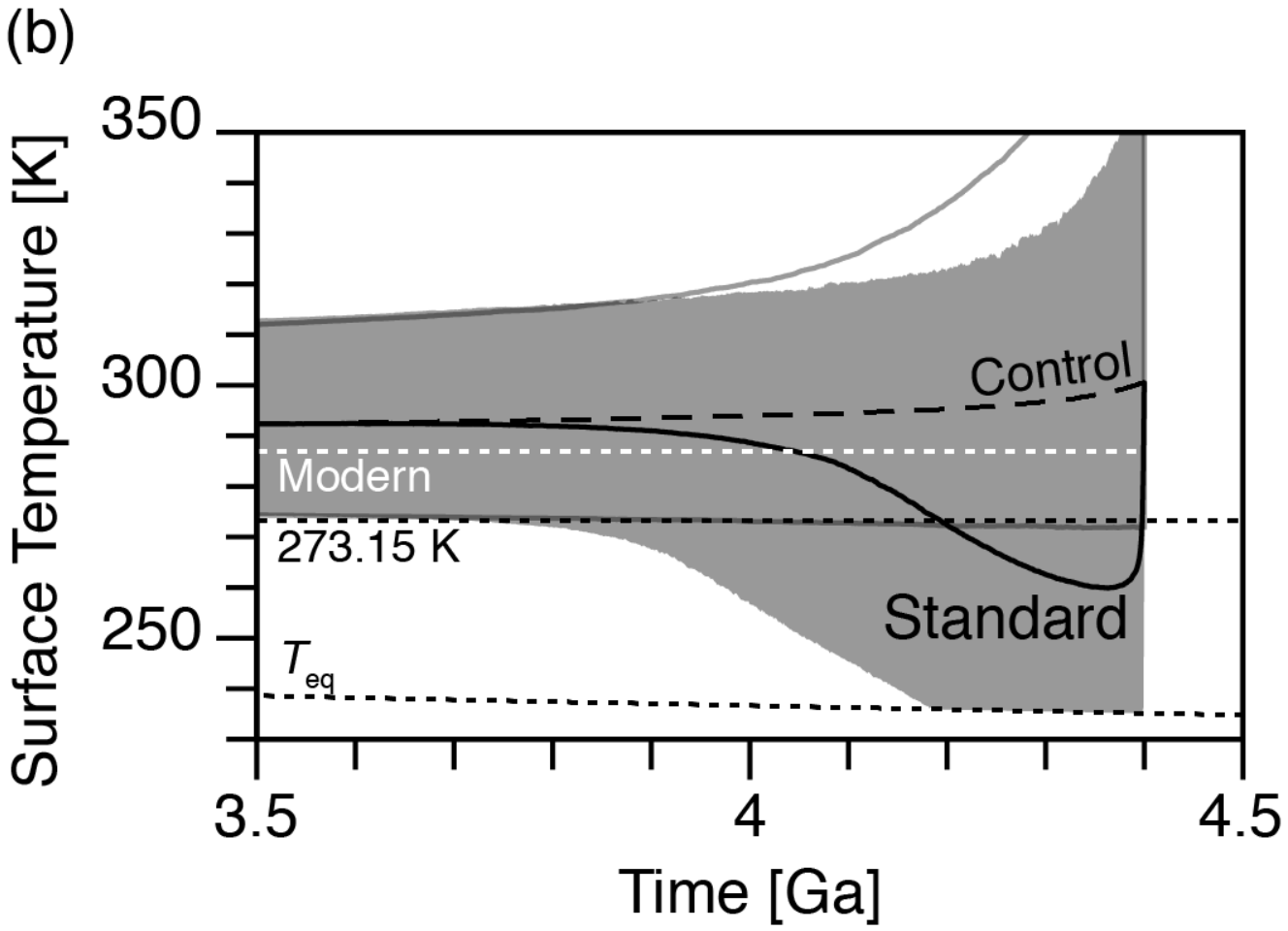
In this study, we calculated the evolution of the surface environment by varying parameters in a geologic carbon cycle model within their ranges of uncertainty. Since the ejecta weathering is a source of carbonate alkalinity (i.e., a sink of CO_2), the pCO_2 and surface temperature of cases with ejecta weathering (hereafter, standard cases) are lower than those of cases without ejecta weathering (hereafter, control cases), as shown in Figure 1a and 1b. The surface temperatures of some standard cases are even lower than 273.15 K (Figure 1a). The coldness does not always mean that the Earth was in a snowball state during the early Hadean; instead, it just indicates a high likelihood of a cold climate. The low pCO_2 of standard cases also results in high ocean pH (Figure 1c). In addition, because the high pH results in a high precipitation rate of carbonate, the carbonate alkalinity of standard cases tends to be lower than that of control cases.

For the standard case, such a relatively cold surface and alkaline ocean are confined to the early Hadean, in which the impact flux (i.e., ejecta production rate) is high. However, the impact craters on the Moon also indicate the possibility of an enhanced impact flux around 4 Ga (i.e., the late heavy bombardment; LHB). The estimated impact flux for the LHB is also high enough to result in a cold surface and alkaline ocean. Hence, we should consider the possibility that life existed in a cold and alkaline early ocean.
Fig. 1. Results with control (without ejecta weathering) and standard cases (with ejecta weathering) for the geologic carbon cycle model for (a) atmospheric partial pressure of CO_2, pCO_2, (b) global mean surface temperature, and (c) ocean pH.

Keywords: Hadean, Climate evolution, Carbonate-silicate geochemical cycle

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[J] Oral | B (Biogeosciences)：B-CG Complex & General

Wed. May 29, 2019 10:45 AM - 12:15 PM JST | Wed. May 29, 2019 1:45 AM - 3:15 AM UTC | 201A 2F

[B-CG07] Decoding the history of Earth: From Hadean to the present

convener:Tsuyoshi Komiya(Department of Earth Science & Astronomy Graduate School of Arts and Sciences The University of Tokyo), Yasuhiro Kato(Department of Systems Innovation, Graduate School of Engineering, University of Tokyo), Katsuhiko Suzuki(Research and Development Center for Submarine Resources, Japan Agency for Marine-Earth Science and Technology), Chairperson:Satoshi Yoshida(Department of Earth Science & Astronomy, Graduate School of Arts and Sciences, The University of Tokyo)

The latest results of Earth's evolution and geological processes through 4.6 billion year
s from Hadean to Modern, based on various approaches including fieldworks, chemical
analyses, experiments and computer simulation, will be presented. In this session, we ai
m to discuss and understand causal relationships and interplay among the evolution of
Earth's deep interior, changes in the surface environments, and development and evolut
ion of life. Wide-ranging topics are accepted.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[BCG07-07] **Impact-induced magmatism on early Earth**

*Hiroshi Ohmoto[1], Uschi M. Graham[2], Yuya Tsukamoto[3], Yumiko Watanabe[3], Takeshi Kakegawa[3], Hiroshi Hamasaki[4], Andrew Chorney[5], Katherine Crispin[1], Zi-Kui Liu[1] (1.The Pennsylvania State University, 2.Univ. of Kentucky, 3.Tohoku Univ., 4.Tokyo Gas, 5.Temple Univ.)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[BCG07-08] An evaluation of impact dating for shocked zircons with planar features (PFs) in the Vredefort dome by LA-ICP-MS multi-spot analysis

*Shinji Yamamoto[1], Taiga Kato[1] (1.Graduate School of Environment and Information Sciences, Yohohama National University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[BCG07-09] **Application of acid-washing to trace element and tungsten isotope analyses of Eoarchean rocks from the Isua Supracrustal Belt**

★Invited Papers

*Hatsuki Enomoto[1], Tsuyoshi Iizuka[1], Yoshitaka Homma[1] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[BCG07-10] Limited primary production in the early Archean oceans and its biogeochemical consequenses

★Invited Papers

*Kazumi Ozaki[1] (1.Toho University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[BCG07-11] Behaviors of carbon cycle system and inevitability of the hot climate in the Archean Earth

★Invited Papers

*Yasuto Watanabe[1], Eiichi Tajika[1], Kazumi Ozaki[2], Peng Hong[3] (1.The University of Tokyo, 2.Toho University, 3.Chiba Institute of Technology)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[BCG07-12] Occurrence and chemical composition of metamorphic carbonate rocks in the Isua supracrustal belt, West Greenland: Implications for the origin of carbonate rocks and compositions of the Eoarchean seawater.

*Yoshida Satoshi[1], Kazutaka Yasukawa[2], Yasuhiro Kato[2], Yusuke Sawaki[3], Tsuyoshi Komiya[3]
(1.Department of Earth & Planetary Science, Graduate School of Science, The University of Tokyo, 2.Department of Systems Innovation, Graduate School of Engineering, University of Tokyo, 3.Department of Earth Science & Astronomy Graduate School of Arts and Sciences, The University of Tokyo)

Impact-induced magmatism on early Earth

*Hiroshi Ohmoto[1], Uschi M. Graham[2], Yuya Tsukamoto[3], Yumiko Watanabe[3], Takeshi Kakegawa[3], Hiroshi Hamasaki[4], Andrew Chorney[5], Katherine Crispin[1], Zi-Kui Liu[1]

1. The Pennsylvania State University, 2. Univ. of Kentucky, 3. Tohoku Univ., 4. Tokyo Gas, 5. Temple Univ.

At the JpGU Meeting 2017, we reported the discovery of numerous fragments (<~3 mm in size) of stony meteorites and impact spherules of basalt in the lowest (i.e., the earliest) ~70 m section of the submarine Apex Basalt that overlies the ~110 m-thick Marble Bar Chert Member (MBCM; ca. 3.46 Ga in age) in the ABDP #1 drill core, which was recovered in 2003 at Marble Bar, Pilbara, Western Australia. We suggested that the asteroid body that produced the meteorite fragments was >10 km in diameter, impacted at ~40 km E of Marble Bar, terminated the deposition of the MBCM, and created a crater (“The Apex Impact Crater”) more than ~100 km in diameter. To test this hypothesis, in the summer of 2018 we conducted a geological survey of the proposed “Apex Impact Crater” utilizing a drone equipped with a high-resolution (4K) camera.

Our survey has revealed the presence of “impact tsunami deposits” at the boundary of the MBCM and the Apex Basalt. They are ~1-40 m thick, extending at least 20 km along the strike in the Marble Bar area. They contain numerous fragments (<5 mm size) of stony meteorites, together with various-sized (<1 mm to ~10 m), generally angular-shaped, fragments and blocks of the MBCM. We have also discovered ~15-40 m thick “impact tsunami deposits” underlying the Apex Basalt at ~80 km SE of Marble Bar. Numerous fractures (mostly perpendicular to the bedding planes, and many extending to 100s of meter into the underlying Duffer Formation), the dislocations and rotations of the MBCM in ~cm to ~100 m scales, as well as the “impact tsunami deposits”, were most likely created by an asteroid impact. Our survey has provided evidence that the ~3km-thick Apex Basalt represents the crater-filing komatiite/basalt lavas that were generated by the sudden decompression-melting of the mantle peridotites, triggered by a giant impact, and that the Mt. Edgar Batholiths (~3.46-3.43 Ga in ages), which intruded in the crater, probably represent the rebound of the older continental crust and the products of partial melting of the mantle peridotite and oceanic crust.

Our investigations suggest that the greenstone-granite complexes (“granite dome complexes”) that characterize the geology of the East Pilbara district may represent 8 or more craters created by impacts of asteroid bodies 10-30 km in diameter during the Archean. Consequently, the magmatism and tectonics of early Earth may have been dictated by gigantic asteroid impacts, rather than by the plume- and/or plate tectonics.

Keywords: Asteroid impact crater, Impact tsunami deposits, Early Earth

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An evaluation of impact dating for shocked zircons with planar features (PFs) in the Vredefort dome by LA-ICP-MS multi-spot analysis

*Shinji Yamamoto[1], Taiga Kato[1]

1. Graduate School of Environment and Information Sciences, Yohohama National University

Shock-metamorphosed zircons, as an indicator mineral of meteorite impact, have often been utilized for impact dating (e.g. Kamo et al., 2009). Mechanical and thermal effect by impact are thought to lead Pb-loss of shocked zircon, resulting in partly and fully age resetting. The 2.02 Ga Vredefort dome, largest and oldest impact crater, crop out highly-shock metamorphosed basement rocks which include shocked zircons with various shock features such as planar features and granular textures. Previous studies demonstrate that shocked zircons with planar features in the Vredefort show various metamorphic ages from 731 to 3104 Ma, and these ages are interpreted to be correspond to age resetting of regional metamorphism and impact metamorphism. Recent analysis using EBSD, SL and SRIMP for shocked zircon by Moser et al. (2011) reveal that shocked zircons with curvi-planar features have a potential for impact dating in the Vredefort (2.02 Ga), and EBSD misorientation map suggest that deformation of zircon by impact event enhances the age resetting. However, impact dating using shocked zircons with planar features has not been established. Erickson et al. (2013) reported SHRIMP U-Pb ages of detrital shocked zircon with PFs recovered from downriver of the Vredefort dome, and conclude that predominant impact age were identified and that most of shocked zircons record regional metamorphic events. Here we report impact resseting ages from detrital shocked zircons with PFs at the Vaal River sand, cutting along the Vredefort Dome, and identified zircon deformation texture revealed by EBSD misorientation maps. Such deformation in shocked zircon supposed to be formed by impact, and their deformation texture (PFs and EBSD map) may help to identify the ancient impact record.

Keywords: meteorite impact, impact dating, shocked zircon, Vredefort

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Application of acid-washing to trace element and tungsten isotope analyses of Eoarchean rocks from the Isua Supracrustal Belt

*Hatsuki Enomoto[1], Tsuyoshi Iizuka[1], Yoshitaka Homma[1]

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The short-lived ^{182}Hf–^{182}W decay system has been widely used to understand early Earth chemical evolution. Recently, ^{182}W anomalies have been found from many Archean terranes (e.g., Willbold et al., 2011; Touboul et al., 2012). These W isotope variations should be produced by the chemical fractionation of Hf/W on the Earth while ^{182}Hf was extant, or contribution of extraterrestrial materials having different W isotope compositions after core formation. While the W isotopic anomalies potentially provide valuable insights into processes on the early Earth, the exact cause of the isotopic anomalies is not yet clearly understood. As the possible causes, early silicate differentiation, early metal-silicate equilibrium at various conditions, and late veneer have been proposed, but these hypotheses respectively are inconsistent with the lack of correlations with Nd, Os isotopic data, and highly siderophile elements abundances (e.g., Rizo et al., 2016b; Puchtel et al., 2018; Touboul et al., 2012). Alternatively, the apparent lack of the correlations may be attributed to secondary disturbance in the W isotope compositions of the Archean rocks, given that W is highly fluid-mobile during metasomatism (e.g., Bali et al., 2012).

In this study, we applied an acid-washing method to Eoarchean metamorphosed rocks from the Isua Supracrustal Belt, with the aims to evaluate the possible effect of metasomatism on the W isotope systems, and to obtain their original W isotope compositions. We measured trace element compositions and W isotope ratios of acid-washes and residues of the metamorphosed basalts using ICP–MS.

The acid-washes show enrichments in light REE, whereas the residues exhibit enrichments in heavy REE. This suggests that acid-washing selectively removed a secondary component gained during metasomatism, given that light REE are relatively fluid-mobile as compared to heavy REE. Negative ^{182}W anomalies were found in the washes showing light REE enrichments. By contrast, non-resolvable ^{182}W anomaly was obtained for the residues displaying heavy REE enrichments. These findings suggest that the Isua metamorphosed basalts have a W isotope heterogeneity even in a single rock sample. Moreover, our results imply that the W isotope compositions of Isua supracrustal rocks could have been modified secondarily as a result of metasomatism. This can account for the lack of correlation between W isotopic data and other geochemical or isotopic data.

Keywords: Hf–W, Isua, acid-washing, early Earth

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Limited primary production in the early Archean oceans and its biogeochemical consequenses

*Kazumi Ozaki[1]

1. Toho University

The activity level of the biosphere is a critical factor controlling the chemical composition of the atmosphere. The modern Earth's biosphere is powered by the oxygenic photosynthesis, which utilizes ubiquitous water as their electron donor, with the result that Earth's surface environment is extremely well oxygenated. Before the advent of the oxygenic photosynthesis, in contrast, primary production would have been limited by the geophysical input rate of critical electron donors (e.g., H_2 and Fe^{2+}) from the Earth's interior to the exogenic system. Here, we revisit previous modelling of the global biogeochemical cycles of H, C, and Fe in order to more precisely reconstruct global net primary production (NPP) during an interval of early Archean time before the advent of oxygenic photosynthesis. The biogeochemical model includes a series of metabolic reactions in the primitive anoxic biosphere (e.g., anoxygenic photosynthesis, methanogens, and fermenters) and takes redox (H) balance in the ocean-atmosphere system into account. I explore the effect of a variety of combination of key parameters (e.g., atmospheric CO_2 levels, geophysical input flux of Fe^{2+}, and volcanic outgassing flux of H_2) with a stochastic approach in order to search the possible solutions which allow for creating a warm climate state (>288 K) during the Archean. The results suggest that NPP by anaerobic metabolisms has been a few percent of the modern value. The H-based producers, photoferrotrophs, and CO-consuming acetogens contribute ~80%, ~18%, and ~2% of total NPP, respectively. The estimated extremely low NPP implies the geological fluxes of H_2 and Fe^{2+} as a limiting factor for biological productivity. The results also show that the atmospheric CO_2 levels are needed to be >~70 PAL (present atmospheric level) for maintaining warm climate state and that atmospheric CH_4 levels would have been >100 ppm despite the limited activity of the biosphere.

Keywords: Archean, Biogeochemical cycles, Methane

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Behaviors of carbon cycle system and inevitability of the hot climate in the Archean Earth

*Yasuto Watanabe[1], Eiichi Tajika[1], Kazumi Ozaki[2], Peng Hong[3]

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Although the luminosity of the Sun in the Archean (from 4.0 Ga to 2.5 Ga) was dimmer than that of today, geological records of $d^{30}Si$ and $d^{18}O$ from marine cherts suggests that the terrestrial surface environment may have been warm or even hot (328-358 K). Recently, along with these geological records, thermostability of reconstructed ancestral enzymes of cyanobacteria, which reflects the temperature of marine photic zone, also supports the hot surface environment.

To achieve such hot environment under the dimmer Sun, greenhouse effect of carbon dioxide and methane is considered to be necessary. Previous study using a coupled model of atmospheric photochemistry and ocean microbial ecosystem showed that the warm climate can be achieved by non-linearly amplified flux of methane to the atmosphere from the marine ecosystem only when H_2-using photosynthetic bacteria and Fe-using photosynthetic bacteria coexisted in the Archean marine ecosystem. This means that the photochemical processes and the marine microbial processes would have been important in realizing the hot environment under low pO_2 condition in the Archean. However, few studies investigated how these processes affected the global carbon cycle in the Archean.

Here we developed a coupled atmosphere photochemistry-marine microbial ecosystem-global carbon cycle model and assessed how the hot climate suggested from the geologic records can be achieved in the Archean. We found that, there are high pCO_2 (hot climate) stable solutions and low pCO_2 (warm climate) unstable solutions against the range of CO_2 degassing rate similar to that of today. In the low pCO_2 solutions (<~100 PAL), CO_2 is removed from the atmosphere-ocean system as the haze particle, hence such a condition is unstable in the Archean carbon cycle system. This finding strongly supports the results of the hot terrestrial environment in the Archean as suggested from many previous studies. The hot climate may be an inevitable result in the Archean carbon cycle system.

Keywords: Archean, Early Earth, Carbon Cycle

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Occurrence and chemical composition of metamorphic carbonate rocks in the Isua supracrustal belt, West Greenland: Implications for the origin of carbonate rocks and compositions of the Eoarchean seawater.

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The Earth is a unique planet where liquid water and life exist through the geologic time. Therefore, reconstruction of the surface environment of the early Earth is an important issue to consider early life. However, we know little about the early Earth, because the first 500 million years record of the Earth was almost lost.

In recent decades, many studies has been done on the reconstruction of surface environment of the early Earth and early life (c.f. Schidlowski et al., 1979; Ueno et al., 2002; Tashiro et al. 2017). Especially, research on the origin of metamorphic rocks derived from banded iron formation (BIF), carbonate rock and chert in the 3.81 Ga Isua supracrustal belt (ISB), southern West Greenland has been actively carried out in order to reconstruct the surface environment of the early Earth (c.f. Rose et al., 1999; Bolhar et al., 2004; Friend et al., 2008; Nutman et al., 2010).

Recent geochemical studies suggested that the meta-carbonate rock in the ISB originated from a chemical sedimentary rock based on their Post-Archean Average Shale (PAAS)-normalized rare earth element (REE) patterns (Friend et al., 2008; Nutman et al., 2010). They argued that the meta-carbonate rocks have positive La ($[La/La^*]_{PAAS}$; $La^* = 2\,Ce - 2\,Pr$), Eu ($[Eu/Eu^*]_{PAAS}$; $Eu^* = 0.5\,Sm + 0.5\,Gd$) and Y (Y/Ho) anomaly. In the ISB, the carbonate rocks occur with one of three types following rocks: meta-chert, meta-conglomerate and meta-basalt. However, the relationship between the occurrence and the chemical compositons of meta-carbonate rocks is still ambiguous.

We estimated origin of the meta-carbonate rocks with different occurrence, and reconstructed chemical composition of the Eoarchean seawater from geochemistry of the meta-carbonate rocks in the northern part of the ISB. The meta-carbonate layers accompanying the meta-chert are several centimeters thick, and interlayered with meta-chert layer. The meta-carbonate rocks accompanying the meta-conglomerate rock occur as matrix of meta-conglomerate or layer formed centimeter thick. Previous workers considered that those meta-carbonate rocks originated from shallow water sediments (e.g. Dimorth, 1982; Nutman et al., 1984), whereas others interpreted that they formed through metasomatic alteration (e.g. Appel et al., 1998); thus the origin of the meta-carbonate rock are still controversial. The meta-carbonate rocks accompanying meta-basalt occur as veins in the meta-basalt and their thickness are centimeter to tens of centimeters. Those differences in the occurrence are related to their origin.

We analyzed major and trace element (e.g. REE and Zr) contents of the whole rocks of the carbonate rocks with X-ray Fluorescence (XRF) for major elements and High-Resolution Inductively Coupled Plasma Mass Spectrometry (HR-ICP-MS) for trace elements at the University of Tokyo, respectively. Some carbonate rocks have high SiO_2, TiO_2, Al_2O_3, and Zr contents, possibly due to involvement of detrital and

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volcanic materials with/without silicification. We selected the carbonate rocks with low SiO_2, TiO_2, Al_2O_3, and Zr contents in order to remove influence of the silicification and contamination of the detrital materials.

The PAAS-normalized REE patterns of meta-carbonate rocks interlayered with the meta-chert show LREE-depleted patterns with positive La (La/La*: 1.18-1.40), Eu (Eu/Eu*: 1.80-5.50) and Y (Y/Ho: 34.9-45.3) anomaly and without Ce anomaly. The meta-carbonate rocks accompanying with meta-conglomerate rocks show LREE-depleted patterns with positive Eu (Eu/Eu*: 1.43-1.91) anomaly, and lack La, Ce and Y anomaly. The meta-carbonate rocks accompanying with the meta-basalt possess LREE-depleted pattern with Eu (Eu/Eu*: 1.35-1.91) anomaly, and lack La, Ce and Y anomaly.

The positive La and Y anomaly indicates that the meta-carbonate rocks were originate from chemical sediments precipitated from seawater (e.g. Webb and Kamber, 1999; Bolhar et al., 2004), and the lack of the Ce anomaly indicates that the Eoarchean seawater was anoxic as many previous works suggested. In addition, the positive Eu anomaly suggests that the meta-carbonate rocks was precipitated from seawater, influenced by hydrothermal activity.
We classified the meta-carbonate rocks in the ISB into two groups based on the occurrence and REE patterns: chemical sedimentary rock and metasomatized rock. The former includes the meta-carbonate rocks interlayered with meta-chert, whereas the latter comprises those accompanied with meta-conglomerate and meta-basalt.

Keywords: Isua supracrustal belt, Carbonate rock, Eoarchean, Rare earth element, Transition metal element

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Wed. May 29, 2019 10:45 AM - 12:15 PM JST | Wed. May 29, 2019 1:45 AM - 3:15 AM UTC | 304 3F

[M-IS19] Paleoclimatology and paleoceanography

convener:Yusuke Okazaki(Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University), Akira Oka(Atmosphere and Ocean Research Institute, The University of Tokyo), Michinobu Kuwae(Center for Marine Environmental Studies), Hitoshi Hasegawa(Faculty of Science and Technology, Kochi University), Chairperson:Yusuke Okazaki

Past environmental changes and events at multi-decadal to tectonic timescale toward an understanding of Earth climate system by an integration of terrestrial and marine proxy studies and numerical modeling will be discussed. At JpGU2019, a series of presentations on present and future climate and environmental changes from paleo-perspective will be held. We welcome a variety of paleo-environmental studies from a wide range of background. We hope that this session will provide an opportunity to promote communication between participants from multidisciplinary field.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MIS19-01] Development of Longitudinal dunes under the Pangean atmospheric circulation

*Hiroki Shozaki[1], Hitoshi Hasegawa[2] (1.Faculty of Science, Kochi University, 2.Faculty of Science and Technology, Kochi University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MIS19-02] Response of primary producers in the ocean anoxic events during the Cretaceous

*Haga Mayuko[1], Eiichi Tajika[1], Kazumi Ozaki[2] (1.The University of Tokyo, 2.Toho University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MIS19-03] The linkage between desertification and tectonism inferred from the provenance change of the terrestrial sediments in the Tarim basin

*Aki Sakuma[1], Ryuji Tada[1], Tomohiro Yoshida[1], Hitoshi Hasegawa[2], Naomi Sugiura[1], Akinori Karasuda[1], Ke WANG[1], Hongbo Zheng[3] (1.Department of Earth and Planetary Science, School of Science, the University of Tokyo, 2.Faculty of Science and Technology, Kochi University, 3.School of Resource Environment and Earth Science, Yunnan University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MIS19-04] Paleoceanographic reconstruction in the northwestern Pacific during MIS 19 using ultra-high temporal resolution oxygen isotope profiles and planktonic foraminiferal assemblage

*Yuki Haneda[1], Nanako Yokokawa[1], Makoto Okada[1], Hiroki Hayashi[2], Yoshimi Kubota[3], Yusuke Suganuma[4] (1.College of Science, Ibaraki University, 2.Interdisciplinary Factulty of Science and Engineering, Shimane University, 3.National Museum of Nature and Science, 4.National Institute of Polar Research)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MIS19-05] Paleoclimate reconstruction using fossil pollen analyses from a sedimentary sequence around the Matuyama-Brunhes polarity transition in the Chiba composite section

*Makoto Okada[1], Hitomi Takizawa[1], Yuki Haneda[2], Yusuke Suganuma[3,4], Quentin Simon[5] (1.Department of Earth Sciences, College of Science, Ibaraki University, 2.Graduate school of Science and Technology, Ibaraki University, 3.National Institute of Polar Research, 4.Graduate University for Advanced Studies, 5.Aix-Marseille University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[MIS19-06] Reconstruction of vertical thermal structure in the western Pacific warm pool over the last 1 Myr

*Fumito Mizuno[1], Takuya Sagawa[2], Keisuke Mukaida[3], Yoshimi Kubota[4], Toshitsugu Yamazaki[5], Junichiro Kuroda[5] (1.Graduate School of Natural Science and Technology. Kanazawa University, 2.Institute of Science & Engineering. Kanazawa University, 3.Collage of Science & Engineering. Kanazawa University, 4.National Museum of Nature & Science, 5.Atmosphere and Ocean Research Institute. The University of Tokyo)

Development of Longitudinal dunes under the Pangean atmospheric circulation

*Hiroki Shozaki[1], Hitoshi Hasegawa[2]

1. Faculty of Science, Kochi University, 2. Faculty of Science and Technology, Kochi University

From the Permian into the Early Jurassic, the supercontinent Pangea dominated our planets. Because of its largest landmass in the Earth’ s history, atmospheric circulation at this period is thought to be significantly different from today. Modelling experiments have suggested cross-equatorial Hadley circulation and its seasonal overturning. However, there are large discrepancy between model-generated surface wind pattern and geological evidence of paleo-wind pattern recorded by eolian sandstones in the central-western U.S.A. Previous study suggested that its discrepancy can be caused by the wrong interpretation of how winds shaped the dune in Pangea. Here, we re-examined Lower Jurassic eolian sandstone records in U.S.A. and reconstructed paleo-wind pattern with focusing on its dune morphology and orientation. Based on the recently revised paleomagnetic reconstructions, sand dune sea was widespread at about 24˚–33˚N. Spatial pattern of paleo-wind directions suggests influence of multi-directed paleo-winds, with dominant westerly winds in northern area and northeasterly winds in southern area. The reconstructed paleo-wind pattern appears to be consistent with the modelling results of paleo-location of subtropical high-pressure belt in the boreal winter of the Early Jurassic. In addition, spatial pattern of eolian slipface orientations suggest that dunes are mainly consists of longitudinal dunes with NNW–SSE orientation in Pangean time, which are markedly different from orientation direction of longitudinal dunes in present desert. We proposed that the development of NNW-SSE oriented longitudinal dunes could be formed by orbitally-induced latitudinal shifts of subtropical high-pressure belt in Pangea supercontinent. Modeling experiments also generated large modulation of strength and location of subtropical high-pressure belt in response to orbital-scale insolation changes. Reconstructed surface wind pattern and different directions of longitudinal dune orientation recorded in Jurassic eolian sandstone records therefore represent a distinct pattern of Pangean atmospheric circulation.

Keywords: Eolian dunes, Navajo sandstone, Pangean supercontinent, Paleowind systems, Atmospheric circulation

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Response of primary producers in the ocean anoxic events during the Cretaceous

*Haga Mayuko[1], Eiichi Tajika[1], Kazumi Ozaki[2]

1. The University of Tokyo, 2. Toho University

In the Cretaceous, it is known that the “Ocean Anoxic Events (OAEs)” occurred repeatedly. In the OAEs, marine biogeochemical cycles, biological activity, and process of sedimentation may have been different from those under the oxic condition like today. In fact, biomarkers of cyanobacteria and green sulfur bacteria have been found from the sediments during the OAEs. It is therefore suggested that the redox condition and the primary procedures were quite different at the time of the OAEs. If we regard OAE as a disturbance to the marine biogeochemical cycle system, it is important to understand the response of photosynthetic ecosystem that plays a key role in controlling the ocean redox condition during OAEs.

In the Cretaceous, the climate was warmer and the sea level were higher than today because seafloor spreading rate were very high, hence the shallow water area expanded due to the transgression. Under such conditions, the ocean tends to be oligotrophic and oxic because vast shelf area is locus for the deposition of organic matters and traps large amounts of phosphate and nitrogen (Ozaki et al, 2013). We, however, do not know the marine biogeochemical cycles of nutrients and the behaviors of primary procedures under such a condition in the Cretaceous. We therefore developed a marine biogeochemical cycle model coupled with a marine ecosystem model and investigated the condition of OAEs ,marine biogeochemical cycles of nutrients and the behaviors of primary producers in the Cretaceous.

We found that algae is the dominant primary procedure under the “normal” Cretaceous condition, but once the global surface temperature rises owing to, such as activities of large igneous provinces (LIPs), concentration of phosphate in the ocean increases owing to enhanced chemical weathering of land surface. This leads to increase in the marine primary production which, in turn, promotes anoxic conditions in the ocean because dissolved oxygen is consumed by organic matter decomposition, initiating OAE. In the anoxic ocean, nitrogen is limited because nitrate is consumed by organic matter decomposition and thiodenitrification, inhibiting photosynthetic activity of algae. Cyanobacteria becomes dominant primary procedure because some of them can fix nitrogen. In the upwelling regions, green sulfur bacteria becomes dominant because hydrogen sulfide produced by sulfate reducing bacteria upwells to the euphotic zone.

Keywords: ocean anoxic events, Cretaceous, biomarkers, marine biogeochemical cycle modeling, green sulfur bacteria, cyanobacteria

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The linkage between desertification and tectonism inferred from the provenance change of the terrestrial sediments in the Tarim basin

*Aki Sakuma[1], Ryuji Tada[1], Tomohiro Yoshida[1], Hitoshi Hasegawa[2], Naomi Sugiura[1], Akinori Karasuda[1], Ke WANG[1], Hongbo Zheng[3]

1. Department of Earth and Planetary Science, School of Science, the University of Tokyo, 2. Faculty of Science and Technology, Kochi University, 3. School of Resource Environment and Earth Science, Yunnan University

The Tarim basin, which locates to the northwest from the Tibetan Plateau, is the area where the most significant aridification was expected as a result of the uplift of the Himalaya and the Tibetan plateau due to the collision between the Indian subcontinent and the Eurasia continent during Cenozoic (e.g. Kitoh, 2005). However, the geological evidence supporting the relationship between the aridification of the Tarim basin and the tectonism in its surrounding areas is not obtained sufficiently. The reason why the difficulty in examining the relationship between the timing of tectonism and aridification arises is that the timing of the onset of aeolian dune deposition in the Tarim basin, which is the good evidence of the aridification, depends on age models and, thus, there is uncertainty in the timing of the desertification. To solve this problem, it is effective to compare the timing of both tectonic and climatic events on the same section.

In this study, the provenance change of the upper Eocene to the middle Miocene fluvial sandstone deposited in the Aertashi section in the southwestern edge of the Tarim basin was examined using the Electron Spin Resonance (ESR) signal intensity and Crystallinity Index (CI) analyses of quartz in the 64-500 μm fraction and the thin section observation. The timing of the tectonic movement in the Pamir estimated from the provenance change is compared with the timing of the desertification implied by the lithology to examine the relationship between the tectonism and the desertification.

The result of the ESR signal intensity and the CI analyses indicates that the provenance changes of the fluvial sandstone in the Aertashi section are divided into six stages and the boundary between stages are ca. 35Ma, ca. 33Ma, ca. 26Ma, ca. 21Ma, and ca. 17Ma, respectively. Thin section observation shows that the composition of the fluvial sandstone changes significantly at ca. 17Ma with higher content of lithic fragments with wide variety of the types, and the relatively high content of biotite and mafic minerals after ca. 17Ma.
The significant provenance changes at ca. 33Ma, ca. 26Ma, and ca. 17Ma showen by the ESR signal and the CI data imply that the tectonic movement in the Pamir possibly occurred around these times. Since the onset of desertification in the Tarim basin is estimated around 35Ma based on the lithology, the uplift of the Pamir does not seem to have been the cause of the initial aridification in the Tarim basin.

Keywords: Tarim Basin, provenance change, desertification

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Paleoceanographic reconstruction in the northwestern Pacific during MIS 19 using ultra-high temporal resolution oxygen isotope profiles and planktonic foraminiferal assemblage

*Yuki Haneda[1], Nanako Yokokawa[1], Makoto Okada[1], Hiroki Hayashi[2], Yoshimi Kubota[3], Yusuke Suganuma[4]

1. College of Science, Ibaraki University, 2. Interdisciplinary Factulty of Science and Engineering, Shimane University, 3. National Museum of Nature and Science, 4. National Institute of Polar Research

The orbital configuration during Marine Isotope Stage (MIS) 19 are characterized by a weak eccentricity-precession forcing and an obliquity maximum associated with a precession minimum as well as MIS 1, although the both absolute values of obliquity are different. Thus, MIS 19c, one of the sub-stages during MIS 19, is assumed as the best analogue for the present interglacial suggesting the timing of the next glacial inception in the future when the anthropogenic influences are excluded.

The Chiba composite section (CbCS) at east-central Japanese island faces the northwestern Pacific containing the Kuroshio Extension Front (KEF) which is north limit of the Kuroshio Current transporting amount of heat and water from the Equatorial to mid-latitude. Modern observation, climate model, and geologic records reveal that variations of the oceanic fronts in the northwestern Pacific (surface temperature and latitudinal position) and atmospheric circulation in the North Pacific interact. However, response of the KEF to external and internal forcings under the modern orbital configuration remain unclear.

Here, we reconstruct detailed paleoceanographic variations in the northwestern Pacific during MIS 19 using stable oxygen isotope ($\delta^{18}O$) and planktonic foraminiferal assemblage records form the CbCS. Spectral and wavelet analyses were conducted in order to assess periodicity of our new $\delta^{18}O$ records. Vertical water temperature structure and their gradient (ΔT), and relative abundance variation of warm-water species exhibit latitudinal displacements of the KEF on multi-millennial scale across the MIS 20–19 transition and during late MIS 19 (MIS 19b to 19a). Results of the spectral and wavelet analyses for the $\delta^{18}O$ records show periodicities of 2,300–6,000 year during late MIS 19. Similarities of timing and periodicity between paleoceanographic records from the CbCS and North Atlantic indicate that disruption of the Atlantic meridional overturning circulation due to freshwater discharge into the North Atlantic caused the southward displacements of the KEF via atmospheric dynamic. A power of the 9,700 year-periodicity in surface planktonic $\delta^{18}O$ and ΔT is stronger during MIS 19c, which probably originates from tropics caused by equatorial insolation at equinoxes with the orbital perihelion. This result indicates the seasonality of the insolation at low-latitudes paced the sea surface condition at the CbCS throughout MIS 19 and this low-latitude influence became larger especially when the North Atlantic forcing by freshwater discharges and AMOC variability was low. Our result suggests that millennial-scale stability and variation of oceanographic condition along the KEF under this orbital configuration depend on North Atlantic climate variability.

Keywords: China composite section, MIS 19, Oxygen isotope, Planktonic foraminifer, northwestern Pacific, Kuroshio Extension Front

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Paleoclimate reconstruction using fossil pollen analyses from a sedimentary sequence around the Matuyama-Brunhes polarity transition in the Chiba composite section

*Makoto Okada[1], Hitomi Takizawa[1], Yuki Haneda[2], Yusuke Suganuma[3,4], Quentin Simon[5]

1. Department of Earth Sciences, College of Science, Ibaraki University, 2. Graduate school of Science and Technology, Ibaraki University, 3. National Institute of Polar Research, 4. Graduate University for Advanced Studies, 5. Aix-Marseille University

To examine the “Svensmark effect”, linking climate cooling and geomagnetic field strength decrease, during the time of geomagnetic reversal, we have conducted a pollen analysis in the Chiba Composite Section including the Matuyama-Brunhes polarity reversal boundary, and correlated the quantitative paleoclimatic variation deduced by the modern analog method with the paleomagnetic and ^{10}Be records. The samples used in this study are from 33 horizons in a stratigraphic interval between 4-31 m above the Byk-E tephra bed where the sample density of pollen fossil data used in the previous study (Suganuma et al., 2018) is low. Samples were subjected to KOH-acetolysis treatment (Moore et al., 1991) and hydrofluoric acid treatment as pretreatment to extract pollen fossils. As a result of microscopic examination with an optical microscope, we identified 27 genera in total of 3 families, 24 genera of woody pollen, 2 genus pollen grasses and 2 spores. The abundant pollen fossils are Pinus, and some other genera distributed in the subarctic to cool temperate zones such as Picea, Tsuga, Fagus, etc.
Applying the modern analog method (Nakagawa et al., 2002) to the pollen assemblage data, the reconstructed paleoclimatic parameters show lower overall temperatures than the current study area. Comparing various climatic parameters from the modern analog method with the oxygen isotope records, insolation, ^{10}Be showing the penetration of galactic cosmic ray into the atmosphere and relative paleointensity, the reconstructed climatic parameters showed a variation consistent with paleoceanographic temperatures deduced from oxygen isotopes of planktonic foraminifera. Moreover, we do not recognize any trend of decreasing in air temperature corresponding to geomagnetic field strength collapse at the M-B boundary as reported by Kitaba et al. (2017).

Keywords: Chiba Composite Section, fossil pollen analysis, Matuyama-Brunhes reversal

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Reconstruction of vertical thermal structure in the western Pacific warm pool over the last 1 Myr

*Fumito Mizuno[1], Takuya Sagawa[2], Keisuke Mukaida[3], Yoshimi Kubota[4], Toshitsugu Yamazaki[5], Junichiro Kuroda[5]

1. Graduate School of Natural Science and Technology. Kanazawa University, 2. Institute of Science & Engineering. Kanazawa University, 3. Collage of Science & Engineering. Kanazawa University, 4. National Museum of Nature & Science, 5. Atmosphere and Ocean Research Institute. The University of Tokyo

The zonal atmospheric circulation in the tropical Pacific, the Walker circulation, is closely related to the zonal gradients of sea surface temperature (SST) and thermocline through the ocean-atmosphere interaction. Variability of such an interaction in a couple of years timescale is known as El Niño Southern Oscillation (ENSO), which has a great influence on climate not only in the tropics but also in wide areas on the globe. Proxy SST records revealed that the zonal SST gradient has changed in various timescales, and it is interpreted that the ENSO-like ocean-atmosphere interaction also worked on the longer timescale. However, there is no definitive evidence that the change in the zonal SST gradient was accompanied by change of the Walker circulation. Here we reconstruct thermocline temperature variability, which is sensitive to the strength of the Walker circulation. By comparing the variations of zonal and vertical temperature gradients, we examined whether the ENSO-like ocean-atmosphere interaction was functioning on the tens of thousands to hundreds of thousands of years timescale. The sample used in this study is a piston core MR14-02 PC4 collected on the Ontong-Java Plateau located in the western Pacific warm pool (WPWP). Surface and thermocline temperatures were reconstructed by Mg/Ca analyses of planktonic foraminifera, *Globigerinoides ruber* and *Pulleniatina obliquiloculata*, respectively, for the last million years. We compared the vertical temperature gradient (difference between surface and thermocline temperature: ΔT_{WPWP}) and the zonal temperature gradient (difference between *G. ruber* SST in this study and alkenone SST in the East Equatorial Pacific ODP Site 846 : ΔSST_{W-E}). As a result, the relationship between ΔT_{WPWP} and ΔSST_{W-E} in the past was not similar to that of the modern ENSO variability. This result suggests that the change of temperature structure in longer timescale was caused by a mechanism different from today. Also, ΔT_{WPWP} and ΔSST_{W-E} showed a longer time scale change than the glacial-interglacial cycles, and the cycle is approximately 400 kyr. This implies that the thermocline variability in the equatorial Pacific might be related to the Milankovitch cycle. The results of this study suggest that it is necessary to discuss vertical and meridional thermal structures in addition to the zonal SST gradient in order to understand the dynamics of past ocean-atmosphere interaction.

Keywords: Western Pacific warm pool, Planktonic foraminifera, Reconstruction of old water temperature

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Wed. May 29, 2019 1:45 PM - 3:15 PM JST | Wed. May 29, 2019 4:45 AM - 6:15 AM UTC | 304 3F

[M-IS19] Paleoclimatology and paleoceanography

convener:Yusuke Okazaki(Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University), Akira Oka(Atmosphere and Ocean Research Institute, The University of Tokyo), Michinobu Kuwae(Center for Marine Environmental Studies), Hitoshi Hasegawa(Faculty of Science and Technology, Kochi University), Chairperson:Michinobu Kuwae(愛媛大学沿岸環境科学研究センター)

Past environmental changes and events at multi-decadal to tectonic timescale toward an understanding of Earth climate system by an integration of terrestrial and marine proxy studies and numerical modeling will be discussed. At JpGU2019, a series of presentations on present and future climate and environmental changes from paleo-perspective will be held. We welcome a variety of paleo-environmental studies from a wide range of background. We hope that this session will provide an opportunity to promote communication between participants from multidisciplinary field.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MIS19-07] Future perspective on the response of marine calcifiers to “evil twins” of climate change due to increased PCO2

*Hodaka Kawahata[1] (1.Atmosphere Ocean Research Institute, the University of Tokyo)

2:00 PM - 2:22 PM JST | 5:00 AM - 5:22 AM UTC

[MIS19-08] Reconstruction of seawater pH and atmospheric CO_2 concentration based on boron isotopic composition of biogenic calcium carbonate

★Invited Papers

*Kaoru Kubota[1] (1.Kochi Institute for Core Sample Research, JAMSTEC)

2:22 PM - 2:37 PM JST | 5:22 AM - 5:37 AM UTC

[MIS19-09] A 70 years changes of the Java Sea surface condition based on geochemical analyses of a coral core

*Ai Genda[1], Atsushi Suzuki[2], Toyoho Ishimura[3], Minoru Ikehara[4], Mayuri Inoue[1] (1.Graduate School of National Science and Technology, Okayama University, 2.Geological Survey of Japan Natinal Institute of Advanced Industrial Science and Technology, 3.National Institute of Technology, Ibaraki College, 4.Center for Advanced Marine Core Research, Kochi University)

2:37 PM - 2:52 PM JST | 5:37 AM - 5:52 AM UTC

[MIS19-10] Reconstruction of paleoenvironments in the western Pacific for the last 220 years

Mutsumi Chihara[1], Ayaka Fukushima[2], Minoru Ikehara[3], Hodaka Kawahata[2], Atsushi Suzuki[4], *Mayuri Inoue[1] (1.Department of Earth Sciences, Okayama University, 2.Atmosphere and Ocean Research Institute, the University of Tokyo, 3.Center for Advanced Marine Core Research, Kochi University, 4.Geological Survey of Japan, AIST)

2:52 PM - 3:15 PM JST | 5:52 AM - 6:15 AM UTC

[MIS19-11] Ocean deoxygenation from the Last Glacial Maximum to the future global warming: inshight from model simulations

★Invited Papers

*Akitomo Yamamoto[1], Ayako Abe-Ouchi[2,1], Rumi Ohgaito[1], Akinori Ito[1], Masahito Shigemitsu[1], Yasuhiro Yamanaka[3], Akira Oka[2] (1.Japan Agency for Marine-Earth Science and TechnologyAtmosphere and Ocean Research Institute, 2.Atmosphere and Ocean Research Institute, The University of Tokyo, 3. Faculty of Environmental Earth Science, Hokkaido University)

Future perspective on the response of marine calcifiers to “evil twins” of climate change due to increased PCO2

*Hodaka Kawahata[1]

1. Atmosphere Ocean Research Institute, the University of Tokyo

This talk is developed from our comprehensive review paper of PEPS: Kawahata, H., Fujita, K., Iguchi, A, Inoue, M., Iwasaki, S., Kuroyanagi, A., Maeda, A., Manaka, T., Moriya, K., Takagi, H., Toyofuku, T., Yoshimura, T., Suzuki, A. (2019) Perspective on the response of marine calcifiers to global warming and ocean acidification –Behavior of corals and foraminifera in a high CO2 world “hot house”. Progress in Earth and Planetary Science 6: 5 (p.1-37).

Our planet will experience global warming and ocean acidification due to increased partial pressure of CO2 in the atmosphere. They are often referred to as the “evil twins” of climate change, potentially inducing severe threats in the near future.

Generally, majority of marine calcifying organisms show decreases in calcification rates in response to acidified seawater by increased pCO2. However, the response often differs depending on situations, species, and life-cycle stage. Calcification of Calcarina gaudichaudii, generally increased with increased pCO2. As one possible cause of these different sensitivities, Calcarina hosts diatoms as its symbiotic algae. High-CO2 seawater is favorable to diatom growth.

X-ray micro-computed tomography will provide valuable information regarding biomineralization including calcification of planktic and benthic foraminifera in response to ocean acidification as well as regarding carbonate dissolution.

Based upon the analysis of the biogeochemical cycle (today, at P/E boundary and in Cretaceous), “high speed” and “high level” pCO2 are the primary and secondary factors, respectively, leading to acidification in the Earth surface’s system. Over the long-term, it is well known that alkalinity has fluctuated largely in the Earth’s surface environment. Therefore, it is important to quantitatively reconstruct alkalinity, which is another key factor determining the saturation state of carbonate minerals.

Keywords: global warming, ocean acidification , calcifiers, carbonate, alkalinity

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Reconstruction of seawater pH and atmospheric CO_2 concentration based on boron isotopic composition of biogenic calcium carbonate

*Kaoru Kubota[1]

1. Kochi Institute for Core Sample Research, JAMSTEC

A lot variety of environmental information is recorded in marine biogenic calcium carbonate that is represented by reef building coral skeletons and foraminifera shells. Among these, **boron isotope ($\delta^{11}B$)** proxy is of great importance in the realm of paleoclimatology and paleoceanography, since it can record seawater pH and CO_2 concentration of the overlying atmosphere. Along with the growing interest to recent environmental problems such as global warming and ocean acidification due to anthropogenic CO_2 emission, past carbon cycle research has been actively conducted, and boron isotope proxy is priceless tool to study it. In 1980s, applicability of this proxy was foreseen, but high precision boron isotope measurement with small sample requirement was difficult at that time. As boron exist abundantly around us (the most representative one is borosilicate grass), analytical technique has evolved as the boron-free clean environment improved. Thermal ionization mass spectrometry (**TIMS**) was first developed, and nowadays multi-collector inductively coupled plasma mass spectrometry (**MC-ICPMS**), secondary ionization mass spectrometry (SIMS), and laser-ablation inductively coupled plasma mass spectrometry (LA-ICPMS) (and others) is now available. Measurable minimum sample amount, achievable analytical precision, and spatial resolution of the analysis are largely different among methods, and efforts to measure boron isotope composition more precisely with smaller amount of samples has continued at research institutes around the world. In **Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology**, boron isotope measurements by using TIMS and MC-ICPMS are available: the former realizes the most precise measurement in the world, and the latter realizes analytical precision and required sample amount that is comparable with major overseas laboratory. In this presentation, I will explain theoretical background why boron isotope of marine biogenic calcium carbonate becomes seawater pH proxy and characteristics of two different mass spectrometry, and then overview already-done research and ongoing research topics. Recent development of visualization technology of pH of calcifying fluid of reef building coral and foraminifera has enabled deeper understandings of boron incorporation systematics. On the one hand, boron isotopes of reef building coral is most-likely a direct indicator of pH of calcifying fluid; on the other hand, those of foraminifera is likely influenced by microenvironment pH gradient surrounding foraminifera. Whatever the mechanism is, a clear relationship between boron isotopes and seawater pH is observed in various samples such as cultured, recently live-collected, and fossil samples, thus many studies use this proxy in paleoclimatology and paleoceanography by understanding empirical relationship collectly ("calibration").

Keywords: boron isotope, coral, foraminifera, carbon cycle, calcification, carbon dioxide

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A 70 years changes of the Java Sea surface condition based on geochemical analyses of a coral core

*Ai Genda[1], Atsushi Suzuki[2], Toyoho Ishimura[3], Minoru Ikehara[4], Mayuri Inoue[1]

1. Graduate School of National Science and Technology, Okayama University, 2. Geological Survey of Japan Natinal Institute of Advanced Industrial Science and Technology, 3. National Institute of Technology, Ibaraki College, 4. Center for Advanced Marine Core Research, Kochi University

At Indonesian Archipelago, observed and instrumental records have not been well recorded because of complex terrain. In this study, we have reconstructed sea surface condition of the Java Sea for past 70 years based on $\delta^{13}C$, Sr/Ca and U/Ca ratios in the coral skeleton.
A coral core (*Porites* sp.) was collected from the the Seribu Islands located at the Java Sea, Indonesia. Measurements of Sr/Ca, U/Ca ratios and $\delta^{13}C$ were performed by inductively coupled plasma (ICP)-optical emission spectrometer, ICP-mass spectrometer and stable isotope ratio mass spectrometer with about 2-month time resolution.
Although it has been reported that both coral Sr/Ca and U/Ca ratios can be used as paleothermometer [Beck et al., 1992; Min et al., 1995], coral U/Ca ratios also depends on seawater pH [Inoue et al., 2011] and carbonate ion concentration ($[CO_3^{2-}]$) [Anagnostou et al., 2011]. Furthermore, since coral $\delta^{13}C$ reflects DIC of ambient seawater, we will discuss about marine environments such as water temperature and seawater pH at the Java Sea for 70 years.

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Reconstruction of paleoenvironments in the western Pacific for the last 220 years

Mutsumi Chihara[1], Ayaka Fukushima[2], Minoru Ikehara[3], Hodaka Kawahata[2], Atsushi Suzuki[4], *Mayuri Inoue[1]

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In the tropics, *Porites* corals are recognized as the excellent archives of past climate and environmental and oceanic conditions because coral skeletal geochemistry, such as oxygen and carbon isotopes and Sr/Ca ratios, provides quantitative information on sea surface temperature (SST) and salinity. However, continuous long records more than 200 years based on coral records have been limited.

Here, we present a 224-year SST record with high time resolution (~2 month) derived from Sr/Ca ratios and stable isotopes ($\delta^{18}O$ and $\delta^{13}C$) from Philippines (13°N, 124°E), which located on the northern edge of the western pacific warm pool (WPWP).

Coral Sr/Ca was measured by an inductively coupled plasma optical/atomic emission spectrometer (ICP-OES/AES) with a precision was better than 0.6 % which is equivalent to 0.5 ℃. Analyses of $\delta^{18}O$ and $\delta^{13}C$ were measured by isotope ratio mass spectrometer (IR-MS). Precision was better than 0.05 ‰for $\delta^{13}C$ and 0.10 ‰for $\delta^{18}O$. In this study, spectral analysis was performed by using the kSpectra. Reconstructed SST varies from 25 to 32 ℃ and shows that there were multiple cold events during the last 224 years in the western tropical Pacific. A decreasing trend in $\delta^{13}C$ for the last 50 years was found which may reflect accelerated increase in the amount of anthropogenic CO_2 (Suess effect).The result of $\delta^{18}O$ analyses implies western pacific climate was cooler and drier in the early 19th century which is almost consistent with other coral records. In contrast, warmer and wetter conditions persist since 1950s.The spectral analysis of the annual SST and $\delta^{18}O$ anomaly for 224 years shows significant peaks at 3-8 years. These frequencies are considered to be related to the ENSO variability.

Keywords: the western Pacific, coral skeleton, paleoclimate

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Ocean deoxygenation from the Last Glacial Maximum to the future global warming: inshight from model simulations

*Akitomo Yamamoto[1], Ayako Abe-Ouchi[2,1], Rumi Ohgaito[1], Akinori Ito[1], Masahito Shigemitsu[1], Yasuhiro Yamanaka[3], Akira Oka[2]

1. Japan Agency for Marine-Earth Science and TechnologyAtmosphere and Ocean Research Institute, 2. Atmosphere and Ocean Research Institute, The University of Tokyo, 3. Faculty of Environmental Earth Science, Hokkaido University

Global warming is expected to decrease ocean oxygen concentration by less solubility of surface ocean, reduced ventilation and enhanced stratification. The associated expansion of the oxygen minimum zone would have adverse impact on marine organisms and ocean biogeochemical cycles. Earth system models show a consistent deoxygenation trend over the twenty-first century; however, longer-term changes in ocean oxygen are still unclear due to the uncertain response of deep ocean circulation.

During the Last glacial maximum, recent proxy data show that, despite greater oxygen solubility due to sea surface cooling, the oxygen concentrations throughout the deep ocean were generally lower. These records provide the response of oxygen content to climate forcing that are comparable in magnitude to the expected future changes. Therefore, the understanding of glacial deoxygenation will help us to better understand and predict future oxygen changes. In addition, glacial deep-water deoxygenation is crucial to understand glacial-interglacial CO_2 change, since glacial deoxygenation reflects increased accumulation of respired carbon in the glacial deep ocean. However, the mechanisms of deep-water deoxygenation and contribution form the biological pump to glacial CO_2 drawdown are poorly understood due to the difficulties in reproducing glacial deoxygenation.

In this study, we report the importance of glaciogenic dust for the glacial deep-water deoxygenation from our numerical simulation which successfully reproduces the magnitude and large-scale pattern of the observed oxygen changes from the present to Last Glacial Maximum. Sensitivity experiments reveal that physical changes (e.g., more sluggish ocean circulation) contribute to only half of all glacial deep deoxygenation, whereas the other half is driven by enhanced efficiency of the biological pump. We found that iron input from the glaciogenic dust with higher iron solubility is the most significant factor for enhancement of the biological pump and global deep-water deoxygenation. The model-proxy agreement of oxygen change supports the simulated contribution of the enhanced biological pump to the decrease of more than 30 ppm of glacial CO_2.

On the other hand, our model underestimates deoxygenation in the deep Southern Ocean due to enhanced ventilation in the Southern Ocean. Our results suggest that the stratified Southern Ocean is required for reproducing glacial deoxygenation in the Southern Ocean. However, present climate models cannot reproduce the stratified Southern Ocean. A possible reason is that climate models are too coarse to capture the process of dense water formation on the Antarctic shelf and tend to underestimate the strength of stratified Southern Ocean. Similar to glacial oxygen changes, our global warming simulation show that changes in ocean circulation in the Southern Ocean are crucial for long-term projecting future oxygen changes associated with global warming. Therefore, the understanding of glacial oxygen changes will help us to better understand and predict future oxygen changes.

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Keywords: Dissolved oxygen, Glacial-interglacial cycle, Global warming, Ocean carbon cycle, Ocean biogeochemical model

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Wed. May 29, 2019 3:30 PM - 5:00 PM JST | Wed. May 29, 2019 6:30 AM - 8:00 AM UTC | 304 3F

[M-IS19] Paleoclimatology and paleoceanography

convener:Yusuke Okazaki(Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University), Akira Oka(Atmosphere and Ocean Research Institute, The University of Tokyo), Michinobu Kuwae(Center for Marine Environmental Studies), Hitoshi Hasegawa(Faculty of Science and Technology, Kochi University), Chairperson:Akira Oka

Past environmental changes and events at multi-decadal to tectonic timescale toward an understanding of Earth climate system by an integration of terrestrial and marine proxy studies and numerical modeling will be discussed. At JpGU2019, a series of presentations on present and future climate and environmental changes from paleo-perspective will be held. We welcome a variety of paleo-environmental studies from a wide range of background. We hope that this session will provide an opportunity to promote communication between participants from multidisciplinary field.

3:30 PM - 3:52 PM JST | 6:30 AM - 6:52 AM UTC

[MIS19-12] Extraction of high-quality ^{14}C data from terrestrial sediments containing pollen fossils

★Invited Papers

*Takayuki Omori[1], Keitaro Yamada[2], Ikuko Kitaba[2], Takeshi Nakagawa[2] (1.The University Museum, The University of Tokyo, 2.Research Centre for Palaeoclimatology, Ritsumeikan University)

3:52 PM - 4:07 PM JST | 6:52 AM - 7:07 AM UTC

[MIS19-13] Oxygen isotope fluctuations of pollen fossils from Lake Suigetsu, Japan

*Keitaro Yamada[1], Takayuki Omori[2], Ikuko Kitaba[1], Takeshi Nakagawa[1] (1.Research Organization of Science and Technology, Ritsumeikan University, 2.The University museum, The University of Tokyo)

4:07 PM - 4:22 PM JST | 7:07 AM - 7:22 AM UTC

[MIS19-14] Reconstruction of lake-level changes during the last glaciation based on fossil diatom record in Lake Biwa

*Takashi Suzuki[1], Yoshio Inouchi[2], Keisuke Otsuka[1], Kaoru Kawakami[3] (1.Graduate School of Human Science, Waseda University, 2.Faculty of Human Sciences, Waseda University, 3.Graduate School of Environmental Science, Hokkaido University)

4:22 PM - 4:45 PM JST | 7:22 AM - 7:45 AM UTC

[MIS19-15] An estimation of microplatcis sedimentation flux in a coastal sea

★Invited Papers

*Hirofumi Hinata[1], Michinobu Kuwae[1], Issei Masumoto[1], Hayato Kawamata[1] (1.Ehime University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MIS19-16] Beppu Bay sediments: Potential palaeoenvironmental archives for a candidate auxiliary stratotype for Anthropocene-Holocene boundary

*Michinobu Kuwae[1], Yoshiaki Suzuki[2] (1.Center for Marine Environmental Studies, Ehime Univ., 2.Department of Eearth Scieces, Fuculty of Education and Integrated Arts and Sciences, Waseda Univ.)

Extraction of high-quality ^{14}C data from terrestrial sediments containing pollen fossils

*Takayuki Omori[1], Keitaro Yamada[2], Ikuko Kitaba[2], Takeshi Nakagawa[2]

1. The University Museum, The University of Tokyo, 2. Research Centre for Palaeoclimatology, Ritsumeikan University

Fossil pollen grains, which are commonly found in various types of sediments, have great potential for radiocarbon chronological research. If measurable amounts of fossil pollen grains can be extracted readily from sediment matrices, then ^{14}C age determination could be performed at any depositional depth, regardless of with or without plant macrofossils, and the quality of the deposition age model can be considerably increased. Thus far, several lake sediments have been tested for pollen ^{14}C. However, technical issues such as complex preparation procedures, collection rate, and purity of concentrated sample persisted and pollen ^{14}C analysis has not been applied routinely. A novel pollen concentration method is developed herein using a next-generation cell sorter to quickly prepare pure concentrates of fossil pollen grains suitable for ^{14}C dating, with a relatively simple preparation procedure.
Cell sorter was originally developed for biomedical researches to instantaneously identify and separate cells of specific fluorescence and shape. Some of the latest model machines can perform machine tuning and sample preparation semi-automatically, and it is designed to solve most issues via the exchange of replacement parts. In the proposed method of pollen purification, pollen-enriched suspension is introduced into cell sorter, which can separate more than a million grains of fossil pollen in half a day. The pollen ^{14}C analysis was conducted using a SG06 sediment core from Lake Suigetsu, which has one of the most reliable age models that we can use as reference. Pollen fossil samples equivalent to 50–100 μgC were extracted from ca. 25-30 g of wet sediment and were measured using a compact AMS system (NEC 0.5 MV 1.5SDH-1) of LRD.UMUT. The ^{14}C data of the pure pollen samples agreed well with the Suigetsu's ^{14}C dataset on terrestrial plant leaf fossils. This result shows that accurate ^{14}C data can be obtained from any depth of the core, even at depths at which plant remains are not present. Using the proposed method, the Suigetsu's ^{14}C data can be enhanced for data density and evenness of the data intervals, both of which would directly contribute to the accuracy of the age model. We also believe that the proposed method can be applied to various sediment types from both marine and terrestrial realms, and will assist high-precision chronological study as well as quantification of marine reservoir age.

Keywords: Radiocarbon dating, Pollen fossil, Cell sorter, Suigetsu

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Oxygen isotope fluctuations of pollen fossils from Lake Suigetsu, Japan

*Keitaro Yamada[1], Takayuki Omori[2], Ikuko Kitaba[1], Takeshi Nakagawa[1]

1. Research Organization of Science and Technology, Ritsumeikan University, 2. The University museum, The University of Tokyo

Interactions of atmospheric, marine, terrestrial, and cryospheric realms are important factors in considering mechanisms of climate change (Lowe et al., 2008). Pollen analysis widely used methods to reconstruct past climate changes. However, comparing pollen data with other geochemical proxies, especially stable isotope signals, is not straightforward due to the non-linearity included in the conventional pollen composition signals. On the other hand, pollen grains are composed of sporopollenin and potentially provide isotopic signals which can be more directly compared with key palaeoclimatic records from across the world (Loader and Hemming, 2004). In this study, we first established a method to extract fossil pollen grains from sediment matrix by “cell sorter”. Then we applied that new method to the varved sediments obtained from Lake Suigetsu, Japan (in particular, transition from the Lateglacial to the early Holocene) in order to test if the isotopic signals of pollen grains are keeping meaningful palaeoclimatic information or not.

Lake Suigetsu (35˚35'N, 135˚53'E, 0 m a.s.l.), Fukui prefecture, is one of the Mikata Five lakes, which measures 3 km east-west by 3 km north-south, with the maximum water depth of ca. 34 m. Lake Suigetsu preserves annually laminated sediments over the last ca.70 kyr with a significant number of event layers that allows precise correlation among parallel cores. Two long cores (SG93, SG06) have previously been recovered from the centre of the lake. An exceptionally precise age model has been established for the cores through a combination of over 800 radiocarbon (^{14}C) dates and high precision varve count (Staff et al., 2011; Marshall et al., 2012; Schlolaut et al., 2012; Bronk Ramsey et al., 2012). In this study, we used well-dated SG06 cores and extracted pollen fossils using cell sorter.

Cell sorter is able to characterise particles using optical parameters (mainly fluorescence), and separate specific particles using electrostatic deflection. Pollen fossils can be isolated by cell sorter without fluorescent dyes using cell sorter because sporopollenin constituting pollen grains is naturally auto-fluorescent (Tennant et al., 2013). After chemical and physical pre-treatments, pollen-enriched suspension was introduced into the cell sorter and extracted half a million pollen fossils from each sample. After drying and weighing, δ^{18}O value of the high-purity pollen pellets were determined using High Temperature Conversion Elemental Analyzer (TC/EA, Thermo Scientific) in the University of Tokyo.

The oscillation of the δ^{18}O value of the extracted pollen pellets roughly mirrored that of the NGRIP, showing typical climatic transitions that characterise the Late glacial period. Our results strongly imply that the stable isotope signal of fossil pollen grains is keeping record of past climate changes.

Keywords: Palaeoclimate, Stable isotope, Pollen, Cell sorter, Suigetsu

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Reconstruction of lake-level changes during the last glaciation based on fossil diatom record in Lake Biwa

*Takashi Suzuki[1], Yoshio Inouchi[2], Keisuke Otsuka[1], Kaoru Kawakami[3]

1. Graduate School of Human Science, Waseda University, 2. Faculty of Human Sciences, Waseda University, 3. Graduate School of Environmental Science, Hokkaido University

This is a report of a research for reconstruction of lake-level change history of Lake Biwa based on the transfer function of diatom assemblage into water depth. We have analyzed diatom assemblages, sand content, and C/N ratio in drilling core sample from the lake bottom of 23.45 m in depth and surface sediment samples from the lake bottom from 5 m to 30 m in depth off estuary of Echi River, Lake Biwa. The relative abundance of planktonic species in diatom assemblage from surface sediments can be changed into water depth. The transfer function applied to fossil diatom record in drilling core sample into lake-level change history during the last 50 ka.
We compared the record with Sanbao & Hulu cave stalagmites $\delta^{18}O$ records in China and NGRIP $\delta^{18}O$ record in Greenland from 50 ka to 10 ka. The result shows that the lake-level change history in Lake Biwa reflects East Asian winter monsoon intensity. Lake-level rose under relatively cold conditions or abrupt cooling like Heinrich Events and lake-level fell under relatively warm conditions. The lake-level response to climate conditions suggests that snowfall in winter depending on East Asian winter monsoon intensity mainly contributed to water balance of Lake Biwa during the last glacial period.

Keywords: Lake Biwa, Planktonic diatom, Transfer Function, Lake-level change, East Asian winter monsoon

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An estimation of microplatcis sedimentation flux in a coastal sea

*Hirofumi Hinata[1], Michinobu Kuwae[1], Issei Masumoto[1], Hayato Kawamata[1]

1. Ehime University

Plastics production has been increasing each year. It is estimated that 4.8-12.7 million tons of plastics flowed out into the ocean in 2010. The plastics weathers due to UV degradation and fragmented into small pieces. Generally, the plastic particles of the 0.3-5mm in size are called microplastics. They are likely to be incorporated into the ecosystem and there is concern about bad influence on ecosystem. Recent studies have found that microplastics sink to the sea bottom. However, the sedimentation flux has not been clarified yet. In this study, the sedimentation flux of microplastics was estimated. We collected and analyzed the sediment cores from the bottom of Beppu Bay. Beppu Bay is suitable for the core sampling, because sediments have not been vertically disturbed.Five cores were taken using Gravity Corer. Four sediment cores were for microplastic analysis, and one for dating sediment layers. The sedimentary age was determined using the Pb-210 method. Microplastics extracted from the four core samples were analyzed by FT-IR to determine the polymer type. A total of 142 pieces of microplastic were detected. The most common polymer type among plastics was polyethylenewhich accounted for 55% of the total in number. The average sedimentary flux from 1998 to 2017 was calculated as 217 [pieces/m^2·y)].

Keywords: microplastics, sedimentation flux

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Beppu Bay sediments: Potential palaeoenvironmental archives for a candidate auxiliary stratotype for Anthropocene-Holocene boundary

*Michinobu Kuwae[1], Yoshiaki Suzuki[2]

1. Center for Marine Environmental Studies, Ehime Univ., 2. Department of Eearth Scieces, Fuculty of Education and Integrated Arts and Sciences, Waseda Univ.

A markedly increasing influence of human activity on the Earth system since 1950s has gained attention as one of the notable turning points of Earth's history, which is noteworthy to propose the 'Anthropocene' as a potential new unit of the International Chronostratigraphic Chart which serves as the basis of the Geological Time Scale. Now is ongoing the definition and selection of the Global Boundary Stratotype Section and Point (GSSP) mainly by the Anthropocene Working Group (AWG), a working group of the Subcommission on Quaternary Stratigraphy (SQS) of the International Commission on Stratigraphy (ICS). There are several candidates of a suitable stratotype for hosting an Anthropocene GSSP, including ice core, tree-ring, and coral that record an increasing fallout signal of ^{14}C and ^{239}Pu as well as a rapid decrease in $\delta^{13}C$ during 1950s. However, since (1) radionuclide fallout did not have major biological or other widespread physical repercussions, (2) ice might disappear itself due to global warming, and (3) ^{14}C signal won't detect in 100, 000 years or more, other stable auxiliary stratotypes and markers may be needed for the establishment of GSSP.

GSSPs previously ratified have often been established in marine sediments; anoxic marine sediments emerges as one of the candidates for Anthropocene auxiliary stratotypes (Waters et al., 2018). In anoxic marine sediments, there are the potential Anthropocene boundary markers, including microplastics, diatom and foraminifer assemblages, metals, organic contaminations, and spheroidal carbonaceous particles, which can be used to correlate globally. Several marine anoxic basins have been addressed for a candidate of auxiliary stratotype, such as Santa Barbara Basin, etc., but, an existence of a Japanese marine anoxic basin has not been well-known. Here we introduce laminated sediments in the anoxic Beppu Bay basin for a potential auxiliary stratotype of Anthropocene and discuss its recent progress of stratigraphy and advantage to propose the candidate, and future tasks to acquire a comprehensive dataset for establishment of the boundary.

Keywords: Anthropocene, Beppu Bay sediments, auxiliary stratotype

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Wed. May 29, 2019 3:30 PM - 5:00 PM JST | Wed. May 29, 2019 6:30 AM - 8:00 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[M-IS22] Electromagnetic phenomena associated with seismic and volcanic activities

convener:Tetsuya Kodama(Research Unit I, Research and Development Directorate, Japan Space Exploration Agency), Toshiyasu Nagao(Institute of Oceanic Research and development, Tokai University), Chairperson:Tetsuya Kodama, Toshiyasu Nagao

This session deals with reviews and contributions on the recent studies of electromagnetic (EM) phenomena associated with earthquakes and volcanic eruptions. One of the main targets of the session is to clarify the mechanism of seismo-EM emission and Lithosphere-Atmosphere-Ionosphere (LAI) coupling. Recently, some scientists claim that seismic activities are the critical phenomena. These kinds of approach are also welcome.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MIS22-01] Stress-induced charges in gabbro at high temperature

*Chihiro Yamanaka[1], Daiki Maezono[1] (1.Graduate School of Science, Osaka University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MIS22-02] Evaluation of ULF seismo-magnetic precursor phenomena at Kakioka, Japan over 1983 – 2018 by using SEA and Molchan’s error diagram

*Katsumi Hattori[1], Kei Takahashi[2], Peng Han[3] (1.Department of Earth Sciences, Graduate School of Science, Chiba University, 2.Department of Earth Sciences, Faculty of Science, Chiba University, 3.Southern University of Science and Technology, China)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MIS22-03] On the tsunami and electromagnetic pulses appeared abound 10min. after the 2011 Tohoku earthquake

*Yuji Enomoto[1], Tsuneaki Yamabe[1], Shigeki Sugiura[2], Hitoshi Kondo[2] (1.Shinshu Univeristy, Ueda Campus Fii, 2.Genesis Reserach Institute, Inc.)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MIS22-04] Reinvestigation of correlation between groundwater anomalies and earthquakes carried out by an amateur network in Japan

*Yoshiaki Orihara[1], Masashi Kamogawa[2], Toshiyasu Nagao[1] (1.Institute of Oceanic Research and Development, Tokai University, 2.Dpt. of Phys., Tokyo Gakugei Univ.)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MIS22-05] Participation Report of S-Booster 2018

*Tetsuya Kodama[1] (1.Research Unit I, Research and Development Directorate, Japan Space Exploration Agency)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MIS22-06] The future direction of EMSEV, IUGG International Working Group

*Toshiyasu Nagao[1] (1.Institute of Oceanic Research and development, Tokai University)

Stress-induced charges in gabbro at high temperature

*Chihiro Yamanaka[1], Daiki Maezono[1]

1. Graduate School of Science, Osaka University

Preseismic ionospheric disturbance just before large earthquakes was found at the 2011 off the Pacific coast of Tohoku Earthquake (Heki,2011). Similar phenomena up to 18 cases (Heki's TEC anomaly) were found in earthquakes of M 7-9 since 1994. It should be noted all the earthquakes larger than M 8.5 during that duration were 5 times and Heki's TEC anomaly was observed for all of them.
Assuming the phenomena were drived by surface electromagnetic field due to stress induced charges distributed thinly around focal or nucleation zone, we have been studying stress-induced charges from silicate rocks. A dried gabbro sample (10×10×3 cm) was heated up to 350℃, then stress-induced current under uniaxial stress of 10 MPa was observed with the variation of temperature.
Experimental results showed that stress-induced charges increased from room temperature to 200℃ but then decreased at higher temperature. We would like to discuss the mechanism of Heki's TEC anomaly based on the experimental results and computer simulation.

[1] K. Heki (2011), Geophys. Res. Lett. 38, L17312.
[2] L. He and K. Heki (2017), J. Geophys. Res. Space Phys., 122, 8659-8678.
[3] K. Heki and Y. Enomoto (2015), J. Geophys. Res. Space Phys., 120, 7006-7020.
[4] L. He and K. Heki (2017), J. Geophys. Res. Space Phys., 123, 4015-4025.

Keywords: Ionosphere disturbance, Heki’ s TEC anomaly, stress induced charges

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Evaluation of ULF seismo-magnetic precursor phenomena at Kakioka, Japan over 1983 –2018 by using SEA and Molchan’ s error diagram

*Katsumi Hattori[1], Kei Takahashi[2], Peng Han[3]

1. Department of Earth Sciences, Graduate School of Science, Chiba University, 2. Department of Earth Sciences, Faculty of Science, Chiba University, 3. Southern University of Science and Technology, China

To clarify and verify the ultralow frequency (ULF) seismo-magnetic phenomena, we have performed statistical studies on the geomagnetic data observed at the Kakioka (KAK) station, Japan, during 1983-2017. We investigated the energy of ULF geomagnetic signals of the frequency around 0.01 Hz using wavelet transform analysis. To minimize the influences of artificial noises and global magnetic perturbations, we used only the geomagnetic data observed at midnight time (LT 2:30 AM to 4:00 AM).We define the geomagnetic anomalies when the Z components of geomagnetic data exceeds median +1.5 IQR, where IQR is the interquartile range. Considering that ionospheric disturbances may also lead to enhancements in the Z component, we exclude the anomaly when the energy of H component exceeds median +3.0 IQR. Statistical analysis of superposed epoch analysis have indicated that ULF magnetic anomalies are more likely to appear before sizable isolated earthquake events rather than after them, especially 6-10 days before the events. Finally, we have evaluated the precursory information of ULF geomagnetic signals for local sizable earthquakes using Molchan’ s error diagram. The results show that the ULF seismo-magnetic phenomena at Kakioka clearly contain precursory information and have a possibility of improving forecasting of large earthquakes. The details will be given in the presentation.

Keywords: Earthquake Precursor Phenomena, Statistical Significance, Molchan's Error Diagram Analysis

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On the tsunami and electromagnetic pulses appeared abound 10min. after the 2011 Tohoku earthquake

*Yuji Enomoto[1], Tsuneaki Yamabe[1], Shigeki Sugiura[2], Hitoshi Kondo[2]

1. Shinshu Univeristy, Ueda Campus Fii, 2. Genesis Reserach Institute, Inc.

Tsunami and electromagnetic pulses have appeared about 10 min. after the 2011 Tohoku-Oki earthquake(Heki, GRL, 2011; Utada et al. EPS Lett., 2011; Tsunagawa et al. EPS Lett., 2011). The disturbance to the ionosphere is thought to have been influenced by the atmospheric gravity wave caused by the tsunami. But this model could not explain the variation of geomagnetism, observed at Esahi site. In order to explain geomagnetic variation, we present a model that positively charged mists flied up with the atmospheric gravity wave along with the atmospheric electric field as the tsunami pulse was generated.

Keywords: Seismo-electromagneic phenomena, Tsunami, Geomagnetic change

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Reinvestigation of correlation between groundwater anomalies and earthquakes carried out by an amateur network in Japan

*Yoshiaki Orihara[1], Masashi Kamogawa[2], Toshiyasu Nagao[1]

1. Institute of Oceanic Research and Development, Tokai University, 2. Dpt. of Phys., Tokyo Gakugei Univ.

An amateur volunteer group for an earthquake prediction, “the catfish club”, had monitored groundwater levels and the temperature of thermal water to detect earthquake precursor signals since 1976. More than 200 participants in Kanagawa, Tokyo, Shizuoka, and some prefectures monitored them. Their sampled data are sent to the office of the catfish club, and the summarized reports were published every month. Oki and Hiraga (1988) reported the probably predicted events such as the 1978 Izu-Ohshima kinkai earthquake (M 7.0) and the 1978 Miyagiken-Oki earthquake (M 7.4). In this study, we statistically evaluate the anomaly appearance rate, the earthquake occurrence rate, and the probability gain using the data from 1977 to 1987.

Acknowledgment: This study was supported by the Earthquake Research Institute The University of Tokyo Joint Usage/Research Program.

Keywords: the catfish club, earthquake prediction, groundwater, statistical evaluation

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Participation Report of S-Booster 2018

*Tetsuya Kodama[1]

1. Research Unit I, Research and Development Directorate, Japan Space Exploration Agency

"Tsunami Early Warning Service by Geostationary Positioning Satellite" and "Prediction of Earthquake Occurrence by Microsatellite Constellation and Global Ground Station Network" which were applied for S-Booster 2018 sponsored by the Cabinet Office, both of which were left in the final selection. The background and results will be reported.

Keywords: S-Booster, tsunami, earthquake prediction, QZS-3, microsatellite

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The future direction of EMSEV, IUGG International Working Group

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1. Institute of Oceanic Research and development, Tokai University

EMSEV (Electromagnetic Studies of Earthquakes and Volcanoes) was established in 2001 as a mother foundation of IAGA, IAVCEI, and IASPEI under IUGG (International Union of Geodesy and Geophysics). At that time, many studies of electromagnetic precursory phenomena were reported in earthquake prediction research but never seemed to be recognized by the traditional seismology community. For this reason, the grassroots movement had been expanded for the necessity of promoting international research.

Therefore we urged the establishment of an organization to study earthquake prediction and volcanic eruption prediction based on the electromagnetics in IUGG. It was officially launched in 2001 and the first meeting was made during the IUGG Sapporo in 2003.

Professor emeritus of the University of Tokyo, Seiya Uyeda served as the first chair of EMSEV, then Dr. Jacques Zlotnicki of the French National Science Research Center took the chair till 2018. EMSEV meeting was held, which organizes every two years, in Potenza in Italy in 2018. During the meeting, Professor Toshiyasu Nagao was proposed to serve as the next chair. This proposal was approved through the discussion of the mailing list.

In the future EMSEV, we must show the statistical correlation between the ionospheric anomaly and the earthquake first, then we have to prove why the earthquake precursors phenomena appear in the ionosphere based on the lithosphere - atmosphere - ionosphere coupling hypothesis. In particular, from satellite observations, France launched the DEMETER satellite in 2004, showing the statistical significance of VLF band anomalies just before the earthquake. Inspired by this result, China launched the CSES (Chinese Seismo-Electromagnetic Satellite) in 2018.

We decided that the next meeting of EMSEV will be held in Taiwan in the fall of 2020.

Keywords: IUGG, EMSEV, Earthquake prediction

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-SD Space Development & Earth Observation from Space

Wed. May 29, 2019 9:00 AM - 10:30 AM JST | Wed. May 29, 2019 12:00 AM - 1:30 AM UTC | 302 3F

[M-SD44] Future Missions of Satellite Earth Observation

convener:Yoshiaki HONDA(Center for Environmental Remote Sensing, Chiba University), Yukari Takayabu(Atmosphere and Ocean Research Institute, the University of Tokyo), Shinichi Sobue(Japan Aerospace Exploration Agency), Yuki Kaneko(Japan Aerospace Exploration Agency), Chairperson:Yoshiaki Honda

Satellite observation can be an effective tool in science and can be applied to the rapid global environmental change. Monitoring for a long term, advancing new ideas and developing technologies to support them are needed to solve social and scientific problems.
The Task Force on Future Space R&D System of the Subcommittee on Remote Sensing (TF) supported by 25 academic societies and affiliated organizations has formulated the ''Grand Design of Earth Observation'' in FY2017. From the academic point of view, it suggests earth observation missions that Japan should conduct within a decade. From September 2018 to December 2018, the TF calls for proposals of earth observation missions as a trial that aims to discover new ideas from the scientific and practical domains and refine those ideas through multidisciplinary discussion. The adopted proposals will be mentioned in the revised Grand Design, and the TF will work with the government on using it as a reference in updating the Implementation Plan of the Committee on National Space Policy.
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9:00 AM - 9:05 AM JST | 12:00 AM - 12:05 AM UTC

Introduction

9:05 AM - 9:20 AM JST | 12:05 AM - 12:20 AM UTC

[MSD44-01] Experimental platform for design and advance evaluation of frequent satellite observations to innovate weather, ocean and land surface predictions

*Takemasa Miyoshi[1], Shunji Kotsuki[1], Koji Terasaki[1], Shigenori Otsuka[1], Takumi Honda[1], Atsushi Okazaki[1], Kohei Takatama[1] (1.RIKEN)

9:20 AM - 9:35 AM JST | 12:20 AM - 12:35 AM UTC

[MSD44-02] Technology demonstration mission for next generation precipitation observation radars

*Tomoo Ushio[1], Toshio Iguchi[2], Kenji Nakamura[4], Kinji Furukawa[3], Riko Oki[3], Daisuke Jodoi[3] (1.Tokyo Metropolitan University, 2.NICT, 3.JAXA, 4.Dokkyo University)

9:35 AM - 9:50 AM JST | 12:35 AM - 12:50 AM UTC

[MSD44-03] Mission of creating base maps as public infrastructures for disaster and monitoring

*ISHITSUKA Naoki[1] (1.The Remote Sensing Society of Japan)

9:50 AM - 10:05 AM JST | 12:50 AM - 1:05 AM UTC

[MSD44-04] Aerosol monitoring, forecasting and estimate of its impacts with multispectral imager data

*Keiya Yumimoto[1,2], Takashi Maki[2], Taichu Y Tanaka[2], Thomas Sekiyama[2], Toshihiko Takemura[1] (1.Kyushu University, 2.Meteorological Research Institute)

10:05 AM - 10:20 AM JST | 1:05 AM - 1:20 AM UTC

[MSD44-05] Global aerosol and cloud observation by space-borne multi-wavelength polarization high-spectral-resolution lidar

*Tomoaki Nishizawa[1], Hajime Okamoto[2], Syoken Ishii[3], Yoshitaka Jin[1] (1.National Institute for Environmental Studies, 2.Kyushu University, 3.National Institute of Information and Communication Technology)

10:20 AM - 10:30 AM JST | 1:20 AM - 1:30 AM UTC

Discussion

Experimental platform for design and advance evaluation of frequent satellite observations to innovate weather, ocean and land surface predictions

*Takemasa Miyoshi[1], Shunji Kotsuki[1], Koji Terasaki[1], Shigenori Otsuka[1], Takumi Honda[1], Atsushi Okazaki[1], Kohei Takatama[1]

1. RIKEN

We propose to develop a unique platform with an advanced data assimilation technology, realizing numerical simulation experiments for advance evaluation of future satellite missions in their design phase. This will provide a scientific, objective approach to an effective design of future satellite missions to maximize the benefit to practical applications such as hydrometeorological prediction and resource control of fisheries. The authors have been leading data assimilation research to explore the best mix of computer model simulations and real-world data for weather forecasting, taking advantage of new-generation technologies such as the K computer and Himawari-8 satellite. The authors' previous research revealed that every-10-minute Himawari-8 observations could lead to a large improvement of typhoon and heavy rainfall predictions, though every-30-minute observation was insufficient. We would expect that frequent observations would also be beneficial for ocean and land surface prediction. Therefore, we aim to develop a platform for numerical experimentation to evaluate potential future satellite missions such as quasi-zenith orbiters and small cube-sat constellations for frequent observation over Japan and its surrounding area. This platform will be useful for designing future satellite missions with high cost-benefit performance.

Keywords: satellite mission planning, numerical simulation experiment, data assimilation

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Technology demonstration mission for next generation precipitation observation radars

*Tomoo Ushio[1], Toshio Iguchi[2], Kenji Nakamura[4], Kinji Furukawa[3], Riko Oki[3], Daisuke Jodoi[3]

1. Tokyo Metropolitan University, 2. NICT, 3. JAXA, 4. Dokkyo University

We have studied doppler velocity measurement for precipitation particles using a precipitation observation radar in a low Earth orbit as a post-mission of Dual-frequency Precipitation Radar (DPR) on the Global Precipitation Measurement (GPM) core satellite. Also, we have studied Geostationary Precipitation Radar (GPR) which can observe precipitation continuously and flexibly from a geostationary orbit as a future mission. In this study, we have studied the method which can separate precipitation echoes from ground/sea clutters by the doppler velocities in order to observe high latitude areas. Therefore, we need to verify the feasibility of the doppler velocity measurement for precipitation particles. Additionally, we need to improve antenna performance drastically in order to observe precipitation from a geostationary orbit which is far away from a low Earth orbit. Therefore, we need to verify the feasibility of upsizing an antenna for the GPR.

Based on the above background, the purpose of the proposed mission is to demonstrate that it is possible to measure the doppler velocity of precipitation particles from an orbit by a pulse compression radar using a planar antenna and to operate antenna deployment and connection mechanisms normally in an orbit. Also, we aim to get data regarding antenna deployment behavior and structural characteristics.

We consider the value of the proposed mission as follows. Firstly, the value of the doppler velocity measurement demonstration is as follows.
This demonstration contributes to realize post-GPM/DPR mission. If the doppler velocity measurement becomes possible in the mission, it is expected to understand the mechanical structure of a precipitation system globally and to improve the accuracy of weather and flood forecasts. This demonstration contributes to realize the GPR mission. If the GPR becomes possible, it is expected to identify the forming process of a typhoon and to improve the accuracy of weather and flood forecasts.
Next, the value of the antenna deployment and connection demonstration is as follows.
This demonstration contributes to improve the performance of satellite antennas for earth observation, communication, radio astronomy, disaster monitoring, national security, etc. because the deployment and connection mechanisms make it possible to enlarge planar antennas. This demonstration contributes to realize innovative missions like the GPR because the deployment and connection mechanisms make it possible to construct a 30-m-class large planar antenna. The deployment and connection mechanisms have the potential to construct super large space structures like Space Solar Power Systems (SSPS).
We consider the feasibility of the proposed mission as follows. When we assume that the size of a demonstration system is 1.2m x 2.2m x 0.7m in storage state and 1.2m x 2.2m x 4.4m in deployment state, we expect that the system meets the installation condition for HTV-X which has been developed as a post-KOUNOTORI (HTV) by JAXA. Also, as a result of thermal analysis for the system, we expect that the system meets the thermal condition for HTV-X. Furthermore, we demonstrated that it is possible to operate the half size deployment and connection mechanisms of the system normally by a ground experiment in FY2017.
As future works, we will study the feasibility of the doppler velocity measurement from the aspect of HTV-X attitude control performance. Also, we will improve the function and performance of the deployment and connection mechanisms.

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Keywords: Precipitation Radar, Technology Demonstration, Doppler Velocity, Deployable Antenna, GPM/DPR Follow on

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Mission of creating base maps as public infrastructures for disaster and monitoring

*ISHITSUKA Naoki[1]

1. The Remote Sensing Society of Japan

As a satellite earth observation mission to be realized as Japan, we propose a mission of creating base maps as public infrastructures for disaster and monitoring.

The purpose of the proposed mission, is the observation and the base map prepared, as well as the monitoring and elucidation of global resources from long-term and continuous quantitative monitoring of large-scale disasters. Optical and SAR sensors, which are the genealogy of ALOS, observe with high spatial resolution, so that it can be applied to basic information (land cover, topography), disaster prevention / reduction (change detection, flooding, illegal dumping) Actual utilization such as agriculture(precision farming, food security), forestry, fishery, energy (geology, reserves, resource management, pollution monitoring), climate change (glacier, drift ice, flood), environment (coastal environment, carbon stock) , To earth science, and so on.

High resolution earth observation data with a wide swath is necessary for detailed map creation which is limited in medium resolution satellite. The high-resolution base map created from the satellite data covering the whole earth will be developed as public infrastructures and become a data access hub and can contribute to social implementation of satellite images such as disaster and agriculture. Then, it will serve as a basis for use in policies to solve international and regional issues, and for use in providing services enriching our lives. In particular, agriculture, forestry and fisheries industry and land management, disaster prevention, social infrastructure is a leading application area. For example, it is difficult to predict when and where a disaster occurs, so it is necessary to maintain wide-area high-resolution images as a base map. In SIP the second phase by the Japanese Cabinet Office, "strengthening national resilience (disaster prevention and reduction)" is started, high-resolution satellite as public infrastructure, supposed to be the supply of data and information There. Also, for use in the map creation field, there are cases where ALOS data was used for updating maps at the Geographical Survey Institute, etc. and for field polygon production work at Ministry of Agriculture and Fisheries. Underlying data of these G space is necessary essential to the realization of data society called “Society 5.0” promoted by the government. In SAR, it is required to make observation of the ground change due to forest monitoring and interferometric SAR, making full use of the achievement of Japan 's L band. In addition, there is great expectation for high resolution monitoring of polar sea ice and glacier utilizing observational weatherability. It is desirable for both sensors to operate at the same time, since various effects such as complementation and improvement in accuracy can be obtained by using the optical sensor and the SAR sensor in an integrated fashion.

Thus, for optical, it is necessary capability to observe a wide range of several tens of km high resolution image having m ~ sub meter. In addition, it is regrettable that ALOS-3 could not install the all-time stereoscopic observation that was an advantage over other countries in ALOS, and it is desirable to have a resurrection by successor satellite. With regard to SAR, it is considered to adopt a new method by DBF in ALOS - 4, and it is considered that wide range high resolution observation such as several hundred kilometers at several m resolution by DBF technology can be continued for succeeding machines depending on the result.

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However, since the data becomes extremely large in both optical and SAR, the part of downlinking this data becomes a bottleneck. It is important to continue to cooperate with the development of other data downlink environments including data transmission speed, data on board processing, data relay satellite, ground station and communication, basic research on data compression technology.

In addition, the observed frequency secure has become a real operational issues, this is a need for a solution to break, the number of satellites increases or the constellation, a wide swath, the study of technologies, such as the attitude maneuver. In addition, as an innovative solution, it is necessary to consider the high resolution observation from the geostationary orbiting satellite, etc.

Environmental changes caused by global warming, earth resources from the viewpoint of long-term monitoring of (mineral resources, biological resources, water resources, etc.), and continues without interrupted the ALOS Series with high resolution sensor is desired. We believe it will lead to a worldwide presence improvement of the ALOS series.

Keywords: High resolution, wide swath, ALOS series

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Aerosol monitoring, forecasting and estimate of its impacts with multispectral imager data

*Keiya Yumimoto[1,2], Takashi Maki[2], Taichu Y Tanaka[2], Thomas Sekiyama[2], Toshihiko Takemura[1]

1. Kyushu University, 2. Meteorological Research Institute

Airborne aerosols are tiny particles that are globally distributed in the atmosphere from the troposphere to the stratosphere and that affect various aspects of human society and health and the Earth system including ocean biogeochemistry and climate. Our understanding of the aerosol lifecycle and aerosol impacts has been advanced by the following activities: (1) aerosol monitoring: observations of distributions of aerosol components and their radiative impacts, (2) assimilation/forecasting: aerosol (PM2.5) numerical prediction and early warning system to reduce effects on human society and health, and (3) climate data: long-term records including aerosol reanalysis product contributing climate and epidemiology studies. Multispectral imagers (from near UV to near infrared) onboard polar-orbiting and geostationary satellites have been providing essential data to those activities. In this presentation, we will make a brief review of those activities to show how multispectral imagers play the important role in aerosol studies and to provide an opportunity to consider their future plan.

Keywords: Aerosol, Satellite observation

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Global aerosol and cloud observation by space-borne multi-wavelength polarization high-spectral-resolution lidar

*Tomoaki Nishizawa[1], Hajime Okamoto[2], Syoken Ishii[3], Yoshitaka Jin[1]

1. National Institute for Environmental Studies, 2. Kyushu University, 3. National Institute of Information and Communication Technology

We propose global satellite measurements of vertical distributions of aerosols and clouds (particles) by multi-wavelength polarization high-spectral-resolution lidar (HSRL) using both HSRL and polarization measurement techniques. This proposal realizes polarization HSRL measurements in ultraviolet, visible, and near-infrared spectral regions (355, 532, and 1064nm) and conducts multi-wavelength and multi-parameter measurements of particles simultaneously.
The proposed lidar, which has twice or larger measurement channels than the previous space lidars, measures global, three-dimensional (vertical and horizontal) distributions of particles; this enables to observe various optical and microphysical properties (e.g., extinction, size distribution, chemical components) simultaneously and to obtain more reliable particle information in quantitative and qualitative than the past. Observational studies using both these global, three-dimensional data of particles and numerical models (e.g., aerosol chemical transport model, and cloud resolving model) will lead to understating preprocess on aerosol-cloud interaction better, reducing uncertainties on evaluation the particle effects on climate change, and improving prediction accuracy of the climate change. Furthermore, this space lidar observation can be used to monitor and forecast transport and diffusion of aerosols getting air quality worse (e.g., volcanic ash, mineral dust, smoke, and air pollution) and to evaluate the aerosol effects on atmospheric environment (e.g., human health, vegetation, and air quality). These improvements of the scientific knowledges contribute to internationally consensus building to solve global warming issues and improving environmental measures both within and outside Japan.
The proposed lidar should have a role to be a succession sensor of space lidar mission to observe global particle distributions such as CALIPSO satellite lidar (CALIOP) launched in 2006 and EarthCARE satellite lidar (ATLID) launched in 2021 and lead internationally particle observation mission by space lidar after EarthCARE mission. More advanced techniques on laser and lidar in space by improving the laser and lidar techniques established in vegetation lidar mission MOLI as well as HSRL techniques developed for ground-based lidars are established in this proposal. The developed techniques are also key techniques for lidars to measure meteorological parameters such as temperature, wind speed, and water vapor. Thus, this proposal is also a bridge for the technical development of the space lidar to measure meteorological parameters.

Keywords: Space-borne lidar, Aerosols, Clouds, HSRL, multi-wavelength

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-SD Space Development & Earth Observation from Space

Wed. May 29, 2019 10:45 AM - 12:15 PM JST | Wed. May 29, 2019 1:45 AM - 3:15 AM UTC | 302 3F

[M-SD44] Future Missions of Satellite Earth Observation

convener:Yoshiaki HONDA(Center for Environmental Remote Sensing, Chiba University), Yukari Takayabu(Atmosphere and Ocean Research Institute, the University of Tokyo), Shinichi Sobue(Japan Aerospace Exploration Agency), Yuki Kaneko(Japan Aerospace Exploration Agency), Chairperson:Kazuhiro Asai(東北工業大学), Toshiyoshi Kimura(宇宙航空研究開発機構)

Satellite observation can be an effective tool in science and can be applied to the rapid global environmental change. Monitoring for a long term, advancing new ideas and developing technologies to support them are needed to solve social and scientific problems.
The Task Force on Future Space R&D System of the Subcommittee on Remote Sensing (TF) supported by 25 academic societies and affiliated organizations has formulated the ''Grand Design of Earth Observation'' in FY2017. From the academic point of view, it suggests earth observation missions that Japan should conduct within a decade. From September 2018 to December 2018, the TF calls for proposals of earth observation missions as a trial that aims to discover new ideas from the scientific and practical domains and refine those ideas through multidisciplinary discussion. The adopted proposals will be mentioned in the revised Grand Design, and the TF will work with the government on using it as a reference in updating the Implementation Plan of the Committee on National Space Policy.
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10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MSD44-06] Dual-Doppler-velocity-mission using cloud radar and lidar

*Okamoto Hajime[1], Kentaroh Suzuki[2], Tomoaki Nishizawa[3], Shoken Ishii[4] (1.Kyushu University, 2.The university of Tokyo, 3.National Instuitute for Environmental Studies, 4.National Institute of Information and Communications Technology)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MSD44-07] Global wind profiling with space-based Doppler wind lidar for improvement of numerical weather prediction

*Shoken Ishii[1], Kozo Okaoto[2,1], Takuji Kubota[3], Atsushi Sato[4,1], Daisuke Sakaizaw[3], Tomoaki Nishizawa[5], Ayako Matsumoto[6], Tetsuya Tugami[6], Toshiyuki Ishibashi[2], Taichu Y Tanaka[2], Philippe Baron[1], Makoto Aoki[1], Riko Oki[3], Masaki Satoh[7], Toshiki Iwasaki[8] (1.National Institute of Information and Communications Technology, 2.JMA/MRI, 3.JAXA, 4.TIT, 5.NIES, 6.ANA, 7.University of Tokyo, 8.Tohoku University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MSD44-08] Technology demonstration of space-borne water vapor DIAL

*Makoto Abo[1], Chikao Nagasawa[1], Yasukuni Shibata[1], Osamu Uchino[2], Takashi Shibata[3] (1.Graduate School of System Design, Tokyo Metropolitan University, 2.National Institute for Environmental Studies, 3.Nagoya University)

11:30 AM - 12:00 PM JST | 2:30 AM - 3:00 AM UTC

[MSD44-09] Short presentation of poster session

*Yoshiaki HONDA[1] (1.Center for Environmental Remote Sensing, Chiba University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

Discussion

Dual-Doppler-velocity-mission using cloud radar and lidar

*Okamoto Hajime[1], Kentaroh Suzuki[2], Tomoaki Nishizawa[3], Shoken Ishii[4]

1. Kyushu University, 2. The university of Tokyo, 3. National Instuitute for Environmental Studies, 4. National Institute of Information and Communications Technology

Dual-Doppler velocity measuring mission from space-borne cloud radar and lidar is proposed. 94GHz cloud radar and lidar with Doppler function will measure three-dimensional air motion in clouds as well as in clear sky, respectively. High spectral resolution functions at 355nm and 532nm with polarization are planned to distinguish cloud particle type and aerosols. The lidar will have multiple field of views in order to penetrate relatively thick clouds. Since the radar will have capability to observe clouds and lidar will measure aerosols, it will be a successor mission to CloudSat and CALIPSO launched in 2006 and EarthCARE satellite in 2021. The mission will also serve to construct continuous records of clouds and aerosols for climate change studies.

Keywords: Doppler, cloud radar, lidar, clouds, wind

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Global wind profiling with space-based Doppler wind lidar for improvement of numerical weather prediction

*Shoken Ishii[1], Kozo Okaoto[2,1], Takuji Kubota[3], Atsushi Sato[4,1], Daisuke Sakaizaw[3], Tomoaki Nishizawa[5], Ayako Matsumoto[6], Tetsuya Tugami[6], Toshiyuki Ishibashi[2], Taichu Y Tanaka[2], Philippe Baron[1], Makoto Aoki[1], Riko Oki[3], Masaki Satoh[7], Toshiki Iwasaki[8]

1. National Institute of Information and Communications Technology, 2. JMA/MRI, 3. JAXA, 4. TIT, 5. NIES, 6. ANA, 7. University of Tokyo, 8. Tohoku University

Wind is one of key meteorological elements describing the atmospheric state as well as pressure, temperature, and humidity. Global wind profile observation is important to significantly improve the initial conditions essential for numerical weather prediction (NWP) and other meteorological studies. Although space-based observation system is a very important role in NWP, current space-based wind observing system has a problem that it is biased to observation related to temperature and water vapor compared with wind observation. The World Meteorological Organization wants to develop a global wind profiling system. Space-based Doppler Wind Lidar (DWL) can provide global wind profiles, which is a promising technique to fill the current gap. Under the circumstance, ESA launched the first space-based DWL Aeolus in August 2018. Since target mission period of Aeolus is three years, many NWP and science communities want continuous global wind profile observation. The working group on Japanese space-based DWL has made feasibility study for the space-based DWL for future global wind profiling since 2011. In 2017, ANA Holdings Inc. proposed to apply for optimizing aviation route using wind data improved by the future space-based DWL wind measurement at the space business promotion event S-Booster 2017. The proposal won the grand prize at S-Booster 2017, and the space-based DWL for the space business has been spotlighted since the event. The proposal is based on the global wind profile observation with the space-based DWL. The purposes of the global wind profile observation are to improve the precision of NWP and to contribute to understandings of mechanism of natural disasters and climate change and to new applications of wind data use.

Keywords: Lidar, Doppler Wind Lidar, space-based observation, global wind profiling

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Technology demonstration of space-borne water vapor DIAL

*Makoto Abo[1], Chikao Nagasawa[1], Yasukuni Shibata[1], Osamu Uchino[2], Takashi Shibata[3]

1. Graduate School of System Design, Tokyo Metropolitan University, 2. National Institute for Environmental Studies, 3. Nagoya University

We propose technology demonstration of space-borne water vapor differential absorption lidar (DIAL) for global high-resolution water vapor observations in the troposphere and lower stratosphere, to improve the understanding about the role of water in the global water and energy cycles and main physical processes (e.g., convection, emission, rainfall, the troposphere-stratosphere exchange of chemical species).

Keywords: DIAL, water vapor, space-borne

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Short presentation of poster session

*Yoshiaki HONDA[1]

1. Center for Environmental Remote Sensing, Chiba University

The author will do a short presentation of the paper presented at the poster session of this session "M-SD44 Future Missions of Satellite Earth Observation".

Keywords: Global environmental, Satellite Earth Observation, Grand Design of Earth Observation

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-SD Space Development & Earth Observation from Space

Wed. May 29, 2019 1:45 PM - 3:15 PM JST | Wed. May 29, 2019 4:45 AM - 6:15 AM UTC | 302 3F

[M-SD44] Future Missions of Satellite Earth Observation

convener:Yoshiaki HONDA(Center for Environmental Remote Sensing, Chiba University), Yukari Takayabu(Atmosphere and Ocean Research Institute, the University of Tokyo), Shinichi Sobue(Japan Aerospace Exploration Agency), Yuki Kaneko(Japan Aerospace Exploration Agency), Chairperson:Riko Oki(宇宙航空研究開発機構)

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1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MSD44-10] **Himawari-8/9 follow-on satellites program**

*BESSHO Kotaro[1] (1.Japan Meteorological Agency)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MSD44-11] Impact assessment of hyperspectral infrared sounders toward Himawari-8/9 follow-on satellites

*Kozo OKAMOTO[1], Hiromi Owada[2], Masahiro Kazumori[2], Michiko Otsuka[1], Yoshifumi Ota[2], Naotaka Uekiyo[1], Hiromu Seko[1], Akiyoshi Ando[2], Ryo Yoshida[2], Hiroshi Ishimoto[1], Masahiro Hayashi[1], Haruma Ishida[3], Yoshiaki Sato[2], Hiroshi Kunimatsu[2], Kotaro Bessho[2], Hironobu Yokota[2] (1.Meteorological Research Institute, 2.Japan Meteolological Agency, 3.Meteorological Satellite Center)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MSD44-12] Observation system simulation experiments for a hyperspectral infrared sounder onboard geostationary satellite

*HIROMI OWADA[1], Kozo OKAMOTO[2], Masahiro Kazumori[1], NAOTAKA UEKIYO[2], Hiroshi Ishimoto[2], Masahiro Hayashi[2] (1.Japan Meteorological Agency, 2.Meteorological Research Institute)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MSD44-13] Realization of pseudo high frequency high resolution observation by geostationary satellite and orbiting satellite combined observation

*Yoshiaki HONDA[1] (1.Center for Environmental Remote Sensing, Chiba University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MSD44-14] **Geostationary Optical Earth Observation Satellite**

*Kazuo Oki[1], Toshiyoshi Kimura[2], Tadahito Mizutani[2], Takeo Tadono[2] (1.The University of Tokyo, 2.JAXA)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

Discussion

Himawari-8/9 follow-on satellites program

*BESSHO Kotaro[1]

1. Japan Meteorological Agency

This presentation will show the Himawari-8/9 follow-on satellites program.

Keywords: Satellite, Himawari, JMA

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Impact assessment of hyperspectral infrared sounders toward Himawari-8/9 follow-on satellites

*Kozo OKAMOTO[1], Hiromi Owada[2], Masahiro Kazumori[2], Michiko Otsuka[1], Yoshifumi Ota[2], Naotaka Uekiyo[1], Hiromu Seko[1], Akiyoshi Ando[2], Ryo Yoshida[2], Hiroshi Ishimoto[1], Masahiro Hayashi[1], Haruma Ishida[3], Yoshiaki Sato[2], Hiroshi Kunimatsu[2], Kotaro Bessho[2], Hironobu Yokota[2]

1. Meteorological Research Institute, 2. Japan Meteolological Agency, 3. Meteorological Satellite Center

Japan Meteorological Agency has started the discussion on Himawari-8/9 follow-on satellites to be launched in 2028. We are investigating impacts on numerical weather prediction of a hyperspectral infrared sounder on the follow-on satellites using an observing system simulation experiment (OSSE) approach. We will present preliminary results of simulation and global and regional data assimilation experiments of the sounder.

Keywords: Himawari follow-on satellite, data assimilation, OSSE , hyperspectral infrared sounder

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Observation system simulation experiments for a hyperspectral infrared sounder onboard geostationary satellite

*HIROMI OWADA[1], Kozo OKAMOTO[2], Masahiro Kazumori[1], NAOTAKA UEKIYO[2], Hiroshi Ishimoto[2], Masahiro Hayashi[2]

1. Japan Meteorological Agency, 2. Meteorological Research Institute

At the Japan Meteorological Agency, we started preparation for the Himawari-8/9 follow-on satellites. Hyperspectral infrared sounder (HSS) is one of the instruments to consider to be installed in the follow-on satellites. By installing HSS on a new geostationary satellite, it is possible to acquire information on highly accurate profiles of temperature and water vapor at high frequency, and it is expected that accuracy of numerical weather prediction is greatly improved by using this new data in data assimilation system. In order to confirm this assumption, we evaluate the impact on numerical weather prediction when we install HSS on the follow-on satellites and assimilate their data with observation system simulation experiment (OSSE).

In this presentation, we report on the generation of HSS pseudo observation data and the initial results of OSSE in JMA's current global data assimilation system.

Keywords: Himawari-8/9 follow-on satellites, Hyperspectral infrared sounder, Observation system simulation experiments

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Realization of pseudo high frequency high resolution observation by geostationary satellite and orbiting satellite combined observation

*Yoshiaki HONDA[1]

1. Center for Environmental Remote Sensing, Chiba University

Observation data of the earth observation optical sensor data from both the earth science and the actual utilization is required more frequently and higher resolution. However, in order to realize this high frequency observation and high resolution observation at the same time, it is impossible with one satellite, and it is being realized by many operations of micro satellite. However, in general, micro satellites have problems such as short design life and no calibration system. On the other hand, satellites of medium size or more including geostationary satellites have a long design life and have a calibration system. However, in order to realize high frequency and high resolution with satellites of medium size or larger, if we try to secure the number of satellites, its budget is enormous and not realistic. This proposal is based on high frequency observation of geosynchronous satellites with relatively low resolution among satellites launched by Japan (assumed to be successors such as Himawari, GCOM - C, ALOS etc), and high resolution but low frequency orbiting satellite observations We aim to manufacture pseudo high frequency high resolution observation data through a model that adjusts part of sensor specifications of each satellite and adjusts the difference between observation geometries, and provides such a high quality long-term framework . This aims to expand the use of satellite optical sensor data in earth science and practical use fields, and to expand scientific progress and practical use. This framework is a planned budget size, one step to get bigger results, and expansion of the actual field of use will also contribute to the continuity of the Earth observation in Japan. Furthermore, by incorporating newly planned satellites of other countries into this framework, we aim to increase the presence of our Earth observation in the field of earth science and practical use.

Keywords: Geostationary satellite, Orbiting satellite combined observation, Pseudo High Frequency High Resolution Observation

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Geostationary Optical Earth Observation Satellite

*Kazuo Oki[1], Toshiyoshi Kimura[2], Tadahito Mizutani[2], Takeo Tadono[2]

1. The University of Tokyo, 2. JAXA

Geostationary satellite is the most practical Earth Observation for its instantaneous observation and ability to choose target area on demand. Some kind of users, especially disaster monitoring, agriculture and national security users are demanding such unique character crucially. However, technical difficulties prevent from realization of the system, so far. Practical observation needs a certain fine ground resolution. But it means necessity for huge main mirror for the satellite optics. For an example, 5~7m resolution at Nadir position needs 3.6m diameter mirror. So far, 1~2m diameter one-piece mirrors were studied, in contrast. Recent optical technologies make it possible to have an extra large telescope using segmented mirrors for astronomical telescope on the ground, like Keck astronomy or TMT project. Using such technologies, we studied geostationary satellite telescope system with 3.6m diameter segmented telescope to materialize 7m ground resolution at Nadir position. Observation bands should have good correlation with ALOS-3 satellite on low Earth orbit, i.e. panchromatic, RGB, NIR and additional bands. To ensure the night observation, IR band is under consideration in addition. Such new Earth observation scheme improves time resolution dramatically, and it will make possible to observe movement of target like video camera. It will reveal many motile phenomena including Tsunami, Typhoon and human activities like car traffics. Also, it is expected that various social services unprecedented in cities, forests, agriculture, water (rivers and oceans), etc. are expected to be offered, and we believe that many users will appear in the field of science and practical use. The study started in 2018 and will end in 2020 to confirm the technical readiness level of required technologies, observation plan and algorithms for new earth observation data products.

Keywords: Geostationary Satellite, Extra large telescope, Geostationary satellite telescope system, ALOS-3, Social services, New earth observation data products

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[J] Oral | U (Union)：Union

Thu. May 30, 2019 9:00 AM - 10:30 AM JST | Thu. May 30, 2019 12:00 AM - 1:30 AM UTC | IC 2F

[U-06] Japan's contribution to IUGG celebrating 100th anniversary

convener:Setsuya Nakada(National Research Institute for Earth Science and Disaster Resilience), Kenji Satake(Earthquake Research Institute, University of Tokyo), Kumiko Goto-Azuma(National Institute of Polar Research), Chairperson:Kumiko Goto-Azuma(National Institute of Polar Research), Setsuya Nakada(NIED)

International Union of Geodesy and Geophysics (IUGG) is one of the 40 unions in the International Science Council (ISC), celebrating its 100th anniversary in 2019. IUGG promotes and coordinates research on the interior and the periphery of the Earth. The IUGG has associations of eight research fields (IACS, IAG, IAGA, IAHS, IAMAS, IAPSO, IASPEI, and IAVCEI), which carry out semi-autonomously activities in cooperation with each other. In addition, IUGG encourages research to respond to social needs such as reduction of natural disasters and environmental conservation. The IUGG Subcommittee at the Japan Science Council's Earth and Planetary Science Committee and the eight association-committees under the former serve as representatives of Japan for the IUGG and 8 Associations.
 In this session, as IUGG celebrates its 100th anniversary, researchers related to each association exchange the ideas on the role of IUGG in earth science and the contribution that Japanese researchers should make to IUGG.

9:00 AM - 9:20 AM JST | 12:00 AM - 12:20 AM UTC

[U06-01] **Centennial of the International Cooperation in Earth and Space Sciences**

★Invited Papers

*Alik Ismail-Zadeh[1,2,3] (1.Karlsruhe Institute of Technology, 2.International Union of Geodesy and Geophysics, 3.International Science Council)

9:20 AM - 9:40 AM JST | 12:20 AM - 12:40 AM UTC

[U06-02] IUGG and Japan: the past, the present, and the way to go from now

★Invited Papers

*Masaru Kono[1] (1.Tokyo Institute of Technology)

9:40 AM - 9:55 AM JST | 12:40 AM - 12:55 AM UTC

[U06-03] **Contributions from the Science Council of Japan to international cooperation in the field of Earth and planetary science**

*Hisashi Nakamura[1] (1.Research Center for Advanced Science and Technology, University of Tokyo)

9:55 AM - 10:15 AM JST | 12:55 AM - 1:15 AM UTC

[U06-04] History and Japanese contribution to the International Association of Cryospheric Sciences IACS

★Invited Papers

*Ralf Greve[1] (1.Institute of Low Temperature Science, Hokkaido University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[U06-05] **Japan's Contributions to IAG**

*Yoichi Fukuda[1] (1.Department of Geophysics, Graduate School of Science, Kyoto University)

Centennial of the International Cooperation in Earth and Space Sciences

*Alik Ismail-Zadeh[1,2,3]

1. Karlsruhe Institute of Technology, 2. International Union of Geodesy and Geophysics, 3. International Science Council

The International Union of Geodesy and Geophysics (IUGG) was established in 1919 under the umbrella of the International Research Council (later ICSU, and now the International Science Council) as one of the unions to promote activities of existing associations dealing with geodesy, terrestrial magnetism and electricity, hydrology, meteorology, physical oceanography, seismology, volcanology. This presentation describes the origin and the development of the Union for the last century and until today. During the initial period (1919-1939), the number of member countries increased from nine founding Member countries to 35 Member countries; general assemblies were held every three years, each in a different international venue, and the number of delegates attending the assemblies increased from a few dozen to several hundred scientists. The World War II (WWII) interrupted the cooperation, and international scientific activities were resumed in 1946. The Union continued cooperation with many international scientific organizations of ICSU, and began cooperation with new intergovernmental organizations such as UNESCO and the World Meteorological Organization, and their programs. The technologies developed during the WWII were brought to bear in the extraordinary global scientific effort that was the International Geophysical Year (1957-1958). Changes in the geopolitical landscape brought about changes in the IUGG’ s structure. International campaigns encompassing multiple disciplines became commonplace, and international scientific bodies were organized. At the beginning of the 21st century IUGG added an eighth association on cryospheric sciences, developed new grants, science education, and recognition programs, and added new commissions on geophysical risk & sustainability, climatic & environmental change, data & information, and planetary sciences to existing commissions on mathematical geophysics and study of the Earth’ s deep interior. IUGG has been initiating, developing, and implementing international cooperative programs, setting scientific standards, developing research tools, educating and building capacity, and contributing to science for policy. Today, IUGG is a vibrant modern scientific union of 72 nations and scientists from all over the world promoting research, linking scientific knowledge to societal needs, and working toward a sustainable Earth.

Keywords: international cooperation, IUGG, Earth and space sciences

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IUGG and Japan: the past, the present, and the way to go from now

*Masaru Kono[1]

1. Tokyo Institute of Technology

International Union of Geodesy and Geophysics (IUGG) was formed in 1919 and held its first General Assembly in 1922. A hundred years has passed since then. Japan was one of the seven member countries which joined IUGG at the inauguration. Prof. A. Tanakadate of Tokyo University represented Japan at that time, and he was elected as one of three Vice-Presidents for 1919-1922. Since then, except the period that Japan was vetoed to take part in the Assemblies after Japan was defeated in 1945, Japan has consistently been a strong supporter of the IUGG activities.

Because of the "cold war" after the end of the world war, there were very few chances that east and west scientists meet at the same place, IUGG and other international scientific organizations were playing an important role in providing such opportunities. In particular the International Geophysical Year (IGY) of 1957-1958 was a splendid opportunity for cooperation between east and west countries. Japan took part in this project in many subject including the rocket observation, but among them, the start of the antarctic research which was carried out with the concent of the international community, was a highlight of this project.

Several decades have passed since then. In these years, the status of IUGG became quite low. IUGG holds it General Assembly every four years, collecting 3000 to 4000 scientists, but AGU Fall meeting is held every year, and nowadays they receive about 30,000 participants while keeping the scientific standards quite high. Nowadays, there are EGU, JpGU, and others which collect more than 10,000 participants. These societies also have well-cited jounals to output scientific results in printed form. It looks that there is little possibility that IUGG can compete with these societies in the scientific merit.

With these situations in mind, which way should IUGG go in the future? One possibility is to work in problems which concerns the whole Earth, and thus it is impossible to find the solution in a single country. A clear example of such a problem is the Global Warming. The international scientific organization which deals with this is IPCC, but the scientists working in IPCC have strong ties with some of the Associations in IUGG (eg., IAMAS, IAPSO, IAHS). Another possibility is to look for a scientifically important probem, which usually has small number of scientists engaged in the problem. A good example in IUGG is SEDI which works in the deep interior of the Earth. It is also an interdisciplinary science including seismology, geomagnetism and others. SEDI seems to prosper by providing an interdisciplinary platform for these hundred or so very high-level scientists.

Keywords: IUGG, International cooperation, Way to go from now

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Contributions from the Science Council of Japan to international cooperation in the field of Earth and planetary science

*Hisashi Nakamura[1]

1. Research Center for Advanced Science and Technology, University of Tokyo

Since its establishment in 1949, the Science Council of Japan (SCJ) has made a variety of contributions to international academic cooperation in every field of natural and social sciences as an official member of the International Science Council (ICSU: currently InterAcademy Council). The budget for international commitment has been stable in spite of continuous decline of the entire budget of SCJ. Recognizing that international cooperation is essential for research activities in the field of Earth and planetary science, ICSU has promoted the International Geophysical Year (IGY: 1957-58) and the 4th International Polar Year (IPY: 2007-08), while offering its membership to 12 international unions/associations in our field, including the International Union of Geodesy and Geophysics (IUGG). Under this international framework, the Japanese government has been offering financial support to those unions/associations through SCJ, in which 12 branch committees are organized under the Earth and Planetary Science Committee to appoint some members as delegates to executive meetings of those unions/associations and promote related domestic activities. In addition, SCJ co-hosts a general assembly of an international union/association held in Japan under the approval of the SCJ International Affairs Committee, as exemplified by the 2017 IAG-IASPEI Joint Scientific Assembly in Kobe. This presentation offers an overview of specific contributions from SCJ to international cooperation in the field of Earth and planetary science.

Keywords: Science Council of Japan, international cooperation, IUGG

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History and Japanese contribution to the International Association of Cryospheric Sciences IACS

*Ralf Greve[1]

1. Institute of Low Temperature Science, Hokkaido University

The International Association of Cryospheric Sciences, or IACS, is the eighth association of the International Union of Geodesy and Geophysics (IUGG), launched by the IUGG Council on 2007-07-04. Despite being the latest of the IUGG associations, IACS looks back on a history of 125 years, starting with the International Commission on Glaciers (Commission Internationale des Glaciers) founded in 1894. It then evolved via the International Commission of Snow and Ice (ICSI) of the International Association of Hydrological Sciences (IAHS) and the transitional Union Commission for the Cryospheric Sciences (UCCS) into its current constitution as an independent IUGG association, recognizing the increased importance of cryospheric sciences within the context of Global Change. In this presentation, we will outline the history of IACS and its precursor organizations, describe the current activities of IACS and highlight the Japanese links with IACS in the form of contributions to its governance, divisions and research activities.

Keywords: IUGG, IACS, Cryosphere, Cryospheric sciences, Earth sciences

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Japan's Contributions to IAG

*Yoichi Fukuda[1]

1. Department of Geophysics, Graduate School of Science, Kyoto University

In this presentation we introduce the roles of the modern geodesy and the activities of IAG (the International Association of Geodesy) as well as the Japan's contributions to IAG.

Keywords: International Association of Geodesy, GGOS

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[J] Oral | U (Union)：Union

Thu. May 30, 2019 10:45 AM - 12:15 PM JST | Thu. May 30, 2019 1:45 AM - 3:15 AM UTC | IC 2F

[U-06] Japan's contribution to IUGG celebrating 100th anniversary

convener:Setsuya Nakada(National Research Institute for Earth Science and Disaster Resilience), Kenji Satake(Earthquake Research Institute, University of Tokyo), Kumiko Goto-Azuma(National Institute of Polar Research), Chairperson:Kumiko Goto-Azuma(National Institute of Polar Research), Kenji Satake(Earthquake Research Institute, the University of Tokyo)

International Union of Geodesy and Geophysics (IUGG) is one of the 40 unions in the International Science Council (ISC), celebrating its 100th anniversary in 2019. IUGG promotes and coordinates research on the interior and the periphery of the Earth. The IUGG has associations of eight research fields (IACS, IAG, IAGA, IAHS, IAMAS, IAPSO, IASPEI, and IAVCEI), which carry out semi-autonomously activities in cooperation with each other. In addition, IUGG encourages research to respond to social needs such as reduction of natural disasters and environmental conservation. The IUGG Subcommittee at the Japan Science Council's Earth and Planetary Science Committee and the eight association-committees under the former serve as representatives of Japan for the IUGG and 8 Associations.
 In this session, as IUGG celebrates its 100th anniversary, researchers related to each association exchange the ideas on the role of IUGG in earth science and the contribution that Japanese researchers should make to IUGG.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[U06-06] IAGA activities in the era of too many international conferences

*Toshihiko Iyemori[1] (1.Kyoto University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[U06-07] The role of IAHS in education, research, social issues concerning water and future perspective

*Maki Tsujimura[1] (1.Faculty of Life and Environmental Sciences, University of Tsukuba)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[U06-08] Centenary of the atmospheric sciences: Its progress and future issues

*Teruyuki Nakajima[1] (1.Japan Aerospace Exploration Agency)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[U06-09] Contributuins of Japan to IAPSO

*Yukio Masumoto[1] (1.Graduate School of Science, The University of Tokyo)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[U06-10] IASPEI- activities, history and Japan’s contribution

*Kenji Satake[1], Thorne Lay[2], Johannes Schweitzer[3] (1.Earthquake Research Institute, University of Tokyo, 2.IASPEI President , 3.IASPEI Secretary General)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[U06-11] Recent history of IAVCEI in Japan and young researchers’ response to IUGG and IAVCEI

*Setsuya Nakada[1] (1.National Research Institute for Earth Science and Disaster Resilience)

IAGA activities in the era of too many international conferences

*Toshihiko Iyemori[1]

1. Kyoto University

During the last 20 years, the size of international meeting such as AGU, EGU and AOGS has been getting larger and larger, and they are now the major place for the researchers in geoscience and space science to show their results and collect new information. This tendency is the same also for the scientists in our country, and the role of IAGA need to change its role. In this presentation, IAGA activities and our contribution in the last 20 years will be presented.

Keywords: geomagnetism and aeronomy, international conference

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The role of IAHS in education, research, social issues concerning water and future perspective

*Maki Tsujimura[1]

1. Faculty of Life and Environmental Sciences, University of Tsukuba

IAHS (International Association of Hydrological Sciences) was launched in 1922, and now have approximately 5500 individuals, 10 commissions and 3 working groups. The Scientific Assembly is held every 4 years and held in Yokohama, Japan 1993. Professor in Emeritus Dr. Kuniyoshi Takeuchi, Yamanashi University has served as a president of IAHS from 2001 through 2005, thus Japan has taken an important role in IAHS.

The commission consists of Continental Erosion, Coupled Land-Atmosphere Systems, Groundwater, Remote Sensing, Statistical Hydrology, Snow and Ice Hydrology, Surface Water, Tracers, Water Quality, Water Resources Systems, and it covers a variety of field in hydrology. Also, a working group “PANTA RHEI –Change in Hydrology and Society” has been launched in 2013 focusing on changing hydrological cycle system with changing human system.

The Japan National Committee of IAHS in cooperation with Japan National Committee of IHP (International Hydrology Programme) hold a symposium “Japan Water 2012: International Contribution from Japan in education/ research of water science and technology”. Also, Japan Association of Hydrology and Water Resources, Japanese Association of Hydrological Sciences, Japanese Association of Groundwater Hydrology and Japan Society of Physical Hydrology collaborated to publish Hydrological Research Letters (HRL) since 2017. Additionally, IAEA (International Atomic Energy Agency) Regional Training Course on Isotopic Data Processing and Interpretation –Hands on Exercises is held in March 2019, Tsukuba, Japan supported by Japan National Committee of IAHS and Japan National Committee of IHP.
On the other hand, the changing environment in hydrology and water resources in Japan and the world requires the change of the role in IAHS. We need to promote a collaboration between IAHS and IHP, early career support and career paths developments in future.

Keywords: IAHS

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Centenary of the atmospheric sciences: Its progress and future issues

*Teruyuki Nakajima[1]

1. Japan Aerospace Exploration Agency

IAMAS (International Association of Meteorology and Atmospheric Sciences), one of associations of IUGG (International Union of Geodesy and Geophysics), celebrates in 2019 its centenary after establishment with IUGG. Held are commemorative projects and memorial events at the IUGG general meeting in Montreal in this July. Atmospheric science has long been developed as a science related to various weather phenomena related to the lives of mankind. As a result, there are many important issues related to society. Especially over the past 100 years, there are major developments such as establishment of weather prediction infrastructure, researches to global warming problem and environmental problems such as ozone hole etc. An overview of these progresses will be important for us to think about what we should do next. In particular, in this era, as climate and environment changes have become apparent and disasters increase, observation and understanding of the phenomena is increasingly necessary through collaborations with other areas such as the social science etc. I like to discuss that point.

Keywords: Atmospheric sciences, 100 years

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Contributuins of Japan to IAPSO

*Yukio Masumoto[1]

1. Graduate School of Science, The University of Tokyo

The International Association for the Physical Sciences of the Oceans (IAPSO) is one of eight associations of the International Union of Geodesy and Geophysics (IUGG). IAPSO is promoting the study of scientific problems relating to the oceans and the interactions taking places at the sea floor, coastal, and atmospheric boundaries insofar as such research is conducted by the use of mathematics, physics, and chemistry. IAPSO has addressed this goal through four fundamental objectives: (1) Organize, sponsor, and co-sponsor formal and informal international forums permitting ready means of communication amongst ocean scientists throughout the world; (2) Establish commissions, sub-committees, and organize commensurate workshops to encourage, stimulate, and coordinate new and advanced international research activities; (3) Provide basic services significant to the conduct of physical oceanography, and (4) Publish proceedings of symposia, meetings, and workshops, and fundamental references on the current state-of-the art and knowledge of physical oceanography.
The Japanese ocean research communities have been contributing to IAPSO mainly through their research activities at the IAPSO assemblies and through administrative works by taking a position of the exective committee member for about 20 years, with the president position by Prof. Imawaki for four years from 2003. This presentation summarizes the Japanese contributions to IAPSO and discuss on future relation between the Japanese research communities and IAPSO.

Keywords: Ocean Sciences, IAPSO, the Decade of Ocean Science for Sustainable Development

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IASPEI- activities, history and Japan’s contribution

*Kenji Satake[1], Thorne Lay[2], Johannes Schweitzer[3]

1. Earthquake Research Institute, University of Tokyo, 2. IASPEI President , 3. IASPEI Secretary General

IASPEI (International Association of Seismology and Physics of the Earth’s Interior) is one of the eight associations of IUGG, and promotes the study of earthquakes and other seismic sources, the propagation of seismic waves, and the Earth's internal structure, properties, and processes. IASPEI has seven commissions on seismological observation and interpretation, on tectonophysics and crustal structure, on earthquake generation process - physics, modelling, and monitoring for forecast, on earth structure and geodynamics, on earthquake hazard, risk and strong ground motion, on earthquake source mechanics, and on education and outreach. Besides these topical commissions, IASPEI has their regional commissions in Europe (since 1951), Asia (since 1996), Africa (since 2011) and Latin America (since 2013). These regional commissions meet bi-annually, typically with training courses, to promote seismology in each region.

Seismology started as national scale for describing the earthquake phenomena and their effects. First seismological societies were established in Switzerland (1878), in Italy (1879) and in Japan (1880). After the first teleseismic recording in Germany from an earthquake in Japan (1889), seismology became an international science, and Frist International Seismological Conference was held in Strasbourg in 1901, representing 8 countries including Japan. In 1904, International Seismological Society was established. In 1922, it became a part of IUGG (established in 1919), with changing name to IAS in 1930 and IASPEI in 1951.

IASPEI plays important roles in unifying seismological observations, such as naming seismic phases, defining measurement procedures, or improving the network of seismic stations, and published Manuals of Seismological Observatory Practice (the latest version in 2012). IASPEI has a close relation with International Seismological Centre, which has produced seismological bulletins based on the IASPEI standard. IASPEI also provided standard seismic velocity structure models of the earth, such as iasp91 or ak135. Global distribution of earthquakes in the earth and the reference earth models have been important basic data for developing the science such as plate tectonics, or structure and dynamics of the earth’s interior. IASPEI also conducted peer reviews and evaluated the published precursory phenomena for earthquakes. IASPEI developed and distributed seismological software, and International Handbook of Earthquake and Engineering Seismology.

IASPEI supports FDSN (International Federation of Digital Seismograph Networks) which is composed of groups responsible for installation and maintenance of seismological networks, and activities of CTBTO (Comprehensive Test-Ban Treaty Organization) which uses seismic data to detect nuclear explosions. IASPEI also supports joint commissions with other associations of IUGG, such as ILP (International Lithosphere Project), on tsunamis, volcanology or on space geodesy.

The IASPEI commission of Seismological Society of Japan practically acts as the national committee of IASPEI, and disseminates IASPEI information to Japanese seismological community, nominates officers and award candidates. SSJ has made financial supports to ASC (Asian Seismological Commission) and IASPEI, for travel support of participants and for management of the ASC meetings. Several members of executive committees and chairs of commission are elected from Japan. The last scientific assembly of

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IASPEI, joint with IAG, was held in Kobe, Japan, in 2017 with great success.

Keywords: IASPEI, Seismology, IUGG

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Recent history of IAVCEI in Japan and young researchers' response to IUGG and IAVCEI

*Setsuya Nakada[1]

1. National Research Institute for Earth Science and Disaster Resilience

Japanese volcano researchers, especially young scientists, do not recognize well the relationship of IAVCEI with IUGG. IUGG is less visible than IAVCEI to them. The latter used to be introduced first as the international conference that they can challenge. IAVCEI is visible also in the Volcanological Society of Japan (VSJ) of which they are members. Japanese researchers served as the executive board members of IAVCEI, such as its presidents by Hisashi Kuno, Shigeo Aramaki, and Setsuya Nakada for these 100 years. Scientific Assemblies of IAVCEI were held in Japan in 1962, 1981, and 2013. The Cities on Volcanoes (COV) is the second largest international conference of IAVCEI, held every two years between the years of IAVCEI Scientific Assembly and IUGG General Assembly since 1998. COV conference originates from the International Volcano Conference, which was held in the Kagoshima City in 1988, as a forum between scientists and non-scientists for mitigating volcanic disasters. The fifth COV conference was held in the Shimabara City in 2007.

In spite of the fact that IUGG General Assembly was held in Sapporo in 2003, it seems that IUGG has not become well known among young, possibly middle-aged volcano researchers. For example, recent IAVCEI Science Assembly gathers over 1000 participants, while there are only about 300 participants at General Assemble of IAVCEI when IUGG. The latter number is much smaller than around 1000 participants of recent COV. Though one of the reasons may be few excursions for volcanologists, organized in IUGG conferences, it is likely that a simple reason is the size of fields covered by the conferences. Each association itself is wide in fields enough and the assemble of 8 associations will be too wide for young researchers to attend. They may feel not comfortable like business even in AGU and EGU, contrasting to comfort in own associational conference.

This may be similar to the relationship between JpGU and individual national societies. We have to confirm and share the merit of assemblage of large international associations having fields related to but different from each other. In addition, roles of government-contributing organization like IUGG and International Science Council (ISC) should be confirmed among us. In this case, increasing the number of participants to the conference is not the first priority. Global climate change and regional geological hazards such as large earthquakes and volcanic eruptions have become worldwide high priority issues to reduce the risks. Under this situation, the United Nation clarified the sustainable development goals (SDGs) until 2030, therefore, the missions by IUGG and ISC, which are guaranteed by governments, have expanded to solve these issues.

Keywords: IAVCEI, IUGG, geohazard, SDGs

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[J] Oral | U (Union)：Union

Thu. May 30, 2019 1:45 PM - 3:15 PM JST | Thu. May 30, 2019 4:45 AM - 6:15 AM UTC | 101 1F

[U-08] Opinions and recommendations from meeting participants to the future of the Japan Geoscience Union

convener:Yozo Hamano(KOBE Ocean-Bottom Exploration Center, Kobe University), Eiichi Tajika(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Koji Wada(Planetary Exploration Research Center, Chiba Institute of Technology), Ikuro Sumita(Geosciences and Civil Engineering, Institute of Science and Engineering, Kanazawa University), Chairperson:Koji Wada(Planetary Exploration Research Center, Chiba Institute of Technology), Ikuro Sumita

The JpGU meeting 2019 will be the 30th since the start of the Joint Meeting of the Earth and Planetary Science societies, and 15th after the foundation of the Japan Geoscience Union (JpGU).Today, JpGU is becoming indispensable for the Earth and Planetary Science community due to the significant increase in the number of participants and the progress towards one of the International Organization of Geosciences. However, since the voluntary group that originally started aggregating the individual's intentions of the community, grew to a huge organization of about 10,000 members, it becomes rather difficult to reflect requests and opinions as individuals. In addition, by becoming a public interest corporation, it is rather difficult to operate as an academic organization under the constraints of the public interest corporation law. In aiming for further development of JpGU in the future, we would like to invite all the participants of the meeting to express their strict opinion and constructive proposal for the future of JpGU. The opinions of participants will be valuable materials for considering the direction of JpGU after 2020. We would like to invite many participants to present opinions and recommendations from various viewpoints, returning to the bottom-up spirit which is the basic philosophy of the science community.

1:45 PM - 1:51 PM JST | 4:45 AM - 4:51 AM UTC

Introduction

1:51 PM - 2:03 PM JST | 4:51 AM - 5:03 AM UTC

[U08-01] Request and proposal from the Committee on Earth and Planetary Sciences of the Science Council of Japan to JpGU

*Ryoichi Fujii[1] (1.Research Organization of Information and Systems)

2:03 PM - 2:15 PM JST | 5:03 AM - 5:15 AM UTC

[U08-02] Geography in JpGU: current status and future perspectives

*Takashi Oguchi[1], Ikuho Yamada[2], Yuichi S. Hayakawa[3], Daichi Kohmoto[4], Hitoshi Saito[5] (1.Center for Spatial Information Science, The University of Tokyo, 2.Faculty of Science and Engineering, Chuo University, 3.Graduate School of Env.Science, Hokkaido University , 4.Nara University of Education, 5.College of Economics, Kanto Gakuin University)

2:15 PM - 2:27 PM JST | 5:15 AM - 5:27 AM UTC

[U08-03] Biogeoscineces will connect everthing together

*Takeshi Kakegawa[1] (1.Graduate School of Science, Tohoku University)

2:27 PM - 2:39 PM JST | 5:27 AM - 5:39 AM UTC

[U08-04] Coverage of JpGU

*Yukihiro Takahashi[1] (1.Department of Cosmosciences, Graduate School of Science, Hokkaido University)

2:39 PM - 2:51 PM JST | 5:39 AM - 5:51 AM UTC

[U08-05] Is he a bit overkill for English?

*Yoshi-Yuki Hayashi[1] (1.Department of Planetology/CPS, Graduate School of Science, Kobe University)

2:51 PM - 3:03 PM JST | 5:51 AM - 6:03 AM UTC

[U08-06] Globalization of Japan Geoscience Union

*Hirokuni Oda[1] (1.Institute of Geology and Geoinformation, Geological Survey of Japan, AIST)

3:03 PM - 3:15 PM JST | 6:03 AM - 6:15 AM UTC

[U08-07] A proposal for JpGU based on the questionaires to SSJ members

*Koshun Yamaoka[1] (1.Earthquake and Volcano Research Center, Graduate School of Environmental Studies, Nagoya University)

Request and proposal from the Committee on Earth and Planetary Sciences of the Science Council of Japan to JpGU

*Ryoichi Fujii[1]

1. Research Organization of Information and Systems

Japan Geoscience Union (JpGU) and the Committee on Earth and Planetary Sciences (EPS) of the Science Council of Japan (SCJ) has long been collaborating closely for the wide developments of earth and planetary sciences. Recent collaborations are being done, e.g., for the revision of the dream roadmap and the proposal of the large-scale research programs.
In this presentation we would like to present our request and proposal to JpGU and to discuss in depth the future, closer collaborations between the two organizations.

Keywords: JpGU, Dream roadmap, Science Council of Japan

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Geography in JpGU: current status and future perspectives

*Takashi Oguchi[1], Ikuho Yamada[2], Yuichi S. Hayakawa[3], Daichi Kohmoto[4], Hitoshi Saito[5]

1. Center for Spatial Information Science, The University of Tokyo, 2. Faculty of Science and Engineering, Chuo University, 3. Graduate School of Env.Science, Hokkaido University , 4. Nara University of Education, 5. College of Economics, Kanto Gakuin University

Although some geographers and geographical societies have been members of JpGU, the majority of geographers in Japan seldom contribute to JpGU activities. One reason for this is that more than half of Japanese geographers are specialized in human geography, whereas JpGU focuses on physical sciences. However, interdisciplinary studies integrating arts and sciences are becoming all the more important, and modern geography linked to natural hazards and global environmental issues requires knowledge of earth sciences. Therefore, geography in JpGU should play an increasing role. This presentation aims to discuss how to strengthen collaborative relationships between JpGU and geographers.

Keywords: Geography, JpGU, Collaboration

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Biogeoscineces will connect everthing together

*Takeshi Kakegawa[1]

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Biogeosciences Section is unique compared to other sections at JPGU. Other sections have strong affiliation with big national projects, such as wide-sale observation of earthquake, space mission, climate change observation, etc. As a result, Biogeosciences Section has difficulty to establish main or leading subjects in JPGU. Scientific subjects and themes are often overlapped between Biogeosciences Section and other sections. This makes presence of Biogeosciences Section unclear at JPGU. In order to promote Biogeosciences Sections, I am going to suggest some points. It will be important to establish strategic collaborations with other sections of JPGU and other communities, such as microbiology, ecology, agriculture, and /or bio-engineering fields. I think that organizing temporal sections with other communities or having invite speaker from other community will be effective. Biogeosciences Sections should have more functions as an interface with others.

Keywords: Earth, Life

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Coverage of JpGU

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Geoscience unions originally started from classical several categories, namely, solid earth, atmosphere, land and ocean water, upper atmosphere and space, and plant. However, in AGU or EGU, adding to those conventional fields, many new science targets or methodologies are becoming important player in the union. Especially, biology including agriculture and natural hazard became one of the largest communities. On the other hand, such movement in JpGU is going at very slow speed. Here we discuss the strategy about this matter.

Keywords: Coverage , Union

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Is he a bit overkill for English?

*Yoshi-Yuki Hayashi[1]

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English is taught in English or a special subject is also taught in English, indeed, English has been introduced to elementary school, and English examination of college entrance examination has become to be said to be four skill test today, lead this The importance of "international" importance of the leadership including not only the Keidanren that causes it but also the academic community, the direction of individuals' shooting spirit towards these, ... that socioeconomic and cultural academic background I do not know that the various aspects of JpGU are no exception.

However, has not underestimated the influence of stopping recharging of the Japanese space which I have been working diligently since the Meiji era so that education and practice up to the research level can be conducted in my mother tongue almost exclusively in European languages? Do you think that a Japanese language space and its operation ability are natural there and there is nothing to think that it is acquired naturally? As a mother tongue is being trained, we have a wide width and deep depth Although I am able to acquire imagination comprehension ability with, but because it is too "nature" its cost and power can not be forecasted easily, but I am worried that the power is rapidly declining.The language is recharged It goes without saying that training is necessary in order to master this.

I can not predict how far the convergence of language (Englishization) will proceed.The leap in China may brake somebody, but if it keeps it as it is, it will be several generations and Japanese will become a daily word It is a momentum to degenerate into a language that can only be used for the languages of European languages Unlike the multilingualization of the European languages group, it is not easy for the language system to respond at a high level to multilingualization between different languages If you try to secure the breadth and depth of thinking you will have to concentrate on a specific language system and you may be made to choose to switch at the language selection stage. I do not like being there, so I wonder if there can be an avalanche decline.
Advanced knowledge is accumulated in the English space Today, it is desirable to improve the management system to ensure that it contributes to the participation in the Japanese-English system, and it is also wonderful to build an operational system that can accept English sessions. I would like to have English, I would like to forcibrate that the material must be in English, eliminate Japanese sessions that emphasize Japanese language spaces and emphasize provision of knowledge to those with their native language. I would like to be able to accept it rather than it.

By the way I put a raw google translation in English abstract AI seems to need a little time to engage in this issue.

Keywords: Englishization problem

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Globalization of Japan Geoscience Union

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In the presentation, globalization of Japan Geoscience Union (JpGU) is going to be discussed as a member. Although activities of JpGU is broad, JpGU annual meeting and academic publishing are considered as the key pillars. Also, the necessity of globalization on these two have been emphasized. On academic publishing, journal PEPS has been started on 2014 supported by Grant-in-Aid for Publication of Scientific Research Results "Enchancement of International Dissemination of Information" of JSPS. In addition, Impact Factor 2017 has been given to the journal and its future is promising. JpGU meeting was jointly organized successfully with AGU in 2017 and the next JpGU-AGU meeting will be held in 2020. Although globalization of JpGU meeting has been promoted, Japanese language is also considered as important. The burden on the participants and organizers of the meeting by the requirements both in English and Japanese cannot be ignored. Also, there seems to be a barrier in inviting researchers to JpGU meeting from abroad, where number of international sessions and attendees are limited. Number of international meetings on geosciences has been increasing and relative importance of JpGU meeting in the world is decreasing. Thus, the meaning of globalization for JpGU and significant increase of the number of English sessions (or significant decrease of the number of Japanese sessions) of JpGU meeting will be discussed.

Keywords: globalization, academic publishing, JpGU meeting, attendees from abroad, Joint meeting with AGU

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A proposal for JpGU based on the questionaires to SSJ members

*Koshun Yamaoka[1]

1. Earthquake and Volcano Research Center, Graduate School of Environmental Studies, Nagoya University

The Seismological Society of Japan (hereafter, SSJ) is one of the original members of the group which is ancestral of present JpGU. The group consists of several societies including SSJ organized a joint meeting instead of independent meetings which were usually held in early April every year. In this historical circumstances SSJ expects JpGU meeting as one of the regular meetings of SSJ in addition to the SSJ fall meeting. In this regard, sessions that are equivalent to those in the SSJ fall meeting are proposed for JpGU meeting every year.
Academic society exists because members expect benefits in participating the society. Similarly member societies such as SSJ also expect benefits in participating JpGU. JpGU is expected to represent academic community of earth and planetary science, which is sometimes called geoscience, of Japan to raise visibility and recognition in Japan’ s society. Visibility of geoscience, especially in high school education, is still low in spite of Japan’ s geological unstableness. This is one reason that Japan has underestimated the risk of geohazards. Academic characteristics of geoscience which inevitably need tackle the complexity, irreversibility and unrepeatability of earth’ s process is sometimes unreasonably degraded relative to other fields. JpGU also works for encouraging collaboratory researches beyond conventional discipline and national boundaries.
The results of such function of JpGU are sometimes opposed to by members. One member of SSJ make an opposition of the management of JpGU meeting, saying that JpGU meeting is too long, too expensive and too much obsequious to English language. The first issue come from the recent condition of universities, in which academic schedule is getting more and more tight. SSJ send questionnaires asking for such an opinion is common or not. Half of the answers favor the opinion although 2/3 of the answers express the satisfaction in participating JpGU meeting. More effort should be made on the session scheduling by considering the participants’ needs. 90% of the answer favors variety of JpGU sessions which cannot be enjoyed in the independent society meeting. I am personally happy to be able to have sessions in English in regular scientific meetings in Japan because English is de facto common language in science community, and because it is what I dreamed when joint meeting started when I was young.
Another function to be expected to JpGU is providing inter-society communication opportunity. Recently many societies suffer gradual decline of members, especially of young generation. Sharing administration may be one of the measures against financial decline. Merging of societies can also be a solution. We need to look for a relation between JpGU and each societies for the development of science.

Keywords: Seismological Society of Japan, questionnaire

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[J] Oral | U (Union)：Union

Thu. May 30, 2019 3:30 PM - 5:00 PM JST | Thu. May 30, 2019 6:30 AM - 8:00 AM UTC | 101 1F

[U-08] Opinions and recommendations from meeting participants to the future of the Japan Geoscience Union

convener:Yozo Hamano(KOBE Ocean-Bottom Exploration Center, Kobe University), Eiichi Tajika(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Koji Wada(Planetary Exploration Research Center, Chiba Institute of Technology), Ikuro Sumita(Geosciences and Civil Engineering, Institute of Science and Engineering, Kanazawa University), Chairperson:Koji Wada(Planetary Exploration Research Center, Chiba Institute of Technology), Ikuro Sumita

The JpGU meeting 2019 will be the 30th since the start of the Joint Meeting of the Earth and Planetary Science societies, and 15th after the foundation of the Japan Geoscience Union (JpGU).Today, JpGU is becoming indispensable for the Earth and Planetary Science community due to the significant increase in the number of participants and the progress towards one of the International Organization of Geosciences. However, since the voluntary group that originally started aggregating the individual's intentions of the community, grew to a huge organization of about 10,000 members, it becomes rather difficult to reflect requests and opinions as individuals. In addition, by becoming a public interest corporation, it is rather difficult to operate as an academic organization under the constraints of the public interest corporation law. In aiming for further development of JpGU in the future, we would like to invite all the participants of the meeting to express their strict opinion and constructive proposal for the future of JpGU. The opinions of participants will be valuable materials for considering the direction of JpGU after 2020. We would like to invite many participants to present opinions and recommendations from various viewpoints, returning to the bottom-up spirit which is the basic philosophy of the science community.

3:30 PM - 3:42 PM JST | 6:30 AM - 6:42 AM UTC

[U08-08] Opinions and recommendations to the Japan Geoscience Union from Society of Geomagnetism and Earth, Planetary and Space Sciences

Yoshiharu Omura[2], Shigeto Watanabe[3], *Yuto Katoh[1], Takuya Tsugawa[4], Yuichi Otsuka[5], SGEPSS steering committee (1.Graduate School of Science, Tohoku University, 2.Research Institute for Sustainable Humanosphere, Kyoto University, 3.Hokkaido Information University, 4.National Institute of Information and Communications Technology, 5.Institute for Space–Earth Environmental Research, Nagoya University)

3:42 PM - 3:54 PM JST | 6:42 AM - 6:54 AM UTC

[U08-09] Collaboration between Earth & Planetary Science and Information Science ~A trial of mutual benefit in the interdisciplinary field~

*Hirohide Demura[1] (1.The University of Aizu)

3:54 PM - 4:06 PM JST | 6:54 AM - 7:06 AM UTC

[U08-10] Comments from young planetary scientists

*Shunichi Kamata[1], Keiko Hamano[2], Go Murakami[3], Ryuki Hyodo[2], Yusuke Nakauchi[3] (1.Hokkaido University, 2.Tokyo Institute of Technology, 3.JAXA/ISAS)

4:06 PM - 4:18 PM JST | 7:06 AM - 7:18 AM UTC

[U08-11] Japan Geoscience Union should operate based on the perspective of individual academic society and fulfill accountability

*Naoji Koizumi[1] (1.School of Environmental Science,the University of Shiga Prefecture)

4:18 PM - 4:30 PM JST | 7:18 AM - 7:30 AM UTC

[U08-12] A proposal from a representative of General Geoscience Sector on a possible direction to future JpGU: actions for domestic activities could be weighted

*Hidenori Kumagai[1] (1.Japan Agency for Marine-Earth Science and Technology)

4:30 PM - 4:42 PM JST | 7:30 AM - 7:42 AM UTC

[U08-13] Fifteen years of Japan Geoscience Letters and its future

*Shogo Tachibana[1], Eiichi Tajika[2] (1.UTokyo Organization for Planetary and Space Science, University of Tokyo , 2.Dept. Earth and Planetary Science, University of Tokyo)

4:42 PM - 5:00 PM JST | 7:42 AM - 8:00 AM UTC

Discussion

Opinions and recommendations to the Japan Geoscience Union from Society of Geomagnetism and Earth, Planetary and Space Sciences

Yoshiharu Omura[2], Shigeto Watanabe[3], *Yuto Katoh[1], Takuya Tsugawa[4], Yuichi Otsuka[5], SGEPSS steering committee

1. Graduate School of Science, Tohoku University, 2. Research Institute for Sustainable Humanosphere, Kyoto University, 3. Hokkaido Information University, 4. National Institute of Information and Communications Technology, 5. Institute for Space–Earth Environmental Research, Nagoya University

We present opinions and recommendations to the future of the Japan Geoscience Union (JpGU) from members of Society of Geomagnetism and Earth, Planetary and Space Sciences (SGEPSS). The opinions and recommendations are categorized into (1) opinions for the future perspective of JpGU and (2) comments and requests to the organization of the JpGU meeting.

- Future perspective of JpGU as an international meeting and the relation with AOGS

- Increase the number of sessions jointly organized by multiple societies

- Official channel of opinions/suggestions from participants/conveners to JpGU

In this presentation, we summarize the opinions and recommendations from the members of SGEPSS.

Keywords: Opinions and recommendations, Society of Geomagnetism and Earth, Planetary and Space Sciences

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Collaboration between Earth & Planetary Science and Information Science ~A trial of mutual benefit in the interdisciplinary field~

*Hirohide Demura[1]

1. The University of Aizu

Earth and planetary science is interdisciplinary one. This introduces collaboration between Earth & Planetary Science and Information Science in the University of Aizu as a trial of mutual benefit in the interdisciplinary field. I hope exchanging frank opinions about the future of our JpGU.

Keywords: Earth and Planetary Science , Information Science, interdisciplinary field

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Comments from young planetary scientists

*Shunichi Kamata[1], Keiko Hamano[2], Go Murakami[3], Ryuki Hyodo[2], Yusuke Nakauchi[3]

1. Hokkaido University, 2. Tokyo Institute of Technology, 3. JAXA/ISAS

We will present comments to JpGU from young researchers in planetary sciences.

Keywords: JpGU, Future

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Japan Geoscience Union should operate based on the perspective of individual academic society and fulfill accountability

*Naoji Koizumi[1]

1. School of Environmental Science,the University of Shiga Prefecture

Japan Geoscience Union (JpGU) is no longer a bottom-up organization but a top-down organization. JpGU should recognize it and operate based on the perspective of individual academic society and fulfill accountability

Keywords: Japan Geoscience Union

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A proposal from a representative of General Geoscience Sector on a possible direction to future JpGU: actions for domestic activities could be weighted

*Hidenori Kumagai[1]

1. Japan Agency for Marine-Earth Science and Technology

As one of the representative of General Geoscience Sector, here I pointed following items as to be discussed in order to strengthen foundations of JpGU through activation and diversification of domestic earth science community: 1) too much internationalization is to be suppressed, 2) accessibility for the members outside the metropolitan area or the member societies, 3) support for member societies and 4) enhance the function as the "Union." Details described in Japanese (see abstract written in Japanese).

Keywords: General Geoscience Sector, diversify earth science community, focus to domestic activity

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Fifteen years of Japan Geoscience Letters and its future

*Shogo Tachibana[1], Eiichi Tajika[2]

1. UTokyo Organization for Planetary and Space Science, University of Tokyo , 2. Dept. Earth and Planetary Science, University of Tokyo

It has been 15 years since the first issue of Japan Geoscience Letters (JGL), which is a newsletter of JpGU. Fifty-five issues have been published with 157 articles on hot topics in the Earth and planetary science field. The JGL has been a window into various disciplines in Earth and planetary science and is potentially be a good outreach tool to the society. There are many things to do to make the JGL better as the newsletter of JpGU that has been expanding as the largest geoscience community in Japan. However, it is not possible to make them a reality because of limited human resources. In this talk, we will discuss the 15-year publication activity of JGL and its future.

Keywords: Japan Geoscience Letters , Outreach

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[J] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

Thu. May 30, 2019 9:00 AM - 10:30 AM JST | Thu. May 30, 2019 12:00 AM - 1:30 AM UTC | 103 1F

[P-PS08] Lunar science and exploration

convener:Hiroshi Nagaoka(Japan Aerospace Exploration Agency), Masahiro KAYAMA(Department of Earth and Planetary Material Sciences, Faculty of Science, Tohoku University), Masaki N Nishino(Japan Aerospace Exploration Agency, Institute of Space and Astronautical Science), Tomokatsu Morota(Graduate School of Environmental Studies, Nagoya University), Chairperson:Satoshi Tanaka, Masaki Nishino(名古屋大学宇宙地球環境研究所)

Scientific data sets acquired by not only Japanese lunar mission SELENE (Kaguya), but also other countries' missions, have become new standard for lunar science. Analyses of these data have been providing several new knowledge and changing some hypotheses into the truth of the Moon. In concurrence with these studies, some countries including Japan are planning future lunar missions. In this session, we will discuss scientific results based on newly acquired lunar data, strategy for future missions including SLIM, and theoretical and experimental studies for lunar science.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[PPS08-01] Observing simulations of impact-induced moonquakes combined with the lunar impact flash observation data for future lunar seismic explorations

*Keisuke Onodera[1,2], Taichi Kawamura[3], Satoshi Tanaka[2], Yoshiaki Ishihara[4], Takuto Maeda[5], Masahisa Yanagisawa[6], Yuki Uchida[6], Shinsuke Abe[7], Ryuhei Yamada[8], Takaya Okamoto[2] (1.SOKENDAI (The Graduate University for Advanced Studies), 2.Institute of Space and Astronautical Science / Japan Aerospace Exploration Agency, 3.Insitut de Physique du Globe de Paris, 4.National Institute for Environmental Studies, 5.Hirosaki University, 6.The University of Electro-Communications, 7.Nihon University, 8.University of Aizu)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[PPS08-02] New Results from Restored Apollo Magnetic Field Records

*Peter J Chi[1] (1.University of California Los Angeles)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[PPS08-03] Analysis of the High Latitude Region of the Moon with Spectral Profiler Data: Possible Presence of Water Ice

Haramitsu Kyoda[3], *Satoshi Tanaka[1], Makiko Ohtake[1], Hiroshi Nagaoka[2], Yusuke Nakauchi[2], Keisuke Onodera[4] (1.Department of Solid Planetary Sciences Institute of Space and Astronautical Science, 2.Japan Aerospace Exploration Agency, 3.Department of Complexity Science and Enginnering, the University of Tokyo, 4.Department of Space and Astronautical Science, SOKENDAI)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[PPS08-04] Detection of Dark Regions on the Lunar Surface with Shadow Masked Multiband Imager Data

*Riho Ito[1], Hiroka Inoue[2], Makiko Ohtake[2], Hisashi Otake[2], Ryosuke Nakamura[1] (1.National Institute of Advanced Industrial Science and Technology, 2.Japan Aerospace Exploration Agency)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[PPS08-05] Estimation of Moho depth under lunar basins by using only the GRAIL gravity data

*Gaku Nishiyama[1], Noriyuki Namiki[2] (1.Department of Earth and Planetary Science, The University of Tokyo, 2.RISE Project, National Astronomical Observatory of Japan)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[PPS08-06] Ejecta Thickness Distribution of Lunar Schrödinger Basin

*Luyuan Xu[1], Minggang Xie[1] (1.State Key Laboratory of Lunar and Planetary Sciences, Macau University of Science and Technology)

Observing simulations of impact-induced moonquakes combined with the lunar impact flash observation data for future lunar seismic explorations

*Keisuke Onodera[1,2], Taichi Kawamura[3], Satoshi Tanaka[2], Yoshiaki Ishihara[4], Takuto Maeda[5], Masahisa Yanagisawa[6], Yuki Uchida[6], Shinsuke Abe[7], Ryuhei Yamada[8], Takaya Okamoto[2]

1. SOKENDAI (The Graduate University for Advanced Studies), 2. Institute of Space and Astronautical Science / Japan Aerospace Exploration Agency, 3. Insitut de Physique du Globe de Paris, 4. National Institute for Environmental Studies, 5. Hirosaki University, 6. The University of Electro-Communications, 7. Nihon University, 8. University of Aizu

Over the past 50 years, the lunar interior has been investigated by analyzing the Apollo lunar seismic data (e.g. [1]-[3]). However, currently proposed models of the internal structure are not in accordance with each other although each model can explain the Apollo seismic data. This means there still exists a large uncertainty in the lunar internal structure because the Apollo data does not have enough quality to determine the inner structure precisely. Since the internal structure is a significant factor to elucidate the origin of the Moon, it is essential to obtain new seismic data in order to improve our knowledge of the lunar internal structure.

In particular, the lunar crustal structure (e.g. elastic velocity, density, layer-thickness) is significant when discussing the thermal environment at the initial stage of the lunar formation. From the observation results of KAGUYA (SELENE), it is suggested that the lunar crust consists of very pure anorthosite, which means the refractory element Al concentrates within the crust (e.g. [4][5]). Since the bulk amount of refractory elements gives a strong constraint on the thermal condition of the lunar formation, revealing the lunar crustal structure will lead to better understanding of the history of the Moon.

When determining the lunar crustal structure, impact-induced seismic waves are usually used [6]. Generally, at least 3 seismic stations are required to determine seismic source locations. In the case of the Apollo, although 4 seismic stations were placed and made a network on the nearside of the Moon, it was difficult to determine the impact locations (seismic source locations) precisely due to uncertain arrival time readings and unknown origin times. In future seismic explorations, it is required to carry out seismic observations even at a single point since it is difficult to deploy multi-seismic stations at once. In this situation, the precise determination of origin times and impact locations will play an important role in order to improve the crustal structure. However, as described above, it is considered that a single seismic station is not adequate for the precise determination of origin times and impact locations. This is one of the serious problems when performing a future seismic exploration.

In order to overcome this problem, it has been proposed to apply ground observation data of lunar impact flashes to seismic observations on the Moon [7][8]. Since the basic recording system of the impact flash observation allows us to determine impact times and locations more precisely compared to seismological approaches, it will enable to realize seismic observation at single point. However, these fields of study (lunar impact flash and lunar seismology) have been carried out independently in the past. In this study, we bring these two field together by performing observing simulations of impact-induced seismic waves by combining a seismological simulation with the lunar impact flash observation data as a first step for the consideration of a future seismic exploration.

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In the presentation, we will report the simulation results of the lunar seismic observations and discuss the requirements for a future seismic instrument and landing site.

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Keywords: Moon, Moonquake, Future Exploration, Impact, Lunar Impact Flash

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New Results from Restored Apollo Magnetic Field Records

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1. University of California Los Angeles

Three Apollo missions collected digital magnetic field measurements by the Lunar Surface Magnetometers on the surface (Apollo 12, 15, and 16) and by Subsatellite Biaxial Magnetometers in orbit surrounding the Moon (Apollo 15 and 16). After approximately a half century, the Apollo 15 and 16 missions are still the only lunar missions conducting simultaneous surface and orbital magnetic field experiments. The Apollo magnetic field experiments enabled many first discoveries, such as the lunar magnetic anomalies and the electrical conductivity of the Moon.

A recent effort has restored all the Apollo magnetic field records from the archaic data format originally archived. The restored LSM data have revealed many narrowband ion cyclotron waves in the Earth’s magnetotail that were not investigated during Apollo years. The restored data also allow re-analyses for the Moon-solar wind interaction and magnetic sounding of the lunar interior. We find that the observed transfer function responses in both tangential and radial components on the lunar surface are consistent with theoretical expectations at least for frequencies greater than 10^{-4} Hz. The comparison between SBM and LSM data indicates that, when the Moon is in the solar wind, the surface magnetic field is slightly enhanced on the sunward side. This paper summarizes the recent findings from the restored Apollo magnetic field data and discusses the unexplored topics for future magnetic field measurements on the lunar surface.

Keywords: Moon, Apollo magnetic field experiments, plasma waves at the Moon, magnetic sounding of lunar interior, solar wind interaction with the Moon

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Analysis of the High Latitude Region of the Moon with Spectral Profiler Data: Possible Presence of Water Ice

Haramitsu Kyoda[3], *Satoshi Tanaka[1], Makiko Ohtake[1], Hiroshi Nagaoka[2], Yusuke Nakauchi[2], Keisuke Onodera[4]

1. Department of Solid Planetary Sciences Institute of Space and Astronautical Science, 2. Japan Aerospace Exploration Agency, 3. Department of Complexity Science and Enginnering, the University of Tokyo, 4. Department of Space and Astronautical Science, SOKENDAI

Recently, space agencies such as NASA and JAXA are actively planning to explore the polar region of the Moon since its usability as lunar base and possible existence of volatile elements([1],[2]). Landing site selection should be taken into consideration of the sunshine rate, existence of volatile materials in the vicinity [3], and so on. Therefore, geological and geomorphological studies in the polar region of the Moon have become more important. In this paper, we focused on detecting of water ice in the polar region using Spectral Proler(SP) data obtained by KAGUYA. Li et al.,(2018)[4] reported exposed water in the permanently shaded area by M^3 data. It is possible to detect more distinct feature of water absorption by the SP data with high S/N ratio. Data analysis by the SP data in the polar region is still difficult due to the large solar incidence angle, however, we reported that the data could be handled with high-accuracy by estimation of insolation area for each spectrum using deep learning method [5]. Based on the SP data in the fully shaded area classied by the method above, we investigated the spectrum having absorption at 1260 nm and 1500 nm both of which are featured by ice and frost of water. As a result, we found about 300 spectrum data having distinct water absorption. One of the data with this absorption obtained in the middle of April, 2009 was located at around (lat. , lon.)=(-85, 50) at where Li et al., (2018) indicated the presence of water ice, but most of the data locations are not overlapped. Moreover, the solar incident angles of all selected data are too high to detect the direct nor the secondary reflected light from the surface of the target area. It is possible that the floating dust at a distance of several tens of kilometers the Moon originated from the impacts or levitation may have been detected[6].

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Keywords: Moon, spectral profiler, water ice

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Detection of Dark Regions on the Lunar Surface with Shadow Masked Multiband Imager Data

*Riho Ito[1], Hiroka Inoue[2], Makiko Ohtake[2], Hisashi Otake[2], Ryosuke Nakamura[1]

1. National Institute of Advanced Industrial Science and Technology, 2. Japan Aerospace Exploration Agency

The lunar low-reflectance regions, such as Dark Mantle Deposits (DMDs), iron or titanium rich regions, or weathered older mare, have important information for clarifying the process of lunar evolution. To locate the global distribution of the low-reflectance (dark) region is one of important studies for lunar geological science. Since even small dark regions can be detected based on high-resolution lunar images such as Kaguya's Multiband Imager (MI) images, a goal of this research is to identify candidates of the darkest region with various spatial scale on the global lunar surface. However, a simple automatic identification of small dark regions from Kaguya's MI images, such as using a threshold value, may be hindered by shadows. Therefore, in this research, dark regions other than shadows were identified after removing the shadow regions from the MI images.

The areas that have relatively lower reflectance than the surrounding area due to the difference in the local solar incidence angle are treated as same as actual shadows cast by being hidden from sunshine because the areas often show abnormal spectrum patterns. In the first step, to detect shadow regions, we employed conditional generative adversarial networks (cGAN) which is deep learning method. The cGAN is composed of the generator neatwork and the discriminator network. The Generator is trained to generate realistic fake images that cannot be distinguished from real images by the Discriminator, whereas the Discriminator is trained to detect the fake images generated by the Generator. We prepared supervised data which are pair of MI images and correct shadow masks for training the cGAN networks. In this step, Generator was trained for generating a realistic shadow mask as much as possible according to an input MI image. After the training, our Generator successfully provide a shadow mask in which we can detect high contrast shadows and shadows by craters or other land features. On the other hand, we found that our network had low accuracy for smaller shadows and surround regions of invalid values, and these detected shadow masks included many noises.

In the next step, we employed simple thresholding to detect candidates of DMD from the MI images with shadow masks generated by the trained Generator. Since the results of shadow detection are not stable when an image has many invalid values., regions higher than ±60 ˚including relatively many invalid values were excluded from target regions. The threshold value was determined from a histogram of the reflectance which calculated from the band 2 (750 nm) of the MI image after the shadow removal, and regions where the reflectance was lower than the threshold were detected as candidate of the dark region. In this study, because dark regions with a small size in the detected candidates may be mis-detection of the small shadow regions that could not be distinguished and removed by the trained network, dark regions which area are smaller than 900 pixels (0.36 km^2) were excluded from candidates. Though this process may exclude candidates for actual small dark regions that are not shadows, we decided to focus on locating candidates that can be more reliably determined as dark regions. As threshold processing and noise removal method are important factors greatly affecting the detection of the final candidate points, we will consider the improvements for detecting smaller dark regions in the future work.

In the result of applying this method, although some noise remained, some known DMDs, in the Sinus Aestuum, Taurus-Littrow, Sulpicius-Gallus and Mare Vaporum, were detected as candidates of dark regions. Most of the other detected points were also located in the region of high titanium. In this work, analysis results of detected dark regions and utility of the detection methods will be reported and

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discussed.

Keywords: deep learning, shadow detection, Multiband Imager, Dark Mantle Deposit

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Estimation of Moho depth under lunar basins by using only the GRAIL gravity data

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1. Department of Earth and Planetary Science, The University of Tokyo, 2. RISE Project, National Astronomical Observatory of Japan

In order to unravel the formation of solar-system, the subsurface structure of planets and moons will be a key to constrain early differentiation and subsequent thermal evolution. In particular, lunar crustal thickness is of importance for understanding the volume of the ancient magma ocean. Conventionally planetary crustal thickness is estimated by analyzing gravity anomaly data derived from tracking data of spacecrafts using downward continuation filter. In this method, the relief of crust-mantle interface (Moho) are calculated as a variation of surface density anomalies under the condition that a mean crustal thickness or crustal thickness at a specific location has been already known from seismic observation. In this study, however, we demonstrate that the calculation is theoretically incorrect in the point that the Moho relief is imposed on the surface density at certain depth. Downward continuation filter is mathematical trick to stabilize the previous calculation, but it indeed violating gravity theory.

In this study, we show a new method which doesn't require ad hoc assumptions of crustal thickness nor downward continuation filter, but assumes the simple shape of Moho uplift. Under the assumption that the Moho is uplifted like an axisymmetric cylinder beneath Crisium basins , the observed Bouguer gravity anomalies can be expanded in the Bessel-Fourier coefficients . Then we find the best fit parameters such as radius, height and depth of cylinder. Thus, the depth of surrounding crust is estimated to be 37.9±7.7 km. Our estimate is consistent with that of the analysis result of moonquake data measured at Apollo 12 & 14 landing sites. This result indicates that the new method can estimate crustal thicknessby gravity data alone and independently from seismic data. Here we assumed a simple morphology of mass anomalies beneath Crisium basin, however, the top surface of the cylinder as well as surrounding Moho boundary shall be laterally variable. In further research we evaluate an influence of the shape, crustal flexure, and other effects.

Keywords: moon, crust, gravity, GRAIL, Moholovicic discontinuity

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Ejecta Thickness Distribution of Lunar Schrödinger Basin

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A hypervelocity impact on a target with solid surface forms an impact crater, and a fraction of debris is ejected and emplaced ballistically from the crater. The thickness distribution of primary ejecta gives insight into the processes of impact cratering, the stratigraphy of planetary crust, the evolution of planetary surface, and the source of lunar samples. However, the widely used empirical ejecta thickness distribution model of McGetchin et al. (1973) is inconsistent with recent observations of complex craters and the Orientale basin.

As a typical case to address this problem, here we conducted detailed measurements of ejecta thickness distribution for Schrödinger Basin, which is a large impact basin located near the lunar south pole, the best-preserved peak-ring basin, and the second youngest one on the Moon.

Based on LROC WAC, Kaguya TC, and LOLA DTM data, the thickness of primary ejecta is estimated indirectly from the measurements of partially filled pre-basin craters using crater morphometry and the effect of crater degradation is taken into considerations. The results show that the ejecta thickness distribution of Schrödinger Basin is more consistent with Pike (1974)’s model rather than McGetchin et al. (1973)’s, the excavation of Schrödinger basin-forming impact does not penetrate through lunar crust, and the rim relief of Schrödinger Basin consists mostly of rim uplift rather than the primary ejecta.

Keywords: Impact ejecta, rim uplift, Schrödinger Basin

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[J] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

Thu. May 30, 2019 10:45 AM - 12:15 PM JST | Thu. May 30, 2019 1:45 AM - 3:15 AM UTC | 103 1F

[P-PS08] Lunar science and exploration

convener:Hiroshi Nagaoka(Japan Aerospace Exploration Agency), Masahiro KAYAMA(Department of Earth and Planetary Material Sciences, Faculty of Science, Tohoku University), Masaki N Nishino(Japan Aerospace Exploration Agency, Institute of Space and Astronautical Science), Tomokatsu Morota(Graduate School of Environmental Studies, Nagoya University), Chairperson:Ko Hashizume, Hiroshi Nagaoka

Scientific data sets acquired by not only Japanese lunar mission SELENE (Kaguya), but also other countries' missions, have become new standard for lunar science. Analyses of these data have been providing several new knowledge and changing some hypotheses into the truth of the Moon. In concurrence with these studies, some countries including Japan are planning future lunar missions. In this session, we will discuss scientific results based on newly acquired lunar data, strategy for future missions including SLIM, and theoretical and experimental studies for lunar science.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[PPS08-07] Possible evolution paths of the lunar orbit based on tidal response in the global ocean model of the early Earth

*Mai Motoyama[1], Hideo Tsunakawa[1], Futoshi Takahashi[2] (1.Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology, 2.Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[PPS08-08] Geochemical and Petrological Investigations of Lunar Feldspathic Crust by Lunar Sample Studies and Remote Sensing Data

*Hiroshi Nagaoka[1], Yuzuru Karouji[1], Makiko Ohtake[1] (1.Japan Aerospace Exploration Agency)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[PPS08-09] Development of frosting system for lunar simulant and the detectability of ice growing on the simulant by NIR measurement

*Aoi Ogishima[1], Kazuto Saiki[1] (1.Department of Earth and Space Science, Graduate School of Science, Osaka University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[PPS08-10] Volatile studies on Moon - A review toward future exploration programs

*Ko Hashizume[1] (1.Faculty of Science, Ibaraki University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[PPS08-11] Scientific approach for the promotion of lunar polar exploration mission

*Masahiro KAYAMA[1], Ko Hashizume[2], Hiroshi Nagaoka[3], Kazuto Saiki[4], Chihiro Yamanaka[4], Makoto Hareyama[5], Makiko Ohtake[3] (1.Tohoku University, 2.Ibaraki University, 3.Japan Aerospace Exploration Agency, 4.Osaka University, 5.St. Marianna University School of Medicine)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[PPS08-12] Feasibility study of detection of the lunar subsurface ice with UHF-band GPR based on FDTD electromagnetic simulation

*Atsushi Kumamoto[1], Hideaki Miyamoto[2], Toshifumi Nishibori[3], Takafumi Niihara[2], Fuminori Tsuchiya[1], Ken Ishiyama[3] (1.Tohoku University, 2.University of Tokyo, 3.JAXA)

Possible evolution paths of the lunar orbit based on tidal response in the global ocean model of the early Earth

*Mai Motoyama[1], Hideo Tsunakawa[1], Futoshi Takahashi[2]

1. Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology, 2. Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University

The Moon's orbital evolution has been affected by the Earth's ocean tide as well as the solid Earth's tide (e.g. MacDonald, 1964, Kaula, 1964). Many previous studies pointed out that the continental crusts would be few amounts in the early Earth (e.g. Stein & Ben-Avraham, 2007, Rino et. al., 2004), possibly with larger seawater volume than the present day (e.g. Kurokawa et al., 2018, Korenaga et. al., 2017). Thus the early Earth is considered to have been covered by the global ocean for a long time, strongly implying the importance of the ocean tide for the early evolution of the Earth-Moon system. Most of previous studies of the evolution of the Earth-Moon system calculated back to the past with the initial condition of the present state (e.g. Abe et. al., 1997, Rubincam, 2015). The backward calculation is inappropriate to estimate the effects of various parameters concerning the early Earth’s ocean, since there are many uncertain factors such as continental drift. Thus we carried out forward calculation of the lunar orbit from the past for the first 2 billion years to understand characteristic effects of the ocean state in the global ocean model.
Energy dissipation mechanism of the ocean is one of the critical factors in the Moon’s orbital evolution (e.g. Webb, 1982, Lambeck, 1977). Recent studies have revealed that the internal gravity wave, so-called internal tide, is a main mechanism of tidal energy dissipation in the deep ocean (e.g. Taguchi et. al., 2014, Egbert & Ray, 2000). In this study, we considered its effect on the early evolution, assuming the early ocean is as deep as the present abyssal depth.
Our results show that the eigenmode resonance occurs once or more for the first 2 billion years. The Earth-Moon distance rapidly increases with a step-like change at the eigenmode resonance. In the case of the ocean depth decreasing linearly to the time, it is found that the torque due to the oceanic tidal bulge causes continuous increase in the Earth-Moon distance with an especial response of eigenmode oscillation. These acceleration effects could work in the coevolution of the early Earth-Moon system.

Keywords: Moon, Earth, ocean, tide, resonance, orbit

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Geochemical and Petrological Investigations of Lunar Feldspathic Crust by Lunar Sample Studies and Remote Sensing Data

*Hiroshi Nagaoka[1], Yuzuru Karouji[1], Makiko Ohtake[1]

1. Japan Aerospace Exploration Agency

Feldspathic highland crust deriving from ferroan anorthosite (FAN) have been assumed to be formed by the lunar magma ocean (LMO) model, whose the early crust was accumulated by the crystallization and flotation of plagioclase (Warren, 1985). However, the studies of lunar meteorites which originated from the highlands not covered by the Apollo missions, found more magnesian anorthosites than FAN (e.g., Takeda et al., 2006). Furthermore, Kaguya observation revealed feldspathic crust with higher Mg# (= molar 100 ×Mg/(Mg + Fe)) than FAN (Ohtake et al., 2012).
Furthermore, purest anorthosite (PAN) (>98% plagioclase) lithology was found in central peak of several large craters by Kaguya observation. On the basis of Kaguya results, the massive PAN layer are assumed to be distributed under mafic-rich mixing layer in highlands (Ohtake et al., 2009; Yamamoto et al., 2012).
Like this, lunar meteorite studies and global remote sensing data have provided new global information on geological features of lunar crust.

Feldspathic meteorites from lunar highlands are brecciated by impacts on the lunar surface.
The 10-30% mafic minerals (pyroxene and olivine) are included in the meteorites.
These feldspathic meteorites is similar with the surface composition of mafic-rich mixing layer of feldspathic crust in elemental composition (e.g., FeO, Th).
On the other hand, several highly pure anorthosite (PAN) clasts were found among some of feldspathic lunar meteorites (Nagaoka et al., 2014). They are correspond with PAN lithology observed by Kaguya.

In this work, we have measured and summarized the elemental and mineral composition of feldspahtic lunar meteorites, by bulk chemical analyses, electron micro-probe analyses, and UV-VIS-NIR reflectance spectroscopy. In this presentation, we report and discuss geochemical and petrological features of lunar crust on the basis of recent geochemical and petrological studies combined the above lunar samples analyses data and the recent remote sensing data.

Keywords: Lunar Feldspathic Crust, Lunar Meteorites, Remote Sensing

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Development of frosting system for lunar simulant and the detectability of ice growing on the simulant by NIR measurement

*Aoi Ogishima[1], Kazuto Saiki[1]

1. Department of Earth and Space Science, Graduate School of Science, Osaka University

In recent years, many remote sensing studies have suggested the existence of lunar water, but it is still an open issue how or how much water is on the Moon. Lunar prospector launched in 1998 found the concentration of proton around lunar poles. In 2009 Lunar Crater Observation and Sensing Satellite (LCROSS) project observed ejecting debris from Cabeus crater and estimated that concentration of water ice is 5.6±2.9 wt%. Chandrayaan-1 data suggested the abundance of water could be as high as 0.077wt%. After these results, Japan’ s space agency JAXA and India’ s space agency ISRO have signed an Implementation Arrangement (IA) for a Joint Lunar Polar Expedition in December 2017. In preparation for this mission, assuming that the grains of lunar regolith are covered by water frost on the lunar permanently shadowed regions, we made minute ice on lunar simulants and measured their Near-Infrared reflectance spectra. As lunar simulant we use olivine (from San Carlos, 125-250um, Fo90) and lunar simulant FJS-1 (Shimizu Corporation). We developed a frosting system. It’ s a kind of cooling stage in which simulant grains cooled with liquid N2 can be mixed with highly humid air and vibrated. In the stage, water frosts condensed and cover the surface of grains. The top of the stage is covered with silica glass plate, so we can observe the spectra without taking out samples from the stage. We observed the reflectance spectra of the frosted simulants with a Near-Infrared imaging spectrometer developed by Saiki at 950-1600 nm, angle of incidence = 30˚, angle of viewing = 0˚. After the measurement, we weighed the mass of frosts. In order to prevent additional frost during weighing, we made a vinyl house and weighed frosted samples in the house purged with dry N2 gas. Then, the samples were heated and the frosts on them evaporated. After heating we weighed the samples again, regarded the decreased mass as the mass of frosts, and calculated mass fraction of frosts. We succeeded in making the minute ice less than 1wt% on the simulant, but it is difficult to make ice homogeneously and to control the amount. In order to address these problems, we developed a new fall-type frosting system. In this system cooled simulant fall down in humid air and covered by minute ice homogeneously.We continue trial and error on falling distance and humid air volume aiming to control the amount of frost on the order of 0.1 wt%. Latest results will be reported.

Keywords: Lunar polar mission, frosting experiment

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Volatile studies on Moon - A review toward future exploration programs

*Ko Hashizume[1]

1. Faculty of Science, Ibaraki University

I would like to first review the recent findings regarding the water detected on Moon's surface, point out the current issues, then discuss necessary actions in the future exploration programs.

Keywords: Exploration, Isotope Compositions, Volatile Compounds

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Scientific approach for the promotion of lunar polar exploration mission

*Masahiro KAYAMA[1], Ko Hashizume[2], Hiroshi Nagaoka[3], Kazuto Saiki[4], Chihiro Yamanaka[4], Makoto Hareyama[5], Makiko Ohtake[3]

1. Tohoku University, 2. Ibaraki University, 3. Japan Aerospace Exploration Agency, 4. Osaka University, 5. St. Marianna University School of Medicine

Remote sensing spacecraft missions (e.g., LCROSS and Deep Impact), lunar sample studies, and theoretical simulations suggest the existence of various water species (e.g., H_2O ice, hydroxyl and molecular water, and aqueous phase) on the lunar surface and in the subsurface. Lunar water is thought to originate from solar wind, meteorite/asteroid/comet collisions, and/or volcanic eruptions and concentrated locally on the lunar surface to subsurface, especially permanently shadowed regions near the lunar poles. These findings indicate the possibility of the presence of available water resources for future human activity on the Moon. Moreover, lunar water is significant because it is closely related to a formation process of the lunar magma ocean and its differentiation to the mantle. Therefore, Lunar Polar Exploration Mission is planned to be launched in the 2020’s to survey lunar water. From the viewpoint of resources, science and engineering, this mission provides new insights into lunar evolutionary history and lunar base construction. Here, we will discuss analytical techniques for in-situ water analyses on the lunar poles and experiments simulating low-temperature and high-vacuum lunar environment.

Keywords: Lunar polar exploration mission, Lunar water, Infrared spectroscopy, Thermogravimetric analysis, Cavity ring-down spectroscopy, Neutron spectrometry

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Feasibility study of detection of the lunar subsurface ice with UHF-band GPR based on FDTD electromagnetic simulation

*Atsushi Kumamoto[1], Hideaki Miyamoto[2], Toshifumi Nishibori[3], Takafumi Niihara[2], Fuminori Tsuchiya[1], Ken Ishiyama[3]

1. Tohoku University, 2. University of Tokyo, 3. JAXA

Detectability of the subsurface ice by UHF-band (0.5-3 GHz) ground penetrating radar (GPR) onboard the rover in the lunar polar region was investigated based on electromagnetic simulation using finite-difference time-domain (FDTD) method. The water brought on the lunar surface is lost within 1 day due to photodissociation. However, if a part of water molecules jump to polar region within 1 day, they can be kept in the polar shadowed region [Arnord, 1979]. Some observations such as impact experiment in LCROSS mission [Colaprete et al., 2010] and SAR polarization measurements in Chandrayaan mission [Spudis et al., 2010] suggests the existence of the water in the lunar polar region.

In this study, we used Meep code [Oskooi et al., 2010] for FDTD simulation. The simulation space with a size of 0.25 m x 1.25 m is divided into meshes with a size of 0.3 mm x 0.3 mm. The uppermost part with a height of 0.5 m is filled with vacuum (permittivity: 1). The second part with a thickness of 0.5 m is filled with dry regolith, basalt (permittivity: 7) including voids (vacuum). The lowermost part with a thickness of 0.25 m is filled with several kind of media such as (i) cavity (vacuum), (ii) rocks (basalt without pores), (iii) pure ice (permittivity: 3), and (iv) icy regolith, regolith whose voids are filled ice. The porosity of the dry and icy regolith layers was determined based on the report from Apollo missions on the vertical profile of the bulk density of the lunar subsurface soils up to depth of 3 m [Carrier et al., 1991]. Chirp pulse in a frequency range from 0.5 to 3 GHz was transmitted for 167 ns from 0.4 m above the dry regolith surface. The electromagnetic fields in simulation space were evolved with time step of 0.52 ps. At the transmission point, the waveform of electric field component of the echoes was recorded at an interval of 33 ps.

Calculation results suggests that subsurface echoes from (i) cavity, (iii) rocks, and (iv) icy regolith at a depth of 0.5 m can be detected with enough echo powers while the echo power from (iii) pure ice were as large as volume scatters due to inhomogeneity in the regolith. They are a little different from the results of our previous calculation performed in a frequency range 1-15 GHz with subsurface materials at a depth of 0.1 m: The echo powers from ice and icy regolith were as large as volume scatters. We can consider that the difference is from (a) the decrease of the volume scatters power by changing the operation frequency range, and (b) the depth dependence of permittivity contrast in inhomogeneous regolith.

Keywords: Lunar polar exploration, Lunar water ice, Ground penetrating radar (GPR), Finite difference time domain (FDTD) method

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[J] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

Thu. May 30, 2019 1:45 PM - 3:15 PM JST | Thu. May 30, 2019 4:45 AM - 6:15 AM UTC | 103 1F

[P-PS08] Lunar science and exploration

convener:Hiroshi Nagaoka(Japan Aerospace Exploration Agency), Masahiro KAYAMA(Department of Earth and Planetary Material Sciences, Faculty of Science, Tohoku University), Masaki N Nishino(Japan Aerospace Exploration Agency, Institute of Space and Astronautical Science), Tomokatsu Morota(Graduate School of Environmental Studies, Nagoya University), Chairperson:Masahiro Kayama(東北大学), Yusuke Nakauchi(JAXA/ISAS)

Scientific data sets acquired by not only Japanese lunar mission SELENE (Kaguya), but also other countries' missions, have become new standard for lunar science. Analyses of these data have been providing several new knowledge and changing some hypotheses into the truth of the Moon. In concurrence with these studies, some countries including Japan are planning future lunar missions. In this session, we will discuss scientific results based on newly acquired lunar data, strategy for future missions including SLIM, and theoretical and experimental studies for lunar science.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[PPS08-13] Geology of the SLIM landing site on the Moon

★Invited Papers

*Makiko Ohtake[1], Kazuto Saiki[2], Yusuke Nakauchi[1], Hiroaki Shiraishi[1], Yoshiaki Ishihara[3], Hiroyuki Sato[1], Chikatoshi Honda[4] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.Osaka University, 3.National Institute for Environmental Studies, 4.University of Aizu)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[PPS08-14] Observing scenario for the Multi-Band Camera onboard SLIM

*Kazuto Saiki[1], Yuya Igarashi[1], Yusuke Nakauchi[2], Chikatoshi Honda[3], Makiko Ohtake[2], Hiroaki Shiraishi[2], Hiroyuki Satoh[2], Yoshiaki Ishihara[4], Takao Maeda[5], Chihiro Yamanaka[1] (1.Osaka Univ., 2.JAXA, 3.Univ. Aizu, 4.National Institute for Environmental Studies, 5.Chuo Univ.)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[PPS08-15] Current status of a Japanese lunar polar exploration mission

*Takeshi Hoshino[1], Makiko Ohtake[1], Yuzuru Karouji[1], Hiroaki Shiraishi[1] (1.Japan Aerospace Exploration Agency)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[PPS08-16] HERACLES mission: Returning to the Moon by an ESA-JAXA-CSA Joint Study

*Yuzuru Karouji[1], Hiroshi Nagaoka[1], Yoshiaki Ishihara[2], Masahiro KAYAMA[3], Satoru Yamamoto[4], Nobuyuki Hasebe[5], Ko Hashizume[6], Yoshiko Ogawa[7], Toru Yada[1], Junichi Haruyama[1], Masanao Abe[1], Makiko Ohtake[1], HERACLES Science Working Group, HERACLES International Science Definition Team (1.Japan Aerospace Exploration Agency, 2.National Institute for Environmental Studies, 3.Faculty of Science, Tohoku University, 4.J-spacesystems, 5.Advanced Research Institute for Science and Engineering, Waseda University, 6.Faculty of Science, Ibaraki University, 7.The University of Aizu)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[PPS08-17] Lunar Science for Landed Missions – High-Priority Landing Sites Visualized with NASA's Moon Trek

*Brian Hamilton Day[1], Emily Law[2] (1.NASA Solar System Exploration Research Virtual Institute, NASA Ames Research Center, 2.NASA Jet Propulsion Laboratory, California Institute of Technology)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[PPS08-18] NASA SSERVI: Merging Science and Human Exploration

*Brad Eugene Bailey[1], Kristina Gibbs[1], Gregory Schmidt[1] (1.NASA)

Geology of the SLIM landing site on the Moon

*Makiko Ohtake[1], Kazuto Saiki[2], Yusuke Nakauchi[1], Hiroaki Shiraishi[1], Yoshiaki Ishihara[3], Hiroyuki Sato[1], Chikatoshi Honda[4]

1. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2. Osaka University, 3. National Institute for Environmental Studies, 4. University of Aizu

Introduction: Smart Lander for Investigating Moon (SLIM) is a Japanese technology demonstration mission to pinpoint landing within a hundred meters in radius, which will be launched in fiscal year 2021. The lander carries one small instrument (high-resolution Multiband Camera; see Saiki et al. in this conference) to derive the detailed mineralogy of the olivine-rich exposure to investigate a olivine bearing lithology for understanding their origin and investigating the composition of the lunar unsampled mantle or deep crustal material. To directly explore this unexplored lithology, one of the small fresh craters just outside of the Theophilus crater is selected as a landing site for the SLIM mission. In this study, we analyzed geology of Theophilus crater and the selected landing site.

Crater Theophilus (11.4˚S, 26.4˚E) is located in the immediate vicinity (northwest) of the Mare Nectaris on the Moon. It is on the ring of the Nectaris basin. Its diameter is 110 km, and it has a clear central peak at the center of the crater. Previous study revealed the central peak’ s compositional diversity [1][2]. However, the origin of other lithologies and the relation of these rare geologic lithologies in this unique central peak are still not clear. In addition to their geological (mineralogical) diversity.

Data and Results: We used remote sensing reflectance spectra and spectral images obtained by the SELENE (Kaguya) Spectral Profiler (SP) and Multiband Imager (MI). Olivine-dominant lithology at the central peak have clear diagnostic absorption of olivine. Percentage of olivine among olivine and pyroxene of the olivine dominant lithology is estimated to be more than 70. The FeO abundance of the olivine-dominant lithology estimated ranges from 5 to 8 wt.%. Olivine-dominantlithology appears to be present as a basal lithology of the central peak blocks. Olivine dominantlithology is also observed as localized exposures at many small but fresh craters throughout the wall and ejecta region. These fresh craters commonly have a very clear olivine absorption feature, and the FeO abundance of these localized olivine exposures ranges up to 12 wt.%,which corresponds to a nearly pure olivine rock, if Mg# (Mg/(Mg+Fe) in mole per cent) of the olivine is assumed to be similar to the olivine-rich rock types (troctolite and dunite) among the Apollo samples.

Discussion: Based on the modal abundance, FeO abundance, distribution, and morphological information of the observed lithologies, we believe that the central peak of Theophilus crater mainly consists of olivine-dominant lithologies with lesser amounts of purest anorthosite (PAN) and Mg-spinel bearing lithologies. Distribution of Mg-spinel bearing lithology is limited in our datasets and they tend to have a relatively sharp vertical boundary with the adjacent lithology. Therefore, we interpret it is not presented as a laterally extensive unit before the formation of the Theophilus crater as suggested [1]. Observed olivine-rich composition comparable to dunite and a sharp boundary with the adjacent PAN lithology suggest that it is not a part of the continuous crustal material. Instead, it is probably mantle (or the lower part of the crustal) origin, which is excavated by the Nectaris basin forming impact as suggested by the global distribution of the olivine-rich sites [2], well before the formation of the Theophlius.

References:[1] Dhingra D. et al. (2011) *Geophys. Res. Let., 38*, L11201, doi:10.1029/2011GL047314. [2]

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Yamamoto S. et al. (2012) *Geophys. Res. Let., 39*, L13201, doi:10.1029/2012GL052098.

Keywords: Moon, olivine, SLIM, mantle

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Observing scenario for the Multi-Band Camera onboard SLIM

*Kazuto Saiki[1], Yuya Igarashi[1], Yusuke Nakauchi[2], Chikatoshi Honda[3], Makiko Ohtake[2], Hiroaki Shiraishi[2], Hiroyuki Satoh[2], Yoshiaki Ishihara[4], Takao Maeda[5], Chihiro Yamanaka[1]

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Smart Lander for Investigating Moon (SLIM) is being planned by Japan Aerospace Exploration Agency (JAXA). SLIM aims to research and demonstrate the engineering key issues related to the smart landing on the gravitational planets. They are precise guidance algorithm, vision based navigation, smart landing gear. By doing SLIM mission, we expect to achieve the paradigm shift in the field of celestial body landing from ‘landing where easy to land’ to ‘landing where desire to land’. We proposed Multi-Band Camera (MBC) for SLIM lander. MBC is a compact VIS-NIR camera composed of an imaging sensor (InGaAs), a filter-wheel with 10 band-pass filters, and a movable mirror for panning and tilting. Scientific objectives of MBC are the identification of rocks and rock-forming minerals around the lander and the estimation of Mg#(=Mg/(Mg+Fe)) of olivines that might have come from lunar mantle.

MBC has a telescopic optical system and is a camera with a new concept of spectroscopic observation of rock rather than powder called regolith, so various innovative methods are required for its operation. Among them, we will introduce the methodology of scan operation, on-site calibration, autofocus system, spectroscopic observation of rocks, and Mg # estimation.

Since it is dangerous to land on a place covered with rocks, SLIM landing site was carefully selected. The landing site should be the site where the rock distribution does not become an obstacle to landing and the distribution is as much as rocks can be observed. Since MBC is a telephoto optical system in which the horizontal viewing angle is 4 degrees, rocks would not be observed in random shots. Therefore, it has a function to create a map with a combined low resolution scanned images of around 300 shots that can cover the all observable field of view. After specifying the location of the rock to be observed, we will perform spectroscopic observations efficiently. SLIM, a small unmanned spacecraft, arrives at the moon after a much longer period of time than a manned rocket, so it will be attacked much higher levels of radiation. Because there is a possibility that the background signal of the imaging device increases or the transmittance of the filter changes, we plan to calibrate on the moon. Specifically, MBC has a function to acquire deep space images as dark background data and subtract it from observed image. We also plan to carry out luminance calibration by installing a standard diffuse reflection plate. Since MBC is a telephoto optical system, a focus adjustment mechanism is also indispensable. We realized an automatic focus adjustment function using the fact that the file-size compression rate of the acquired image decreases when approaching the best focus. Although spectroscopic observation of rocks in the near infrared range is thought to be inherently difficult, we are planning to make use of the observable conditions obtained by observation experiments of natural rocks and rock-analogs. In addition, we are planning to spline-fit the data of each band intensity and detect subtle change in wavelength of the absorption peak of Fe^{2+} to estimate Mg # of olivine.

Keywords: Moon, SLIM, multiband camera

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Current status of a Japanese lunar polar exploration mission

*Takeshi Hoshino[1], Makiko Ohtake[1], Yuzuru Karouji[1], Hiroaki Shiraishi[1]

1. Japan Aerospace Exploration Agency

Introduction:

Recently, it has been suggested that water ice might be present in the lunar polar region based on spectral measurements of artificial-impact-induced plumes in the permanently shadowed region, and remote sensing observation of the lunar surface using a neutron spectrometer [1], [2] and visible to infrared spectrometer [3]. In addition to the scientific interest about the origin and concentration mechanism of the water ice, there is strong interest in using water ice (if present) as an in-situ resources. Specifically, using water ice as a propellant will significantly affect future exploration scenarios and activities because the propellant generated from the water can be used for ascent from the lunar surface and can reduce the mass of the launched spacecraft of lunar landing missions.

However, currently it is unclear if water ice is really present in the polar region because of the currently limited available data. Therefore, we need to learn that by directly measuring on the lunar surface. If there is water ice, we also need to know it’ s quantity (how much), quality (is it pure water or does it contain other phases such as CO_2 and CH_4), and usability (how deep do we need to drill or how much energy is required to derive the water) for assessing if we can use it as resources. Therefore, JAXA is studying a lunar polar exploration mission that aims to gain the above information and to establish the technology for planetary surface exploration [4]. JAXA is also studying possibility of implementing it within the framework of international collaboration with Indian Space Research Organisation (ISRO).

Spacecraft configuration:

The spacecraft system comprises a lander system and a rover system. The system does not have a communication relay satellite but is based on direct communication with the Earth. The minimum target for the landing payload mass is several-hundred kilograms. The launch orbit is the lunar transfer orbit (LTO). After the spacecraft reaches the Moon it is inserted into a circular orbit having a 100km altitude via a few orbital changes. During powered-descent phase, the position of the lander is estimated by landmark navigation using shadows created by the terrain. After landing, the rover is deployed on the lunar surface using ramps. The rover then prospects water ice with its observation instruments..

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Landing site selection:

Considering the mission objectives and condition of the lunar polar region, we listed the following parameters as constraints.
- Presence of water
- Surface topography
- Communication capability
- Duration of sunshine

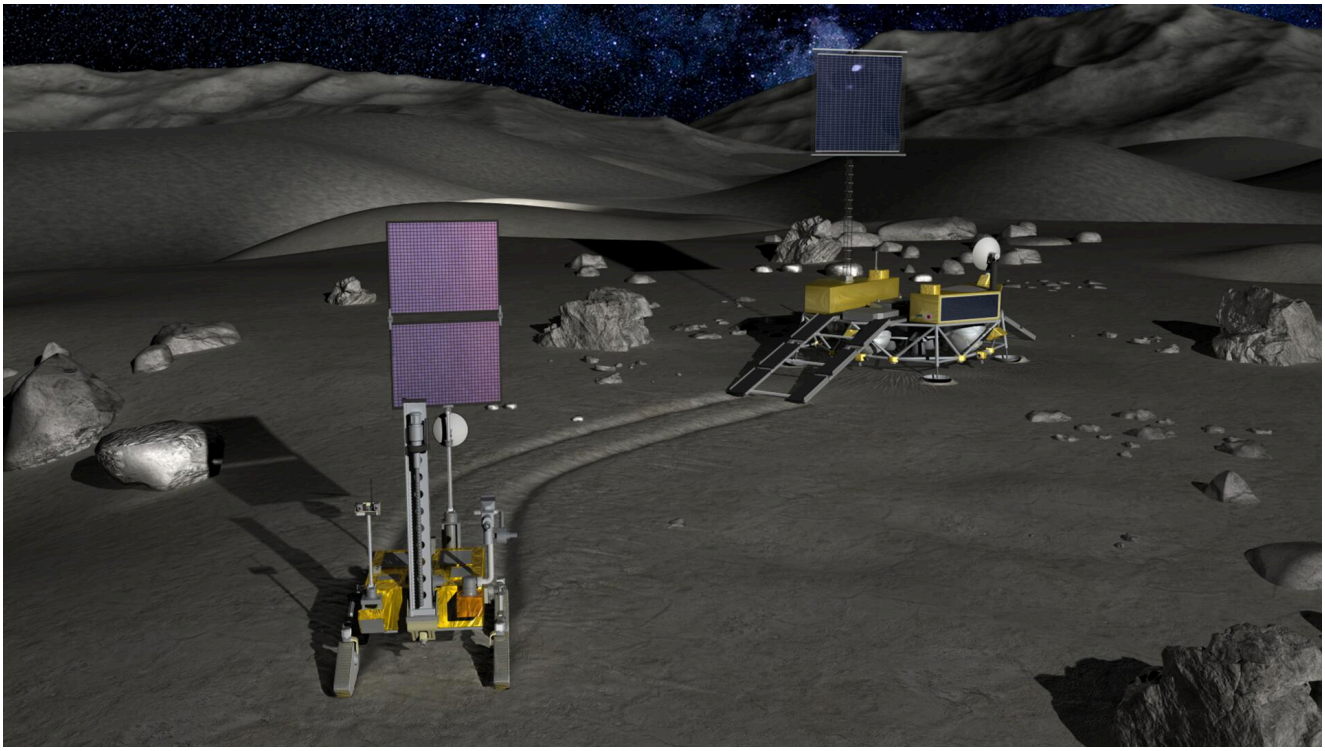
As a first trial of the landing site selection, sunshine is simulated using digital elevation models to obtain the sunlight days per year and the number of continuous sunshine periods at each site. Also, slope and the simulated communication visibility map from the Earth are created. These conditions can be superimposed to select the landing site candidate.

Current status:
Recently, we finished joint mission definition review (JMDR) with ISRO, in which JAXA provide a launch rocket and a rover while ISRO provide a lander system. Related to the instruments which will be carried on the rover or the lander, JAXA selected several candidate instrument study teams for accelerating development of these instruments. In this presentation, we are going to introduce current status of the mission planning.

References:
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[3] Pieters C. M. et al. (2009) *Science,* 326, 568-572.
[4] Hoshino T. et al. (2017) 68th IAC, IAC-17-3.2B.4.

Keywords: lunar polar exploration , lunar water, volatile

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HERACLES mission: Returning to the Moon by an ESA-JAXA-CSA Joint Study

*Yuzuru Karouji[1], Hiroshi Nagaoka[1], Yoshiaki Ishihara[2], Masahiro KAYAMA[3], Satoru Yamamoto[4], Nobuyuki Hasebe[5], Ko Hashizume[6], Yoshiko Ogawa[7], Toru Yada[1], Junichi Haruyama[1], Masanao Abe[1], Makiko Ohtake[1], HERACLES Science Working Group, HERACLES International Science Definition Team

1. Japan Aerospace Exploration Agency, 2. National Institute for Environmental Studies, 3. Faculty of Science, Tohoku University, 4. J-spacesystems, 5. Advanced Research Institute for Science and Engineering, Waseda University, 6. Faculty of Science, Ibaraki University, 7. The University of Aizu

Global Exploration Roadmap published in January 2018 by the International Space Exploration Coordination Group (ISECG) clearly identify the Moon as the next logical destination and defined strategic goals and objectives for its exploration. Returning to the Moon not only yields fundamentally important science opportunities for our understanding of the Solar System but also allows us to test hardware and operational procedures for the exploration and utilization of space beyond Low Earth Orbit (LEO). The Human-Enhanced Robotic Architecture and Capability for Lunar Exploration and Science (HERACLES) is a joint mission under study by European Space Agency (ESA), Japan Aerospace Exploration Agency (JAXA) and Canadian Space Agency (CSA) with NASA and Roscosmos having observer status [e.g., 1]. Thus, HERACLES is an international effort in preparation of returning humans to the Moon and providing opportunities for unprecedented science utilizing the Lunar Orbital Platform-Gateway (Gateway). It is a sub-scale demonstration mission of human lunar exploration aiming for launch in the mid-2020's, and the vehicle is composed to test key components including the three following elements: The Lunar Ascent Element (LAE) will be provided by the ESA, the Lunar Descent Element (LDE) will be provided by the JAXA, and the rover will be provided by the CSA.

The coordination of the planning of science opportunities is performed by the multi-agency HERACLES Science Working Group (SWG). The SWG is also responsible for developing a mission science management plan to describe science themes and science payload instruments selection processes, and data/sample allocation policies. The SWG engaged the science communities of each country and organized the HERACLES international Science Definition Team (iSDT). The iSDT will generate a prioritized list of investigations and will provide input for the landing site selection.

Recently, the iSDT discussed the science scope of the HERACLES mission. The iSDT agreed that the following five non-prioritized topics are the most important lunar science themes that should be addressed by HERACLES; (1) crustal anorthosite composition and crystallization age, (2) mantle composition, (3) improvement of chronology with crater counting of young basalts (<2.5 Ga), (4) internal structure: surface, subsurface, crust, mantle and core, (5) mechanism of material transport (e.g., water) to the Moon. Furthermore, the iSDT has identified several potential landing areas to accomplish these science themes: Jackson crater, Moscoviense basin, Copernicus crater, Schrödinger basin and some young basalts in the Flamsteed region [2, 3].

By the way, the International Space Exploration Program Committee of the Advisory Committee for Space Science and Engineering organized the HERACLES Task Force and independently of SWG, is compiling to recommendations on science and engineering of HERACLES mission. These reports will be submitted at the end of February 2019. These recommentdations will also be taken deeply as opinions of the Japanese scientific community and SWG will discuss how to reflect it in the SWG discussion in the future. In this presentation, we are going to report outcom of previous activities related to the HERACLES SWG and planned discussion within Japanese lunar science community of study in this SWG.

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[1] Landgraf et al. (2018) LPSC 50th, abstract 1030; [2] Hiesinger et al. (2018) LPSC 50th, abstract 1327; [3] Karouji et al. (2018) LPSC 50th, abstract 1736.

Keywords: HERACLES, Lunar Exploration, Sample Return mission

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Lunar Science for Landed Missions –High-Priority Landing Sites Visualized with NASA’s Moon Trek

*Brian Hamilton Day[1], Emily Law[2]

1. NASA Solar System Exploration Research Virtual Institute, NASA Ames Research Center, 2. NASA Jet Propulsion Laboratory, California Institute of Technology

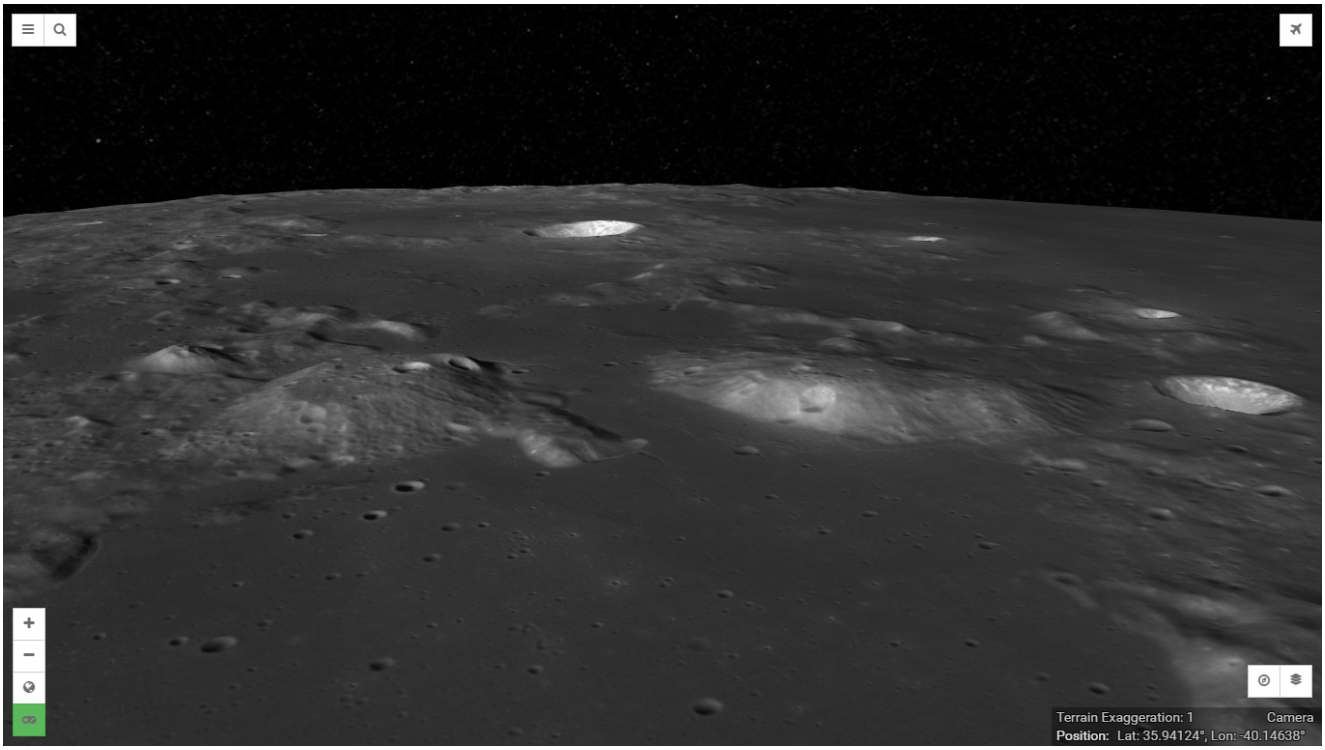
The Lunar Science for Landed Missions workshop was held on 10–12 January, 2018 at NASA Ames Research Center and was attended by lunar scientists, representatives from commercial companies, and representative of various international space agencies including the Japan Aerospace Exploration Agency and the European Space Agency. The workshop was cosponsored by the Solar System Exploration Research Virtual Institute (SSERVI) and the Lunar Exploration Analysis Group (LEAG). The primary goal of the workshop was to produce a set of high-priority landing site targets, generated by the lunar science community, for near-term lunar missions. The scope of such missions was aimed primarily, but not exclusively, at commercial exploration companies with interests in pursuing ventures on the surface of the Moon. The results of this workshop were published in a report that summarized the findings of the workshop and provided an analysis of priority landing sites and how missions to these sites would meet key science and exploration goals determined by NASA and the scientific community (Jawin, et al, 2019). This presentation for JpGU will review the landing sites advocated by the workshop, highlight characteristics that make them high-priority sites, and showcase the sites using visualizations generated using NASA’s Moon Trek data visualization and analysis portal (Day and Law, 2017).

Jawin, E. R., Valencia, S. N., Watkins, R. N., Crowell, J. M., Neal, C. R., & Schmidt, G. (2019). Lunar science for landed missions workshop findings report. Earth and Space Science, 6.

Day, B. H., Law, E. S., 2017, Moon Trek: An Interactive Web Portal for Current and Future Lunar Missions. EPSC Abstracts, Vol. 11, EPSC2017-100, European Planetary Science Congress 2017

Keywords: Moon, Lunar, Landing

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NASA SSERVI: Merging Science and Human Exploration

*Brad Eugene Bailey[1], Kristina Gibbs[1], Gregory Schmidt[1]

1. NASA

NASA's Solar System Exploration Research Virtual Institute (SSERVI) represents a close collaboration between science, technology and exploration, and was created to enable a deeper understanding of the Moon and other airless bodies. SSERVI is supported jointly by NASA’ s Science Mission Directorate and Human Exploration and Operations Mission Directorate. The institute currently focuses on the scientific asp ects of exploration as they pertain to the Moon, Near Earth Asteroids (NEAs) and the moons of Mars, but the institute goals may expand, depending on NASA's needs, in the future. The nine initial teams, selected in late 2013 were funded from 2014 - 2019, have expertise across the broad spectrum of lunar, NEA, and Martian moon sciences. An additional four teams were selected in 2017.

The research includes various aspects of the surface, interior, exosphere, near - space environments, and dynamics of these bodies. In addition, SSERVI has ten International Partners which collaborate with US teams NASA anticipates additional team selections in mid 2019 from the 3rd SSERVI Cooperative Agreement Notice call for proposals. Calls for proposals are issued every 2-3 years to allow overlap between generations of institute teams, but the intent for each team is to provide a stable base of funding for a five-year period.

SSERVI's mission includes acting as a bridge between several groups, joining together researchers from:

1) scientific and exploration communities, 2) multiple disciplines across a wide range of planetary sciences, and 3) domestic and international communities and partnerships.

The SSERVI central office is located at NASA Ames Research Center in Mountain View, CA. The administrative staff at the central office forms the organizational hub for the domestic and international teams and enables the virtual collaborative environment. Interactions with geographically dispersed teams across the U.S., and global partners, occur easily and frequently in a collaborative virtual environment. This talk will consist of an overview of SSERVI’ s mission, current US teams and International Partners.

Keywords: Moon, Asteroids, Lunar, Exploration

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[J] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Thu. May 30, 2019 1:45 PM - 3:15 PM JST | Thu. May 30, 2019 4:45 AM - 6:15 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[P-EM17] Space Plasma Physics: Theory and Simulation

convener:Takayuki Umeda(Institute for Space-Earth Environmental Research, Nagoya University), Takanobu Amano(Department of Earth and Planetary Science, University of Tokyo), Yasuhiro Nariyuki(Faculty of Human Development, University of Toyama), Tadas Nakamura(Fukui Prefectural University), Chairperson:Takayuki Umeda(Institute for Space-Earth Environmental Research, Nagoya University), Takanobu Amano(Department of Earth and Planetary Science, University of Tokyo)

This session focuses on studies of space plasma physics via theoretical and numerical approaches. Papers on a wide variety of topics from natural phenomena to artificial plasma environment as well as theoretical and computational methodologies are welcome.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[PEM17-01] Prediction of the high-resolution numerical flux by using a deep neural network

*Yosuke Matsumoto[1] (1.Graduate School of Science, Chiba University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[PEM17-02] Multiple Boris integrators for particle-in-cell simulation

*Seiji Zenitani[1], Tsunehiko N Kato[2] (1.Kyoto University, 2.National Astronomical Observatory of Japan)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[PEM17-03] Contour Dynamics for Vlasov–Poisson Plasma with the Periodic Boundary

*Hiroki Sato[1], Tomo-Hiko Watanabe[1], Shinya Maeyama[1] (1.Nagoya University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[PEM17-04] Simulation methods and visualization tools for MHD simulations in a sphere

*Akira Kageyama[1], Kumiko Hori[1], Naohisa Sakamoto[1] (1.Graduate School of System Informatics, Kobe University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[PEM17-05] Kármán Vortex Street, Strouhal Number, Hairpin Vortex in 3D global Magnetohydrodynamic MHD simulations in Northward IMF

*DongSheng CAI[1] (1.University of Tsukuba)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[PEM17-06] Correlations between plasma density and magnetic field strength in MHD turbulence in space

*Tohru Hada[1], Yasuhito Narita[2], Yasuhiro Nariyuki[3] (1.Interdisciplinary Graduate School of Engineering Sciences, Kyushu University, 2.Space Research Institute, Austrian Academy of Sciences, 3.Faculty of Human Development, University of Toyama)

Prediction of the high-resolution numerical flux by using a deep neural network

*Yosuke Matsumoto[1]

1. Graduate School of Science, Chiba University

Magnetohydrodynamic simulations have played important roles for understanding space and astrophysical phenomena. In such circumstances, shock waves and turbulence are inherent properties, and both aspects equally affect evolution of the whole system. Therefore development of numerical algorithms capable of solving both shock waves (discontinuities) and turbulence (waves) with high resolution is a challenging task to tackle violent phenomena in space and astrophysical plasmas.

High-order (greater than the fifth) spatial interpolation coupled with approximate Riemann solvers is a promising solution to such problems (Matsumoto et al., 2016; Minoshima, Miyoshi, Matsumoto, 2019). CANS+ (Matsumoto et al., 2016) employs the fifth order MP5 reconstruction scheme coupled with the HLLD approximate Riemann solver (Miyoshi and Kusano, 2005), and it successfully provided highly resolved solutions for both shock waves and turbulence. A drawback of adopting high-order schemes is its large and complex floating-point operations for obtaining the numerical flux at the cell surface, including minmod (with four arguments) limiters and conversion from the primitive to the characteristic variables. These numerical operations in addition to calculation of the HLLD numerical flux dominated overall computational loads.

In this paper, we propose a different way of calculating the numerical flux by adopting supervised learning algorithms. A deep (multilayer) neural network consists of input and output layers, whose sizes are determined by the problem of interest, and arbitrary numbers and sizes of hidden layers. These layers are connected by linear operations followed by a mapping through nonlinear functions such as a sigmoid function (fully connected networks). Weighting parameters used in the linear operations in each layer are updated repeatedly so that the loss function between the output and the label data (true value) becomes a minimum value. In the present particular problem, we prepared learning data by examining a 1-D shock tube problem which contains rarefaction waves and discontinuities by using CANS+. The input and label data are cell states for all primitive variables in six-point stencils centered on a cell and the numerical flux on the right-hand side of the cell, respectively. We have implemented a multi-layer, fully-connected network by using the Chainer framework for the prepared learning data. With the given data set we successfully obtained a network that can predict the numerical flux with 99% accuracy. In this talk we present detailed algorithms and learning data, and discuss future perspectives including application to multidimensional simulations.

Keywords: neural network, MHD simulations

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Multiple Boris integrators for particle-in-cell simulation

*Seiji Zenitani[1], Tsunehiko N Kato[2]

1. Kyoto University, 2. National Astronomical Observatory of Japan

We construct Boris-type schemes for integrating the gyration of charged particles in particle-in-cell (PIC) simulation. The new solvers virtually combine the classic 2-step Boris solver arbitrary n times, and then they provide n^2 times smaller errors. We derive a single-step form of the multiple Boris solvers, whose coefficients are given by polynomials. We carry out numerical tests of the new solvers, in comparison with other particle integrators.

Keywords: Particle-in-Cell (PIC) simulation, Numerical scheme, Boris integrator

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Contour Dynamics for Vlasov–Poisson Plasma with the Periodic Boundary

*Hiroki Sato[1], Tomo-Hiko Watanabe[1], Shinya Maeyama[1]

1. Nagoya University

Zabusky, Hughes, and Roberts presented a contour dynamics algorithm for the Euler equations of fluid dynamics in two dimensions [1].On the paper, they succeed in calculating time development of contours of vorticity on the x-y plane with the contour dynamics(CD) algorithm, which is a method by using contours of vorticity, piece-wise constant function, and line integrals of Green’ s function on the contours. The CD method does not use underlying lattice, but uses nodes on the contours, and it can lead to more accurate calculation for complex deformation of vorticity.

This method is also applied to Vlasov–Poisson system. In order to study the CD in the Vlasov–Poisson plasma, we have developed a method to implement the periodic of potential and its derivative are satisfied.To check validity of out method, we test the Linear Landau damping by means of the CD scheme.While discretization of the distribution function might lead to some difference from that with continuous distribution, soundness of our new scheme is confirmed in comparison with analytical solutions.

We are also investigating in behaviors of the CD in the continuous limit, and in the nonlinear Landau damping as well.

Reference 1. Contour dynamics for the Euler equations in two Dimensions (1978)

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Simulation methods and visualization tools for MHD simulations in a sphere

*Akira Kageyama[1], Kumiko Hori[1], Naohisa Sakamoto[1]

1. Graduate School of System Informatics, Kobe University

In recent years, we have been developing a set of simulation and visualization tools for magnetohydrodynamics (MHD) simulations in the spherical geometry. The adopted numerical scheme is a finite-difference method on the Yin-Yang-Zhong grid [1], which is an overset grid system in the spherical geometry.

The codes are written in Fortran 2003 or in eFortran [2], which is a dialect of Fortran 2008 language. The features of eFortran include; the period "." as the member access operator; block comments, addition/subtraction/multiplication assignment, pre-defined and user-defined aliases, automatic check of "implicit none" call, "just once" block, and "skip" block. We have developed a preprocessor to convert the dialect into the legitimate Fortran. It is a simple text converter in Python that keeps the line numbers of the input dialect and the output standard codes.

We have performed MHD simulations of relaxation process in a sphere [5]. Since the spherical geometry is free from the lateral dynamic pressure on the spherical boundary, we can observe MHD relaxation process in which flow and the magnetic field coexist. Intriguing structures of magnetic/flow fields are observed after relaxations.

One of interesting applications of the spherical MHD solver is the spherical shell convection with resistive inner core. Magnetic field generated by dynamo process in the convective spherical layer can diffuse into the inner solid core. We have solved slowly rotating spherical thin shell convection system and confirmed that the resistive inner core plays important roles to keep the dynamo operating in convection rolls in the ring- or spiral-shape.

We have also applied the Yin-Yang-Zhong simulation code to simulate MHD flows in a precessing sphere. We have confirmed that magnetic field is generated in spherical precession flows in some parameter regimes that are reported in previous studies. The structure and the generation mechanism of the magnetic field is analyzed in detail.

For the visualization purposes, we have developed two kinds of visualization tools for simulation data produced on the Yin-Yang or Yin-Yang-Zhong grid : (a) Two dimensional (cross sectional) in-situ visualization library with vector graphics format (EPS) [3], and (b) three dimensional visualization methods based on an advanced visualization framework KVS (Kyoto Visualization System) [4].

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Keywords: magnetohydrodynamics, sphere, MHD simulation, visualization

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Kármán Vortex Street, Strouhal Number, Hairpin Vortex in 3D global Magnetohydrodynamic MHD simulations in Northward IMF

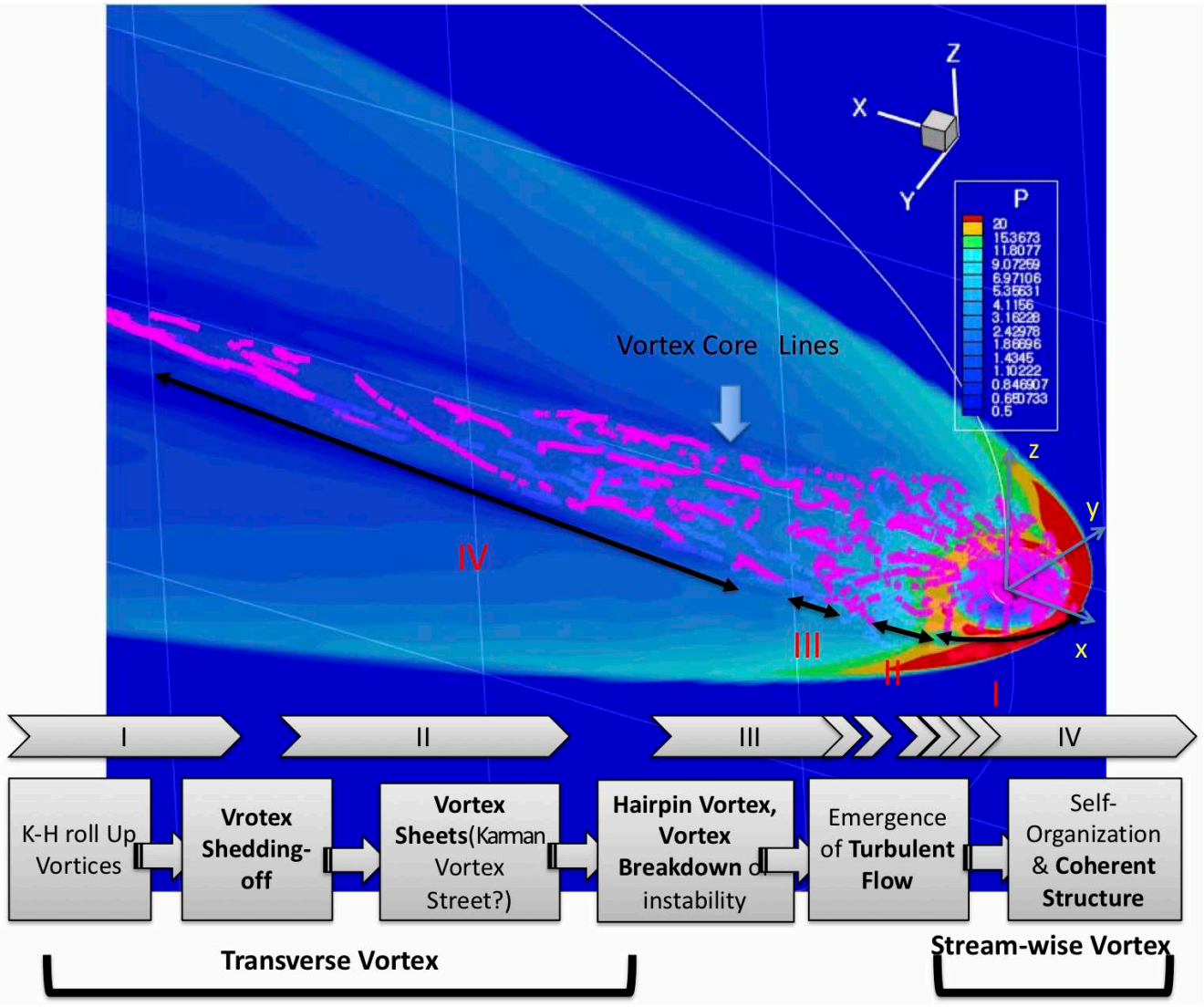
*DongSheng CAI[1]

1. University of Tsukuba

A Kármán vortex street is a repeating pattern of two rows of paired swirling vortices and appears after some obstacles or stagnation areas in fluid or plasma flows. It is caused by a process known as a vortex shedding where vortices leave the shear layer. Recently, several studies have discussed the Kelvin-Helmholtz (K-H) instability and its related waves and vortex structures by using 2D / 3D global (Magneto Hydro Dynamics) MHD simulations in the northward IMF (Interplanetary Magnetic Field). These found a double-vortex sheet in which a vortex train propagates, respectively, along the inner and outer edges of the magnetopause. In the present paper, we show that these two rows of vortices form the Kármán vortex street, and we discuss its generation mechanism with the help of 3D global MHD simulations. These Kármán vortex stretches and elongates in the night side and becomes to be the so-called the Hairpin vortex that is essential for the coherent structure. We also identify the non-dimensional number vortex so-called the Strouhal number in our simulation. The Stouhal number is ubiquitous and represents one of the most significant features in the Kármán vortex street.

Keywords: Kármán vortex street, Strouhal Number, Hairpin Vortex

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Correlations between plasma density and magnetic field strength in MHD turbulence in space

*Tohru Hada[1], Yasuhito Narita[2], Yasuhiro Nariyuki[3]

1. Interdisciplinary Graduate School of Engineering Sciences, Kyushu University, 2. Space Research Institute, Austrian Academy of Sciences, 3. Faculty of Human Development, University of Toyama

Large amplitude magnetohydrodynamic (MHD) turbulence is ubiquitous in space plasma, for example, in the solar wind, in the foreshock region (Narita, World Scientific, 2010) and in the sheath region of the earth's bowshock (e.g., Pollock et al., J. Atmosph. Solar Terr. Phys, 2018). Moreover, recent Voyager observations of large amplitude density and magnetic field fluctuations in the heliosheath behind the termination shock arouse a vivid discussion on the compressible nature and the origin of the observed turbulence (Burlaga and Ness, ApJ, 2009; Gutynska et al., ApJ, 2010). An obvious way of generating the density fluctuations is via the presence of compressive wave modes, such as obliquely propagating MHD waves. The density response is linear to the magnetic field perturbations in this case, and it vanishes in the limit of parallel wave propagation. In a finite (large) amplitude Alfvenic turbulence the density perturbation may be mainly generated via the "frozen-in" of the magnetic field to the plasma or the static balance between the plasma pressure and the magnetic field. Both of these processes result in the quadratic response of the density to the magnetic field perturbations, although their correlation is positive for the former and negative for the latter. This simple fluid picture, sometimes referred to as the "quasi-static" approximation, is known to be significantly modified when the ion response to the turbulence is kinetically treated (Mjolhus and Wyller, Phys. Scripta, 1986; Medvedev and Diamond, Phys. Plasmas, 1996). In this presentation, we address this unsolved issue of the correlations between the plasma density and the magnetic field amplitude in the presence of finite amplitude MHD turbulence by performing hybrid simulations (kinetic ions + fluid electrons), and by examining the in situ Cluster spacecraft data of the foreshock plasma (Narita and Hada, Earth, Planets and Space, 2018).

Keywords: MHD turbulence, quasi-static approximation

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[J] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Thu. May 30, 2019 3:30 PM - 5:00 PM JST | Thu. May 30, 2019 6:30 AM - 8:00 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[P-EM17] Space Plasma Physics: Theory and Simulation

convener:Takayuki Umeda(Institute for Space-Earth Environmental Research, Nagoya University), Takanobu Amano(Department of Earth and Planetary Science, University of Tokyo), Yasuhiro Nariyuki(Faculty of Human Development, University of Toyama), Tadas Nakamura(Fukui Prefectural University), Chairperson:Tadas Nakamura(Fukui Prefectural University), Yasuhiro Nariyuki

This session focuses on studies of space plasma physics via theoretical and numerical approaches. Papers on a wide variety of topics from natural phenomena to artificial plasma environment as well as theoretical and computational methodologies are welcome.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[PEM17-07] Stochastic models of phase space diffusion via wave-particle interaction with parallel propagating electromagnetic waves

*Yasuhiro Nariyuki[1] (1.Faculty of Human Development, University of Toyama)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[PEM17-08] Electron beam instability in collisionless magnetic reconnection with a strong guide field

*Kazuya Shimomura[1], Tomo-Hiko Watanabe[1], Shinya Maeyama[1], Akihiro Ishizawa[2] (1.Nagoya Univertsity, 2.Kyoto University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[PEM17-09] Particle acceleration with precursor wave driven wakefield in relativistic shocks

*Masanori Iwamoto[1], Takanobu Amano[1], Masahiro Hoshino[1], Yosuke Matsumoto[2] (1.Graduate School of Science,The University of Tokyo, 2.Graduate School of Science, Chiba University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[PEM17-10] Stochastic Shock Drift Acceleration in the Shock Transition Region with Finite Pitch-Angle Anisotropy

*Takuma Katou[1], Takanobu Amano[1] (1.The University of Tokyo)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[PEM17-11] Near-fields and its Applications in Space Plasmas

*Tadas Nakamura[1] (1.Fukui Prefectural University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[PEM17-12] Problems of Gravitational Waves and Origin of Gravitational Fields Raised by Studies on Binary Black Hole

*Hiroshi Oya[1] (1.Department of Geophysics Graduate School for Science Tohoku University)

Stochastic models of phase space diffusion via wave-particle interaction with parallel propagating electromagnetic waves

*Yasuhiro Nariyuki[1]

1. Faculty of Human Development, University of Toyama

Particle diffusion due to electromagnetic waves is one of fundamental processes in various phenome in space plasms such as electron acceleration in the outer radiation belt [e.g., Saito et al, JGR, 2016], astrophysical shock [e.g., Yamazaki, JHEA, 2015], and solar wind [e.g., Seough et al, APJ, 2015]. Although quasi-linear theories are widely used as a standard theory of particle scattering, nonlinear wave-particle interactions such as particle trapping also affect particle diffusions in the presence of finite amplitude waves. Saito et al [JGR, 2016] demonstrated that nonlinearity of whistler chorus waves plays a significant role in electron diffusion though nonlinear wave-particle interactions.

In Saito et al [JGR, 2016], the artificial randomization of gyrophases (phase breaking) is incorporated to discuss suppression of coherent wave-particle interactions. Remark that such a randomization corresponds to a noise term in equations of motion of each particles. In this sense, phase breaking causes not only the suppression of coherent processes but also diffusions in phase space. In the present study, we discuss the generalization of phase breaking. It is shown that particle diffusion depends on probability density functions of noises and their parameters. Noise terms in equations of the pitch angle are also necessary to describe diffusion in phase space. Treatment of phase breaking as a stochastic differential equation is also discussed.

Keywords: particle diffusion, wave-particle interactions, stochastic model, whistler waves, magnetohydrodynamic waves

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Electron beam instability in collisionless magnetic reconnection with a strong guide field

*Kazuya Shimomura[1], Tomo-Hiko Watanabe[1], Shinya Maeyama[1], Akihiro Ishizawa[2]

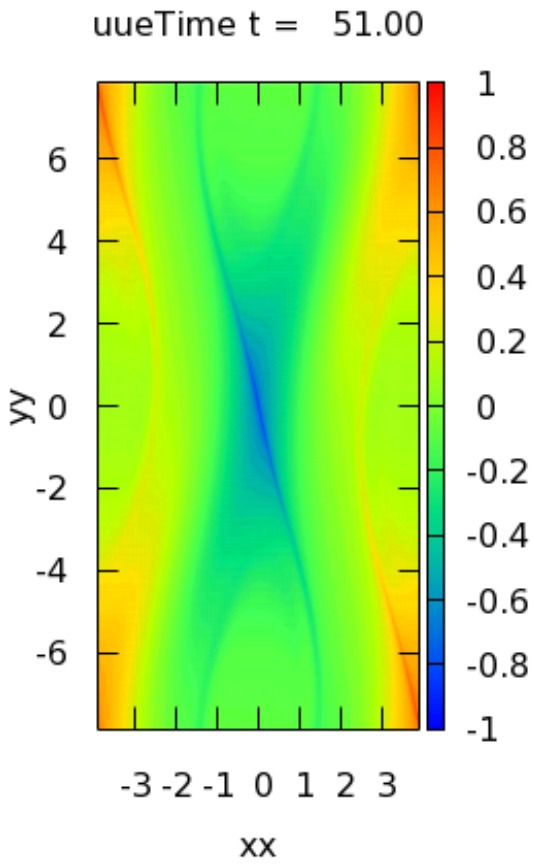
1. Nagoya Univertsity, 2. Kyoto University

Magnetic reconnection is a fundamental physics mechanism in magnetized plasma that causes a topological change of magnetic field lines and a conversion of magnetic energy to kinetic energy, leading to a self-organization of plasmas in laboratory and space. It is considered that the two-fluid effects or the kinetic effects facilitate the fast reconnection of magnetic field lines in colllisionless plasmas. Anomalous resistivity (AR) is one of the candidates that contributes to continuously drive the magnetic reconnection. A recent simulation study reports that AR induced by the Buneman instability accelerates the magnetic reconnection [1]. However, it is not clear how the instability causing the AR is spontaneously driven during the reconnection.
In our study so far, we have carried out numerical simulations of the collisionless magnetic reconnection by means of the gyrokinetic model of a slab plasma with a strong guide field [2][3]. During the reconnection, the parallel electric field is induced by the electron inertia at the X-point where electrons are acccelerated along the guide field. A liner analysis by use of the dispersion releation shows that the kinetic Alfvén waves (KAWs) are destabilized when the electron beam velocity exceeds the Alfvén speed, where, we assumed a plane wave in an uniform background profile. Furthermore, in this δf gyrokinetic model, the total distribution function F is approximately described as $F=FM+\delta f=(1+Uv)FM\tilde{}1/2pi\ exp(-(v-U)^2/2)$, where FM, δf and U are the Maxwellian, perturbed distribution function, and a beam velocity component, respectively. In order to analyze a stability of the KAWs in an inhomogeneous background profile during the collisionless magnetic reconnection, we must use the total distribution function rather than δf, since the KAWs are stable for $(1+Uv)FM$, according to the Nyquist criteria. Therefore, in this study, the magnetic reconnection process triggered by the electron inertia is simulated by use of a full-f gyrokinetic model of a slab plasma with the guide field. As a result, the shifted Maxwellian is formed at the X-point self-consistently by the parallel electric field. The attached figure shows distribution of the parallel electron beam on the reconnection plane in the nonlinear phase during the reconnection. It is possible to carry out the stability analysis in an inhomogeneous background by use of this simulation results. Results of the stability analysis will also be discussed at the meeting.

[1] H. Che, Phys. Plasmas (2017) 24, 082115
[2] A. Ishizawa, T.-H. Watanabe, Phys. Plasmas (2013) 20, 102116
[3] K. Shimomura, T.-H. Watanabe, et al, submitted to Phys. Plasmas (2019)

Keywords: magnetic reconnection, distribution function, instability, kinetic Alfven wave, gyrokinetic

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Particle acceleration with precursor wave driven wakefield in relativistic shocks

*Masanori Iwamoto[1], Takanobu Amano[1], Masahiro Hoshino[1], Yosuke Matsumoto[2]

1. Graduate School of Science,The University of Tokyo, 2. Graduate School of Science, Chiba University

The acceleration mechanism for generating ultra-high-energy cosmic rays (UHECRs) with energies above 10^{18}eV is one of the most important unsolved problems in astrophysics. Relativistic shocks in extragalactic astrophysical objects such as jets from active galactic nuclei (AGNs) and gamma-ray bursts (GRBs) are considered as efficient acceleration sites and commonly proposed sources for UHECRs. Observations of anisotropy in the arrival direction of the UHECRs favor the extragalactic origin.

In relativistic shocks, large-amplitude electromagnetic waves are excited by synchrotron maser instability (SMI) in the shock transition and propagate upstream (Hoshino & Arons 1991). The precursor wave emission via the SMI is widely studied by means of 1D particle-in-cell (PIC) simulations. Hoshino (2008) demonstrated that the pump electromagnetic wave decays into a Langmuir wave via parametric decay instability and found that nonthermal particles are generated in the manner analogous to wakefield acceleration (WFA) during the nonlinear process of the Langmuir wave collapse. The WFA is first proposed in laboratory plasmas (Tajima & Dawson 1979) and recently applied for UHECR acceleration (e.g., Chen et al. 2002). The WFA in the context of relativistic shocks is considered a promising candidate for UHECR acceleration.

It was believed that in multidimensional shocks, the intense wave emission via the SMI would cease soon due to inhomogeneity along the shock surface. Recently, however, our high-resolution 2D PIC simulations in pair plasmas showed that the wave emission continues (Iwamoto et al. 2017, 2018). Although our studies give positive results for the WFA in relativistic shocks, we could not directly demonstrate it because finite mass difference of two opposite charges is essential for exciting the wakefield.

In this presentation, by performing 2D PIC simulation of ion-electron shocks, we will demonstrate that the wakefield is indeed induced by the large-amplitude precursor wave. Especially for relatively high magnetization, the precursor wave amplitude is significantly amplified and exceeds that in pair plasmas due to a positive feedback process associated with ion-electron coupling through the wakefield. Nonthermal electrons and ions are generated during the nonlinear process of the wakefield collapse and the particle energy spectrum shows a power-law distribution. We will discuss the particle acceleration mechanism in details.

Keywords: cosmic rays, shock waves, acceleration of particles

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Stochastic Shock Drift Acceleration in the Shock Transition Region with Finite Pitch-Angle Anisotropy

*Takuma Katou[1], Takanobu Amano[1]

1. The University of Tokyo

The acceleration of non-thermal electrons is one of the important subjects in space physics. The shock accelerated non-thermal electrons have been observed at Earth's bow shocks (Gostling et al. 1989). These electrons are supra-thermal (with energies from 1keV to 100keV), and their distribution is power-law. However, acceleration models proposed in the past could not reproduce such observed spectra. Recent in-situ satellite observations of Earth's bow shock found wave-particle interactions between whistler waves and electrons at the shock transition region (Oka et.al. 2017). These results indicate that whistler waves play an important role for the acceleration of supra-thermal electrons.

We propose the stochastic shock drift acceleration (SSDA) model as a new acceleration mechanism for non-thermal electrons. It takes into account the effect of stochastic pitch-angle scatterings by whistler waves during the course of the Shock Drift Accelerations (SDA), which is a classical acceleration model for supra-thermal electrons at the shock transition region (Wu 1984, Leroy and Mangeney 1984). By introducing stochasticity with pitch-angle scatterings, the acceleration efficiency may be improved. We theoretically analyzed this acceleration model. We showed that the electron energy spectrum becomes a power-law consistent with observations in the limit of strong scatterings. We also found the maximum energy attainable through the proposed model, and it scales linearly with the pitch-angle scattering coefficient which represents the strength of scatterings. In our previous study, we have assumed the electron pitch-angle distribution is isotropic, and an effective shock speed $u/\cos\theta$ (u: shock speed, θ: shock normal angle) is non-relativistic. The SSDA model cannot consider an anisotropy of the electron pitch-angle distribution. It is well known that the shock with a relativistic effective shock speed has a finite pitch-angle anisotropy. Therefore it is difficult to compare the SSDA model with full particle-in-cell (PIC) simulations which can reproduce only the shock with a relativistic effective shock speed because of the limitation of parameters we can take. To fix this problem, we extend the SSDA model so that it can be applied to such a shock. In this presentation, we discuss the consistency between the extended SSDA model and PIC simulation results.

Keywords: acceleration of particle, Earth, shock waves

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Near-fields and its Applications in Space Plasmas

*Tadas Nakamura[1]

1. Fukui Prefectural University

Solutions to Maxwell's equations consists of two parts: propagating components (electromagnetic waves) and the so-called near-field. Unfortunately, there seems to be considerable confusion on the latter, and the words "near-field" have different meanings depending on authors. For example, Coulomb interaction is often explained as the result of the interchange of virtual photons, however, the Coulomb field is not a photon but a near-field in the sense of this talk. Also, little attention is paid to the difference between propagating plasma waves and plasma near-fields in space physics.

The near-field in the present talk is understood as the off-shell solution to the inhomogeneous linear equations; the term "off-shell" means solutions that do not satisfy the dispersion relation. When the field source is static (Coulomb field or magnetic dipole, for example), it is easy to decompose the field into waves and off-shell near-fields. Here in this talk, the way to do this decomposition for time-dependent field source is explained. When we solve Maxwell's equations, usually we make use of Fourier-Laplace transform to obtain the dispersion relation. The time dependence of the fields is obtained by the inverse Laplace transform using the residue theorem; the wave components are obtained from the residue at the pole of the dispersion relation. One can obtain the near-field component by subtracting this residue contribution from the solution of the inhomogeneous equations.

The author reported the derivation of this result at the fall meeting of SGEPSS last year, and will report its application to space physics this time. The talk at the fall meeting was mainly about the electromagnetic fields in a vacuum; fields in plasmas will be discussed this time. The athematical structure of the fields in plasmas are essentially the same as that in a vaccum, however, currents and charges in plasmas cause a wide variety of phenomena in space. Phenomena such as current generation around small bodies in space plasma flows, the return currents genereted by energetic auroral electrons, and several others will be examined as examples.

Keywords: plasma waves, Laplace transform, near field

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Problems of Gravitational Waves and Origin of Gravitational Fields Raised by Studies on Binary Black Hole

*Hiroshi Oya[1]

1. Department of Geophysics Graduate School for Science Tohoku University

1.INTRODUCTION
As results of a study on the observations and analyses of the decameter radio wave pulses from the center of our Galaxy, it has been concluded that the super massive objects at the center of our Galaxy consist of two black holes which are forming a binary system rotating with common period of 2200sec; two black holes called Gaa and Gab, here, are associated with spin with rotation periods of 176.4±1.7 sec and 148.6±1.0 sec with orbiting velocities 18% and 21% of the light velocity, respectively. The radius of the orbits of Gaa and Gab are 0.13 AU and 0.15 AU ; applying Newtonian dynamics with assumption of coincidence of the orbital plane surfaces with the observing direction, it has been concluded that Gaa and Gab have masses of (2.27±0.06)x10∧6 SM and 1.94±0.03)x10∧6 SM with unit of solar mass (SM).
2.THE THEORETICAL INVESTIGATION OF THE GRAVITATIONAL WAVE PROPAGATION
Considering the all parameters deduced for the Gaa and Gab binary system, fast reduction of the radii of the orbits of the binary due to emissions of gravitational waves is inevitable in so far as we follow the traditional theory of the generation of the gravitational wave from the black hole. In the present studies, the propagation of wave general across the event horizon have been theoretically investigated using the spacetime of Minkowski which is realized in the frame that is making free fall in the black hole space time. The results has indicated, both for Shwarzschild and Kerr black holes, that the waves are ceased to propagate at the event horizon. Then we concluded that black hole is not able to be origin of the gravitational wave.
3.DISCUSSION AND CONCLUSION
For the LIGO results that reported observations of the gravitational wave from the stellar mass black hole mergers, an alternative interpretation of the possible origin of the merger is the merger of the compact stars which have no event horizon. By the result of our study, the existence of the graviton which is currently assumed as origin of gravitational force meets problem because the graviton is also a wave in the regime of the quantum mechanics. We suggest the necessity of new concept otherwise than graviton hypothesis for origin of the gravitational fields.

Keywords: Black Hole Binary, Galaxy Center, Decameter Radio Wave, gravitational Wave, Origin of Gravitational Field

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

Thu. May 30, 2019 9:00 AM - 10:30 AM JST | Thu. May 30, 2019 12:00 AM - 1:30 AM UTC | 102 1F

[A-AS04] Atmospheric Chemistry

convener:Tomoki Nakayama(Graduate School of Fisheries and Environmental Sciences, Nagasaki University), Yoko Iwamoto(Graduate School of Biosphere Science, Hiroshima University), Sakae Toyoda(Department of Chemical Science and Engineering, Tokyo Institute of Technology), Nawo Eguchi(Kyushu University), Chairperson:Hisahiro Takashima(福岡大学)

This session provides a forum for the presentation of the broad spectrum of tropospheric and stratospheric chemistry, including various research topics (e.g., dynamical processes, air quality and climate), approaches (modeling, field measurements, remote sensing, and laboratory studies), and species (gas and aerosol). This session also provides an opportunity for discussing possible future collaboration with other research fields relevant to atmospheric chemistry. We strongly encourage authors to prepare presentation slides and a poster in English.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[AAS04-16] Toward the Reduction of Radiative Forcing of Methane and Tropospheric Ozone: Aiming at the Emission Control of CH_4, $NO_x$and NMVOC in Asia

*Hajime Akimoto[1], Tatsuya NNagashima[1], Hiroshi Tanimoto[1], Zig Klimont[2], Markus Amann[2] (1.National Institute for Environmental Studies, 2.International Institute for Applied Systems Analysis)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[AAS04-17] **Determination of atmospheric NO_2 column densities using a Pandora instrument measuring direct-sun spectra at Yokosuka, Japan: Improved validation of TROPOMI satellite observations**

*Yugo Kanaya[1], Hisahiro Takashima[2,1], Masato I. Nodzu[3], Takashi Sekiya[7], Kazuyuki Miyazaki[1], Henk Eskes[4], Gaia Pinardi[5], Daniel Santana Diaz[6], Moritz Müller[6], Alexander Cede[6] (1.Research and Development Center for Global Change, Japan Agency for Marine-Earth Science and Technology (JAMSTEC), 2.Fukuoka University, 3.Tokyo Metropolitan University, 4.KNMI, 5.BIRA-IASB, 6.LuftBlick, 7.Japan Agency for Marine-Earth Science and Technology (JAMSTEC))

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[AAS04-18] A high-resolution global data assimilation for air pollution analysis on megacity scale using multi-sensor satellite measurements including TROPOMI NO_2 data

*Takashi Sekiya[1], Kazuyuki Miyazaki[2,1], Henk Eskes[3], Folkert Boersma[3], Koji Ogochi[1], Kengo Sudo[4,1], Masayuki Takigawa[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Jet Propulsion Laboratory/California Institute for Technology, 3.Royal Netherlands Meteorological Institute (KNMI), 4.Graduate School of Environmental Studies, Nagoya University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[AAS04-19] Recent trends of NO_2, VOC, and tropospheric ozone concentrations observed around Chiba, Japan in 2013-2018

*Daichi Yonekawa[1], Hitoshi Irie[2] (1.Chiba university Graduate school, 2.Chiba university)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[AAS04-20] Long-term seasonal changes in tropospheric ozone over Japan

*Natsumi Kawano[1], Tatsuya Nagashima[1], Seiji Sugata[1] (1.National Institute for Environmental Studies)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[AAS04-21] **Characteristics of Atmospheric Photochemical Pollution at a Comprehensive Site in Guangzhou, China**

*Yu Zou[1] (1.Institute of Tropical and Marine Meteorology, CMA,Guangzhou,China)

Toward the Reduction of Radiative Forcing of Methane and Tropospheric Ozone: Aiming at the Emission Control of CH_4, $NO_x$and NMVOC in Asia

*Hajime Akimoto[1], Tatsuya NNagashima[1], Hiroshi Tanimoto[1], Zig Klimont[2], Markus Amann[2]

1. National Institute for Environmental Studies, 2. International Institute for Applied Systems Analysis

In order to reduce impacts of climate change, including potential further increase of damages due to extreme events related to global warming, reduction of burdens of $CH_4$and tropospheric ozone in Asia are discussed. In order to mitigate the inevitable further increase of radiative forcing (RF) of ca. 0.8 W $m^{-2}$by 2040 caused by the increase of CO_2in 2040, feasible reduction of the industrial RF of methane (CH_4) and tropospheric ozone (trop-O_3) to the 50% of the values in 2011 are targeted to compensate 50% of the RF increase of CO_2. The remaining RF of $CH_4$and trop-O_3(0.26 and 0.22 W m^{-2}, respectively) correspond to the historical levels in 1960-1970. The necessary reductions of anthropogenic emissions of CH_4, $NO_x$and NMVOC in Asia in 2040 to the level of 1970 from that of 2010 have been estimated to be 35% CH_4, 44% NO_2, and 22% NMVOC from those of 2010 assuming the same necessary reduction ratio as for the global emissions. The estimated reductions have been compared with the reduction amount proposed in the Solution Report prepared under UN Environment Asia Pacific Office in 2018. The presumed reduction of the Asian emissions by 2030 through introducing of proven control measures are 27, 57 and 55% for CH_4 , $NO_x$and NMVOC. Thus, the reduction of RF of more than 50% from the reference year of 2010 is feasible for trop-O_3if the emissions of $NO_x$and NMVOC from other part of the world could be reduced coherently. Further efforts would be necessary for the reduction RF of $CH_4$by more than 50% of the present value.

Keywords: Extreme weather, SLCF, Asian emission control

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Determination of atmospheric NO_2 column densities using a Pandora instrument measuring direct-sun spectra at Yokosuka, Japan: Improved validation of TROPOMI satellite observations

*Yugo Kanaya[1], Hisahiro Takashima[2,1], Masato I. Nodzu[3], Takashi Sekiya[7], Kazuyuki Miyazaki[1], Henk Eskes[4], Gaia Pinardi[5], Daniel Santana Diaz[6], Moritz Müller[6], Alexander Cede[6]

1. Research and Development Center for Global Change, Japan Agency for Marine-Earth Science and Technology (JAMSTEC), 2. Fukuoka University, 3. Tokyo Metropolitan University, 4. KNMI, 5. BIRA-IASB, 6. LuftBlick, 7. Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Satellite observations of NO_2, a key atmospheric pollutant, have provided critical information on global distribution of NO_x sources and their temporal changes since 1995, and advanced understanding of atmospheric chemistry. A recent remarkable improvement is with their spatial resolution, reaching 7×3.5 km for TROPOMI (Sentinel-5P), launched in 2017. However, there is still a fundamental issue of low bias in the determined tropospheric NO_2 column densities (e.g., 25-50% for TROPOMI), when evaluated against ground-based spectroscopic observations. Potential causes would be (1) a-priori vertical profile shapes, (2) co-present aerosols and/or surface albedo, and (3) spatial inhomogeneity of NO_2, while (4) uncertainty in the ground-based observations could also be important. At Yokosuka (32.32˚N, 139.65˚E), located on the south edge of Tokyo-Yokohama metropolitan area, we newly started direct-sun Pandora spectrometer observations in November 2018 and strengthened validation capability, where the scattered-sun MAX-DOAS observations (from a JAMSTEC original instrument) had been solely referenced before. Results during winter 2018/2019 showed TROPOMI (within 0.1˚ from Yokosuka) had ~40% low bias against MAX-DOAS. The magnitude of difference was similar to the results from longer comparison during Feb-Sep 2018 for TROPOMI and earlier comparisons for OMI (QA4ECV). Pandora (in direct-sun mode) gave values ~24 % less than MAX-DOAS; the cause of difference was likely spatial inhomogeneity, as pollution levels were higher in the northeast for the sight of MAX-DOAS than in south for Pandora. This was consistent with the fact that TROPOMI gave ~18% higher values, when the averaging area was shifted to northeast by 10 km. As such, the importance of factors (3) and (4) was newly evaluated. By considering MAX-DOAS profile shapes in the recalculation of satellite products, we will discuss on factor (1), and the possibility to derive near-surface NO_2 concentrations from satellite observations.

Keywords: Satellite observations, Validation, Spectroscopy, Air pollution

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A high-resolution global data assimilation for air pollution analysis on megacity scale using multi-sensor satellite measurements including TROPOMI NO_2 data

*Takashi Sekiya[1], Kazuyuki Miyazaki[2,1], Henk Eskes[3], Folkert Boersma[3], Koji Ogochi[1], Kengo Sudo[4,1], Masayuki Takigawa[1]

1. Japan Agency for Marine-Earth Science and Technology, 2. Jet Propulsion Laboratory/California Institute for Technology, 3. Royal Netherlands Meteorological Institute (KNMI), 4. Graduate School of Environmental Studies, Nagoya University

Intensive human activities lead to high emissions of air pollutants at megacities, causing severe damages to human health. The number of megacities is expected to rise in developing regions in the near future. Thus, it is important to provide information on air pollutants and their emissions on a megacity scale for the globe in a consistent way. In this study, we present the results from global chemical data assimilation of multi-species satellite observations with a resolution of 0.56 degree using an ensemble Kalman filter approach (Miyazaki et al., 2015) and high-resolution global chemical transport model, CHASER (Sekiya et al., 2018). Assimilated data were obtained from the OMI, GOME-2, and SCIAMACHY for tropospheric NO_2 column, the TES for O_3 profile, the MOPITT for total CO column, the MLS for O_3 and HNO_3 profiles, and the OMI for total SO_2 column. Data assimilation at 0.56-degree resolution largely improved agreements with the observed surface NO_2 pollutions on megacity scale, with reductions of the root mean square errors (RMSEs) relative to in-situ measuring networks (AirBase, AQS, Hong Kong EPD, and NIES) by 33% for Europe, by 67% for the U.S., and by 75% for East Asia, compared to the model simulations without data assimilation. With increasing horizontal resolution from 2.8 to 0.56 degree, the global total NO_xemission estimates became lower by 10% mainly because of the effects of non-linear O_3-HO_x-NO_x chemistry, while resolving higher NOx emissions by a factor of 4-5 in most of the megacities than their surrounding areas. Using the high-resolution data assimilation system and applying advanced super-observation approach, we demonstrated that assimilation of tropospheric NO_2 retrievals from TROPOMI improved agreements of tropospheric NO_2 column with the assimilated TROPOMI data itself by 62% and with OMI by 40% (not used for data assimilation) compared to model simulation at 1.1-degree resolution for April 2018. These improvements primarily resulted from substantial emission reductions over the U.S., China and India and increases over rural regions relative to the a priori emissions (HTAP_v2.2+GFED4 +GEIA). These results demonstrated the potentials of the high-resolution global data assimilation with the combined use of advanced satellite observations to provide valuable information on spatial and temporal variations of air pollution on a megacity scale globally.

Keywords: Tropospheric NO2, Megacity, Data assimilation, Emission inversion, Satellite observation

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Recent trends of NO_2, VOC, and tropospheric ozone concentrations observed around Chiba, Japan in 2013-2018

*Daichi Yonekawa[1], Hitoshi Irie[2]

1. Chiba university Graduate school, 2. Chiba university

Tropospheric ozone (O_3) is not only a major photochemical oxidant but also the third important greenhouse gas. In recent years its importance is widely recognized as a short-lived climate pollutant (SLCP). As nitrogen dioxide (NO_2) and volatile organic compounds (VOC) are both important precursors of O_3, they play a central role in photochemical chemistry in the atmosphere. In addition, they have negative direct effects on human health. However, recent trends of O_3, NO_2, and VOC have not been fully understood yet even in Japan.
Using the multi-axis differential optical absorption spectroscopy (MAX-DOAS), we conducted continuous observations of NO_2, formaldehyde (HCHO; as a substitute for VOC) and O_3 concentrations for altitudes of 0-1 km at the SKYNET Chiba site (35.63ºN, 140.10ºE, 21 m asl) for 6 years from 2013 to 2018. Analysis of the data showed that NO_2 and HCHO concentrations decreased by about 30%, but a systematic decrease in O_3 concentration was not observed. Similar trends were seen in tropospheric NO_2 column data obtained by the Ozone Monitoring Instrument (OMI) onboard the Aura satellite of the National Aeronautics and Space Administration (NASA), and concentration data of NO_2, non-methane hydrocarbon (NMHC; as a substitute for VOC), and photochemical oxidant (Ox; as a substitute for O_3) observed by the atmospheric environmental regional observation system (AEROS) called Soramamekun. These results are consistent with previous reports. In this presentation, the observed trends and their causes will also be discussed by utilizing our unique MAX-DOAS system that was directed to 4 different azimuth directions (north, east, west, and south), while traffic is heavy at the north, a residential area is located at the east, there is a sea at the west, and a factory area is located at the south around the SKYNET Chiba site.

Keywords: Nitrogen dioxide, Volatile organic compounds, Tropospheric ozone

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Long-term seasonal changes in tropospheric ozone over Japan

*Natsumi Kawano[1], Tatsuya Nagashima[1], Seiji Sugata[1]

1. National Institute for Environmental Studies

Tropospheric O_3 is the primary source of OH radicals in the troposphere that contribute to the oxidation capacity of the atmosphere. According to the seasonal cycles of surface O_3, different behaviors at the remote and metropolitan areas in northern midlatitude have been pointed out (Parrish et al., 2013; Cooper et al., 2014; McGlynn et al., 2018; Jung et al., 2018). For example, European, American and Asian continental remote sites indicated that the seasonal cycle in the present decade had earlier annual maximum peaks than the maximum in the past decades. On the other hand, delayed maximum peaks appeared in urban locations. In spite of lots of monitoring stations, research for changes in seasonal O_3 cycles in Japan is still unclear. In this study, we investigate the seasonal cycle changes by using long-term continuous O_3 monitoring data at 265 ambient sites.
First, to clarify the annual O_3 maximum, sine function fitting examined by Parrish et al. (2013) was applied to monitoring data between the 1980s and 2010s. Regarding the spatial distribution of seasonal shifting between the 1980s and 2010s, most monitoring sites showed changes in a delayed shift. In particular, the stations with more than 0.2 days/decade delay belong to eastern and southwestern parts of Japan. Next, sine function was fitted to 5-years moving average over the entire data record to acquire the long-term trends of seasonal maximum in each region. All monitoring station were classified based on the 35-years averaged NOx concentration: urban, suburban and rural (Kurokawa et al., 2009). Results in all classifications showed delayed trends over analysis periods. In rural sites, O_3 mixing ratio reached the annual maximum in 5-days earlier than urban and suburban sites. In future work, we will conduct long-term air quality simulation and investigate the mechanism of seasonal cycle delaying.

Acknowledgement
This research was supported by the Environment Research and Technology Development Fund (S-12) of the Ministry of the Environment, Japan.

Keywords: ozone, long-term data record, seasonal cycle

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Characteristics of Atmospheric Photochemical Pollution at a Comprehensive Site in Guangzhou, China

*Yu Zou[1]

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Guangzhou, one of China’ s megacities, is beset with frequent occurrence of atmospheric photochemistry events. In this study, online instruments were used to simultaneously monitor NMHCs, NO*x* and O_3 at Guangzhou Panyu Atmospheric Composition Station (GPACS) of the China Meteorological Administration (CMA), from June 2011 to May 2012, in order to obtain their characteristics, NMHCs reactivity and the control strategies for atmospheric photochemistry. The results showed that during the observation period, the seasonal variation of O_3 mixing ratio was lower in spring and winter compared to summer and autumn, which was opposite that for NMHCs and NO*x*. O_3 mixing ratio began to show a net increase at 8:00LT, likely due to the breakup of the nocturnal boundary layer and increased photochemistry, while a net decrease in O_3 mixing ratio occurred at about 15:00LT, due to the fact that sunlight and its associated photochemistry begin to decrease, leading to low OH radicals and the titration of O_3 by emissions of NO*x*. In terms of NMHCs, aromatics had the largest O_3 formation potential, among which toluene, xylenes, ethylbenzene, 1,2,4-trimethylbenzene and 1,3,5-trimethybenzene were the most important species, with a total contribution of about 44%. Weekday/weekend O_3 differences in the morning and at midday largely depend on how much the O_3 precursors are affected by the different intensity of anthropogenic activities. Although the increase of biogenic NMHCs emissions at midday reverses the sensitivity of O_3 production from NMHCs-sensitive to NO*x*-sensitive, high-reactive NMHCs and NO*x* control can be effective for reducing peak O_3 mixing ratios in Guangzhou. Further investigation based on numerical models is required to reach more robust conclusions.

Keywords: Photochemical Pollution, Guangzhou

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

Thu. May 30, 2019 10:45 AM - 12:15 PM JST | Thu. May 30, 2019 1:45 AM - 3:15 AM UTC | 102 1F

[A-AS04] Atmospheric Chemistry

convener:Tomoki Nakayama(Graduate School of Fisheries and Environmental Sciences, Nagasaki University), Yoko Iwamoto(Graduate School of Biosphere Science, Hiroshima University), Sakae Toyoda(Department of Chemical Science and Engineering, Tokyo Institute of Technology), Nawo Eguchi(Kyushu University), Chairperson:Fumikazu Taketani(海洋研究開発機構), Michihiro Mochida(名古屋大学)

This session provides a forum for the presentation of the broad spectrum of tropospheric and stratospheric chemistry, including various research topics (e.g., dynamical processes, air quality and climate), approaches (modeling, field measurements, remote sensing, and laboratory studies), and species (gas and aerosol). This session also provides an opportunity for discussing possible future collaboration with other research fields relevant to atmospheric chemistry. We strongly encourage authors to prepare presentation slides and a poster in English.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[AAS04-22] LC/MS analysis of molecular markers present in biogenic secondary organic aerosols collected during year-round observations at a cool-temperature forest

*Kei Sato[1], Sathiyamurthi Ramasamy[1], Satoshi Inomata[1], Yuzo Miyazaki[2] (1.National Institute for Environmental Studies, 2.Hokkaido University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[AAS04-23] Surfactant Effects on Acid-Catalyzed Reactions at Aqueous Aerosol Surfaces

*Shinnosuke Ishizuka[1], Tetsuya Hama[2], Shinichi Enami[1] (1.National Institute for Environmental Studies, 2.Institute for Low Temperature Science, Hokkaido University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[AAS04-24] Roles of heterogeneous reactions in the tropospheric chemistry: a global modeling study

*Phuc Thi Minh Ha[1], Fumikazu Taketani[2], Yugo Kanaya[2], Kengo Sudo[1,2] (1.Graduate School of Environmental Studies, Nagoya University, 2.Research and Development Center for Global Change, JAMSTEC)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[AAS04-25] Sensitivity of regional deposition of inhaled atmospheric aerosols in human respiratory tract to their size distribution and hygroscopicity: A case study

*Minrui Wang[1], Toshiyuki Mihara[2,4], Mizuo Kajino[5], Kaori Kawana[2,6], Michihiro Mochida[1,2,3] (1.Institute for Space Earth Environmental Research, 2.Graduate School of Environmental Studies, Nagoya University, 3.Institute for Advanced Research, Nagoya University, 4.Now at Gifu Prefectural Industrial Research Institute, 5.Meteorological Research Institute, Japan Meteorological Agency, 6.Now at Research and Development Center for Global Change, JAMASTEC)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[AAS04-26] Biogeochemical cycle between atmosphere and ocean via particulate matters -Award lecture for JpSAC Young Scientist Award-

★Invited Papers

*Yoko Iwamoto[1] (1.Graduate School of Biosphere Science, Hiroshima University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[AAS04-27] Kinetic Studies for Quantitative Elucidation of Heterogeneous Halogen Chemistry in the Troposphere

-JpSAC Early Career Scientist Award Lecure-
★Invited Papers

*Yosuke Sakamoto[1,2] (1.Graduate School of Global Environmental Studies, Kyoto University , 2.Graduate School of Human and Environmental Studies, Kyoto University)

LC/MS analysis of molecular markers present in biogenic secondary organic aerosols collected during year-round observations at a cool-temperature forest

*Kei Sato[1], Sathiyamurthi Ramasamy[1], Satoshi Inomata[1], Yuzo Miyazaki[2]

1. National Institute for Environmental Studies, 2. Hokkaido University

To understand formation processes for organic nitrogen and dimeric compounds present in forest aerosols, we analyzed molecular markers present in forest aerosols collected during year-round observations using negative/mode electrospray ionization-liquid chromatography-mass spectrometry (ESI-LC/MS). Thirty-seven aerosol filter samples were collected at Tomakomai Experimental Forest between January and December in 2013, and 33 of the collected samples were analyzed in this study. Molecular markers analyzed in this study were cis-pinic acid, 3-methyl-1,2,3-butanetricarboxylic acid (3-MBTCA), α-pinene-derived dimer detected by ESI at m/z 357 (α-pinene dimer), isoprene-derived olganosulfate detected at m/z 215 (isoprene OS), and isoprene-derived nitrooxyorganosulfate detected at m/z 260 (isoprene NOS). Each aerosol filter sample was extracted in methanol; the extract was concentrated under gentle stream of nitrogen; the concentrated extract was dissolved in an analytical solvent to obtain an analytical sample; and the analytical sample was analyzed by an LC/MS instrument (Sato et al., 2007). The seasonal change in the concentration of cis-pinic acid, formed from α-pinene oxidation, was peaked in spring and fall, whereas the seasonal change in the concentration of 3-MBTCA, formed from oxidation of pinonic acid, was peaked in summer. Very similar results were reported in a previous paper on the GC/MS analysis of the same samples (Müller et al., 2017). The seasonal change in the concentration of α-pinene dimer was similar to that of cis-pinic acid, suggesting that a major formation process of the detected dimers was the atmospheric oxidation of α-pinene. The seasonal changes in the concentrations of isoprene OS and isoprene NOS, which are derived from isoprene epoxydiol (IEPOX), were peaked at fall and summer, respectively. The seasonal change in the concentration of isoprene NOS agreed well with that of 2-methyltetrols, molecular markers of isoprene secondary organic aerosol. These results suggest that a major formation process of isoprene NOS is secondary organic aerosol formation from isoprene in the presence of air pollutants.

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Müller, A., Miyazaki, Y., Tachibana, E., Kawamura, K., Hiura, T., Evidence of a reduction in cloud condensation nuclei activity of water-soluble aerosols caused by biogenic emissions in a cool-temperate forest, Sci. Rep., 7, 8452 (2017).

Keywords: Bigenic volatile organic compound, Secondary organic aerosol, Organosurfate, Nitrooxy organosulfate, Organic nitrogen

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Surfactant Effects on Acid-Catalyzed Reactions at Aqueous Aerosol Surfaces

*Shinnosuke Ishizuka[1], Tetsuya Hama[2], Shinichi Enami[1]

1. National Institute for Environmental Studies, 2. Institute for Low Temperature Science, Hokkaido University

The outermost layer of atmospheric aqueous aerosol is covered with amphiphilic organic compounds. Volatile organic compounds (VOCs) in the gas phase should encounter them first at the air/aerosol interface, rather than solute molecules homgeneously distributed in the bulk. It may control the whole reactivity of the aqueous aerosol and play key roles in birth, growth and degradation processes of atmospheric aerosols. Here we studied activities of quaternary alkyl trimethyl ammonium cations $CH_3(CH_2)_{n-1}(CH_3)_3N^+$ (n = 1, 4, 8, 10, 12, 14) at the surfaces of water using surface-sensitive spraying ionization mass spectrometry. The longer-chain alkyl ammonium cations are detected more prominently at the water surface of the equimolar solution, expressed as an exponential function of the alkyl chain length. We suggest the occurrence of competitive adsorption among the quaternary ammonium cations at water surface. Then, the surfactant effects on the gaseous uptake and subsequent reactions of VOCs was investigated. When isoprene is exposed to acidified water surfaces, proton transfer reaction from H_3O^+ to isoprene occurs, which is followed by chain-propagation reactions. We found that the longer-chain ammonium cations suppressed isoprene oligomer signals but rarely hindered chain-propagation reactions even at larger concentrations, e.g., the higher surface coverage. It suggests that gaseous isoprene is directly added to the protonated species at water surface. We conclude that competitive adsorption between isoprene oligomers and the ammonium cations suppressed the acid-catalyzed reactions. Driving force leading to the adsorptive competition will be argued based on experiments performed by adding anionic and neutral surfactants.

Keywords: The Air/Water Interface, SOA

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Roles of heterogeneous reactions in the tropospheric chemistry: a global modeling study

*Phuc Thi Minh Ha[1], Fumikazu Taketani[2], Yugo Kanaya[2], Kengo Sudo[1,2]

1. Graduate School of Environmental Studies, Nagoya University, 2. Research and Development Center for Global Change, JAMSTEC

Heterogeneous reactions in the atmosphere largely affect air quality and climate by changing tropospheric photochemical processes involving gases like O_3, HO_x, NO_x, HNO_3, CO, VOCs, and aerosols. There are many previous studies on the effects of heterogeneous reactions at regional to global scales using direct measurements, remote sensing, and simulation. For the atmospheric chemistry simulation, there is a large uncertainty from the treatment of the heterogeneous reactions in the model due to the still insufficient understanding of the mechanism of heterogeneous reactions.
This study is intended to understand the roles of the heterogeneous reactions in the global tropospheric chemistry using a chemistry-climate model CHASER (MIROCESM) (Sudo et al., 2011) which includes more than 250 chemical reactions in the troposphere and stratosphere with more than 70 chemical species. This model also includes aerosol components (SPRINTARS) for sulfate, nitrate, BC, POA/SOA, dust, and sea-salt; formation of nitrate and SOA, and ageing of BC are calculated tightly linked to the chemistry in CHASER. The present version of CHASER considers heterogeneous reactions of N_2O_5, HO_2, RO_2, and HCHO for surfaces of the individual aerosol components and cloud particles.
The model simulation is validated with the observational data from EANET, EMEP and the ship-based observation. Our performed sensitivity simulations with respect to the heterogeneous reactions show that the impacts of the N_2O_5 heterogeneous reaction may not be as large as previously reported; surface concentrations of NO_x, O_3 and OH are only reduced by 1.6%, 2.2%, 2.6%, respectively, in global mean (in regional, at most, 23%, 5.4%, and 12.8%). Whereas, the HO_2 reaction (to form H_2O_2) can cause a significant effect on distributions of O_3 and related species (NO_x, O_3, OH are changed by 68.7%, -21.5% and -70.1%). In addition to the polluted areas in China and India, we found that in the North Pacific region the heterogeneous reactions can play a critical role in the concentrations of NO_x, O_3, CO, OH, HO_2 (up to 69%, 21%, 7%, 70%, 81%, respectively). The possible large impacts of the heterogeneous reactions are also verified with the ship-based observational data for the North Pacific and Alaska regions.

Keywords: heterogeneous reaction, chemical climate model, North Pacific

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Sensitivity of regional deposition of inhaled atmospheric aerosols in human respiratory tract to their size distribution and hygroscopicity: A case study

*Minrui Wang[1], Toshiyuki Mihara[2,4], Mizuo Kajino[5], Kaori Kawana[2,6], Michihiro Mochida[1,2,3]

1. Institute for Space Earth Environmental Research, 2. Graduate School of Environmental Studies, Nagoya University, 3. Institute for Advanced Research, Nagoya University, 4. Now at Gifu Prefectural Industrial Research Institute, 5. Meteorological Research Institute, Japan Meteorological Agency, 6. Now at Research and Development Center for Global Change, JAMASTEC

Aerosols, which inhaled to human respiratory tract, can cause various diseases that threaten one's health. In order to estimate aerosol's health risk, it is significant to elucidate the sensitivity of regional deposition of inhaled aerosols.

In this study, by applying size distribution and hygroscopic growth factor data of aerosol (measured by a scanning mobility particle sizer in September 2009 and July-August 2010) to an MPPD (Multiple-Path Particle Dosimetry) model, we calculated the regional deposition differentiated by size diameter/hygroscopicity for a resting/light exercising adult male. As a result, regional deposition ratio in intrathoracic region (both tracheobronchial airway and alveolar interstitium) showed a bimodal distribution among particle size diameter ranging between 24.1~359.0 nm, in which the maximum value was 50.1%/50.0% at 24.1 nm (during light exercise). In general, there was a decreasing trend in deposition ratio when particle size diameter increased. For mode particles (dry diameter $d_{p,dry} < 100$ nm), the regional deposition of particles that have low hygroscopicity parameter (κ) tent to be larger than those with higher κ. However, for larger particles (especially when $d_{p,dry} > 200$ nm), this trend became reversed.

In 2009 the measurement was continuous for 10 days, while daily variation was found in aerosol number-size distribution and regional deposition. Therefore, we analyzed the meteorological data of the measurement period in 2009, comparing daytime (12:00-18:00 LST) and nighttime (00:00-06:00 LST) in order to indicate meteorological matters that affect the temporal variation of regional deposition. The result showed that the relative humidity (RH) during daytime was basically lower than 50% except September 15 and September 22~23 due to continuous rain, and the distribution of regional deposition was maximum for relatively hydrophobic mode particles ($d_{p,dry} < 100$ nm, hygroscopic growth factor g ranges between 1.0~1.2). On the other hand, RH during nighttime was mostly higher than 60%, and a bimodal distribution of both hydrophobic and hydrophilic (g ranges between 1.2~1.4) particles was found. Meanwhile, on September 23 RH was high (over 75%) during whole day, we found a monomodal distribution of regional deposition with a maximum value for hydrophilic particles that last about 6 hours in the afternoon.

According to our results we suggested that along with the temporal variation of artificial emission, changes in ambient humidity could also influence the composition of inhaled aerosol particles to a great extent, and therefore affected the regional deposition.

Keywords: Aerosol, size distribution, hygroscopicity, regional deposition

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Biogeochemical cycle between atmosphere and ocean via particulate matters
-Award lecture for JpSAC Young Scientist Award-

*Yoko Iwamoto[1]

1. Graduate School of Biosphere Science, Hiroshima University

The oceans absorbs carbon dioxide which is increasing in the atmosphere and has the ability to mitigate sudden climate change. The biological pump driven by marine phytoplankton play an important role in the global carbon cycle. In order to accurately estimate the carbon absorptive capacity of the oceans, it is important to know the supply amount of nutrient elements that support the growth of phytoplankton. Despite the fact that iron is an essential element for marine phytoplankton, the concentration of dissolved iron in the surface ocean is extremely low. Iron containing aerosols such as mineral dust in the atmosphere could be important as a source of iron to the surface ocean.

In my previous work, the sporadic deposition of atmospheric mineral dust by sea fog over the North Pacific was observed during an Asian dust event. By using bulk and individual particle analyses for suspended particulate matters in seawater, the biogeochemical impact of the dust deposition was investigated. As a result, it was found that the bioavailable iron supply to the surface ocean by an Asian dust event was sufficient to promote the growth of phytoplankton, and it also contribute the carbon absorption to the northern North Pacific. In addition, from a mapping data covering the North Pacific and its marginal seas, it was revealed that mineral particles of atmospheric origin existed ubiquitously in the surface ocean even during summer when the influence of Asian dust event is small.

On the other hand, the growth of marine phytoplankton causes changes in the atmospheric environment through aerosol generation. My current research focuses on oceanic aerosols acting as cloud condensation nuclei. From the continuous observation conducted at Noto ground-based research observatory (NOTOGRO) facing the Sea of Japan, it was found that the growth rate of cloud droplets delayed when the organic mass fraction of the aerosol was high. Currently, researches on the linkage between phytoplankton species and marine biogenic aerosol and the climate effect of aerosol generated by bubble bursting at the air-sea interface are conducted.

Keywords: the North Pacific, Mineral dust, Aerosol, Biogeochemical cycles, Cloud condensation nuclei

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Kinetic Studies for Quantitative Elucidation of Heterogeneous Halogen Chemistry in the Troposphere
-JpSAC Early Career Scientist Award Lecure-

*Yosuke Sakamoto[1,2]

1. Graduate School of Global Environmental Studies, Kyoto University , 2. Graduate School of Human and Environmental Studies, Kyoto University

Ozone is one of the most important species in the troposphere since it has health and environmental effects, and relates to atmospheric oxidation capacity and climate change. Halogen species are deeply involved in the tropospheric ozone chemistry by forming catalytic reaction cycles. Observations, model simulations and laboratory experiments have suggested that heterogeneous reactions of gaseous oxidants such as ozone and OH radical with halide ions in sea water/ice and sea salt aerosol are important halogen emission sources. However, quantitatively we still have not had conclusions of their importance in many cases due to experimental difficulties to determine kinetic parameters for the heterogeneous reactions. To obtain quantitative kinetic parameters of gas-liquid heterogeneous oxidation reactions of halide ions which are difficult for conventional methods, this study has developed original approaches using laser spectroscopy or mass spectrometry, and applied them to kinetic studies. This presentation includes results of three reaction systems: 1. gaseous ozone with iodide solution (Sakamoto et al. 2009, 2013), 2. gaseous ozone with bromide solution (Sakamoto et al. 2018a), 3. gaseous OH radical with chloride containing deliquesced aerosol (Sakamoto et al. 2018b), and also discussion on contribution of interfacial process to total reaction rate.

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Keywords: earth, aerosol, oxidant

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

Thu. May 30, 2019 3:30 PM - 5:00 PM JST | Thu. May 30, 2019 6:30 AM - 8:00 AM UTC | 103 1F

[A-AS04] Atmospheric Chemistry

convener:Tomoki Nakayama(Graduate School of Fisheries and Environmental Sciences, Nagasaki University), Yoko Iwamoto(Graduate School of Biosphere Science, Hiroshima University), Sakae Toyoda(Department of Chemical Science and Engineering, Tokyo Institute of Technology), Nawo Eguchi(Kyushu University), Chairperson:Hideaki Nakajima(国立環境研究所)

This session provides a forum for the presentation of the broad spectrum of tropospheric and stratospheric chemistry, including various research topics (e.g., dynamical processes, air quality and climate), approaches (modeling, field measurements, remote sensing, and laboratory studies), and species (gas and aerosol). This session also provides an opportunity for discussing possible future collaboration with other research fields relevant to atmospheric chemistry. We strongly encourage authors to prepare presentation slides and a poster in English.

3:30 PM - 4:00 PM JST | 6:30 AM - 7:00 AM UTC

[AAS04-28] Planetary atmosphere - Mars and Venus -

★Invited Papers

*Hiroyuki Maezawa[1] (1.Department of Physical Science Osaka Prefecture University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[AAS04-29] Validation of methane profile observed with FTIR at Tsukuba

Yuki Dai[2], *Isao Murata[1], Hideaki Nakajima[3], Isamu Morino[3] (1.Graduate School of Environmental Studies, Tohoku University, 2.Graduate School of Science, Tohoku University, 3.National Institute for Environmental Studies)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[AAS04-30] **Retrieval of HFC-23 from FTIR observations at Syowa Station, Rikubetsu and Tsukuba**

*Masanori Takeda[1,2], Hideaki Nakajima[2,1], Isao Murata[1], Tomoo Nagahama[3], Isamu Morino[2] (1.Graduate School of Environmental Studies, Tohoku University, 2.Center for Global Environmental Research, National Institute for Environmental Studies, 3.Institute for Space-Earth Environmental Research, Nagoya University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[AAS04-31] Roles of cloud distribution in global atmospheric photochemistry

*Ryoki Matsuda[1], Kengo Sudo[1,2] (1.Graduate School of Environmental Studies, Nagoya University , 2.Japan Marine-Earth Science and Technology)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[AAS04-32] Evaluating global distribution and interannual variation of stratosphere-troposphere exchange of ozone: impacts of climate variabilities

*Kengo Sudo[1,2], Xin Li[1] (1.Graduate School of Environmental Studies, Nagoya University, 2.Research and Development Center for Global Change, JAMSTEC)

Planetary atmosphere - Mars and Venus -

*Hiroyuki Maezawa[1]

1. Department of Physical Science Osaka Prefecture University

Recently, research on extraterrestrial planets and protoplanetary disks has been rapidly increasing. Mars and Venus, lacking intrinsic magnetic fields, are valuable research targets for further understanding atmospheric environments, habitability of earth-type planets, and the influence of activity of the central star on planetary atmospheres.

On Mars, methane has been detected and research continues to investigate its originand destruction processes by oxidation reaction networks in the atmosphere and on the surface. For an Earth-type planet with an atmosphere mainly of CO_2, the CO_2 is photo-dissociated into CO and oxygen by UV radiation from the sun. Mars and Venus have small percentages of CO and oxygen, and how they are oxidized back into CO_2 has not yet been fully elucidated. This is known as the “CO_2 stability problem”. Also, in order to understand the evolutionary processes of the Martian atmosphere, detailed and systematic observations of the spatial and temporal fluctuations of H_2O and oxidants, including H_2O_2, O_3, O_2, etc., and their altitudinal distributions are important.

Venus experiences high-speed super-rotation winds at approximately the cloud altitude and day to night circulation at higher altitudes. Recently, for example, it has gradually become clear that the latter convection does not show a similar pattern in the morning and afternoon. In addition, the Akatsuki satellite (JAXA) has captured large-scale, bow-shaped patterns induced by atmospheric gravity waves. It is also important to investigate how the complex dynamics seen in the Venusian atmosphere drive material circulations and oxidation reaction networks including those with respect to minor species such as SO_x, HO_x, CO_x, chloride, aerosol, sulfuric acid, etc. Venus and Mars also provide important insights into how abiotically the biomarkers, O_2 and O_3, are formed in typical terrestrial planets with mainly CO_2 atmospheres.

In this talk, the observations of planetary atmospheres, explored via heterodyne spectroscopy with radio telescopes such as the Atacama Large Millimeter/submillimeter-wave Array (ALMA) interferometer, as well as measurements of various wavelengths with ground-based telescopes and satellites will be also discussed. Since the wavelengths of milli/submillimeter waves are comparatively long, they are less attenuated by absorption and scattering by aerosols/dust. In addition, the Doppler shift of the spectrum obtained with heterodyne spectroscopy provides important information about the velocity fields of the mesosphere and lower thermosphere. Also, regardless of the presence or absence of background light sources such as the sun heterodyne spectroscopy allows us to observe day and night-side atmospheres of planets.

Keywords: Planetary Atmosphere, Terrestrial planet, Solar System, Mars, Venus, Heterodyne Spectroscopy

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Validation of methane profile observed with FTIR at Tsukuba

Yuki Dai[2], *Isao Murata[1], Hideaki Nakajima[3], Isamu Morino[3]

1. Graduate School of Environmental Studies, Tohoku University, 2. Graduate School of Science, Tohoku University, 3. National Institute for Environmental Studies

CH_4 is the second greenhouse gas and the concentration near the surface is increasing. But there are many emission sources and the increasing rate is varying year by year. The profile of CH_4 can be observed with a ground-based high-resolution Fourier transform spectrometer using spectral inversion analysis. However, the validation of the retrieved profile doesn't have been performed enough. Then, we compared some retrieval parameters and validated the retrieved tropospheric partial columns using aircraft sampling measurements.
We analyzed the spectra taken at Tsukuba between 2012 and 2017. SFIT4 spectral fitting program was used to derive the profiles from spectra in 3 micrometer region. H_2O as interference species affects the accuracy of the retrieved CH_4 profiles. Two initial profiles of H_2O are provided: monthly mean (v1) and daily analyzed (v5). Two kinds of microwindows for the retrieval are also provided according to Sussmann et al. (2011): 5 microwindows (5MW) and 3 microwindows (3MW). Fitting results were compared based on the root mean square residual (RMS) and degree of freedoms (DOFs). As a result, 5MWv1 is worse for both RNS and DOFs than other 3. Then, we compared the results of 5MWv5, 3MWv1, and 3MWv5 with aircraft sampling.
The monthly mean tropospheric partial columns integrated from 0 to 8 km were compared with those calculated from aircraft sampling observed by the center for atmospheric and oceanic studies, Tohoku University near Sendai from 2012 to 2017. When all derived partial columns were compared with aircraft results, all 3 cases (5MWv5, 3MWv1, and 3MWv5) showed 5 -10 % differences in summer when H_2O concentration is high. But when the derived partial columns for which RMS is less than 0.15 were compared, all 3 cases agreed with aircraft results within the uncertainty besides for the -2.9 % bias.

Keywords: FTIR, Methane, Height profile, Accuracy

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Retrieval of HFC-23 from FTIR observations at Syowa Station, Rikubetsu and Tsukuba

*Masanori Takeda[1,2], Hideaki Nakajima[2,1], Isao Murata[1], Tomoo Nagahama[3], Isamu Morino[2]

1. Graduate School of Environmental Studies, Tohoku University, 2. Center for Global Environmental Research, National Institute for Environmental Studies, 3. Institute for Space-Earth Environmental Research, Nagoya University

The Montreal Protocol on Substances that Deplete the Ozone Layer has successfully been regulated production and consumption of chlorofluorocarbons (CFCs) and global atmospheric CFCs concentration have kept decreasing. On the other hand, production and consumption of hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs) as alternatives for CFCs are expanding up to the present. Especially, HFC-23 (CHF_3) which has very high global warming potential (100yr-GWP: 12,400) is generated as unavoidable by-product of HCFC-22 ($CHClF_2$) production and their emissions into atmosphere have been increasing relevant to production of HCFC-22. Observations of these gases are possible not only by in-situ gas-chromatogram/mass-spectroscopy systems, but also by infrared spectroscopic measurements. Ground-based Fourier Transform Infrared spectrometer (FTIR) has a capability to monitor multiple gas species simultaneously. In this study, we retrieved total column abundances and vertical profiles of HFC-23 from ground-based FTIR observations with the SFIT4 version 0.9.4.4 based on the optimal estimate method (Rodgers, 2000).
We operated atmospheric solar absorption measurements using ground-based FTIR instrument at Antarctic Syowa Station (69.0ºS, 39.6ºE) in 2007, 2011 and 2016. We used two micro-windows (MWs) of 1138.5-1148.0 cm^{-1}(MW1) and 1154.0-1160.0 cm^{-1}(MW2) in this study. As the spectroscopic parameters of HFC-23, the pseudo line lists produced by G. C. Toon (NASA/JPL) were used. For other interfering species, the line parameters from HITRAN2008 were used. Temperature and pressure vertical information from surface to 40 km a.s.l. were taken by the daily temperature and pressure profiles from NCEP (National Centers for Environmental Prediction) Reanalysis-1 dataset. Meteorological information above 40 km a.s.l. were adopted from the monthly climatological profiles from the COSPAR International Reference Atmosphere (CIRA-86) dataset. The HFC-23 a priori profile was taken fromthe simulated profile by Naik et al. (2000), but that was scaled to make the concentration of the lowest level equal to 20 pptv which is the approximate value of surface concentration in southern hemisphere in 2007. For H_2O and its isotopologues, the a priori profiles were taken from independent preliminarily profile retrievals for each observed spectra. For other interfering species, 40 years (1980-2020) mean profiles of the monthly profiles provided from WACCM (Whole Atmosphere Community Climate Model) version 6 were used as a priori profiles. Figure 1 shows the timeseries of the FTIR-retrieved total columns of HFC-23. According to the error analysis, mean systematic and random errors on the HFC-23 retrievals were ~40% and ~10% to retrieved HFC-23 total column, respectively. The FTIR observation is practicable to estimate the trend of atmospheric HFC-23, because the random uncertainty is relatively small.
In addition, we performed retrievals of HFC-23 from FTIR spectra at Rikubetsu (43.46ºN, 143.77ºE) and Tsukuba (36.05ºN, 140.12ºE) in Japan in the same way as the retrieval strategy at Syowa Station. In the presentation, we will discuss on the differences of HFC-23 trends among these three FTIR sites, along with the trends of HCFC-22 from FTIR observations.

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Keywords: HFC-23, HCFC, FTIR

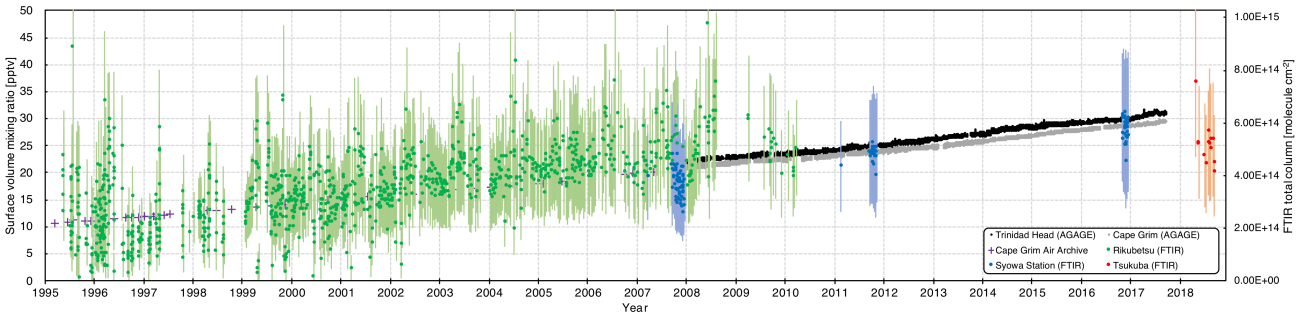


Figure 1. The timeseries of the FTIR-retrieved total columns of HFC-23 at Rikubetsu (green), Syowa Station (blue) and Tsukuba (red) with the retrieval uncertainties, along with ground-based in-situ measurements at Trinidad Head (41.05°N, 124.15°W; black) and Cape Grim (40.68°S, 144.69°E; grey). Also, Cape Grim Air Archive data (purple) is plotted during the period of 1995 to 2007.

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Roles of cloud distribution in global atmospheric photochemistry

*Ryoki Matsuda[1], Kengo Sudo[1,2]

1. Graduate School of Environmental Studies, Nagoya University , 2. Japan Marine-Earth Science and Technology

Chemical reactions in the atmosphere directly affect formation and loss of ozone, methane, nitrogen oxides, sulfur oxides and aerosols, and have a great influence on the atmospheric environment and climate change. Since these reactions are driven by photodissociation of ozone and related species caused by ultraviolet radiation, they can be largely modulated by distribution of clouds. This study quantitatively investigates the photolytic impacts of clouds on atmospheric chemistry by using a global chemical transport model (chemical climate model) and observational (satellite and aircraft) data.
First, verification with satellite data (ISCCP D2) shows that the model (CHASER) reproduced well the global distribution of cloud amount as in the satellite data.
Sensitivity experiments were also performed to estimate clouds impacts on the photolytic processes and global photochemical field in the atmosphere. As a result, it was shown that OH radical (OH) concentrations decrease by 10 to 20% near the surface and increase by 10 to 20% in the upper troposphere. The changes basically reflect scattering and reflection of solar UV radiation by low-middle clouds, which is consistent with the previous studies. The global mean OH concentration, proxy of the oxidizing capacity of the atmosphere, increased by about 12% due to clouds while the global mean tropospheric ozone (O_3) concentration increased by about 0.7%.
The above results for clouds impacts on the atmospheric chemical field calculated in the model were verified by using aircraft observation (NASA ATOM-1). The result shows that the observed OH and O_3 concentrations are reproduced more accurately when clouds are properly considered in the model.
These results indicate that clouds have significant influences on the global atmospheric chemistry (especially on the OH concentration field). Since OH determines the concentrations of chemical species such as methane, carbon monoxide (CO), fluorocarbons (CFCs), etc. which are important for climate and stratospheric ozone, this study suggests that the variation and trends in clouds can largely affect the chemical species, which may give an additional influence on climate and atmospheric environment.

Keywords: Cloud, Chemistry-transport model, Ozone, OH radical

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Evaluating global distribution and interannual variation of stratosphere-troposphere exchange of ozone: impacts of climate variabilities

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The stratosphere-troposphere exchange (STE) of ozone (O_3) can have significant impacts on the interannual variability and long-term trend of global tropospheric ozone and radiation budget. This study investigates global STE of O_3 particularly focusing on the roles of major climate variabilities such as ENSO, PDO, and QBO and climate trend (surface temperature). Using a chemistry coupled climate model, this study estimates temporal variation in the vertical and meridional STE O_3 fluxes during the years of 2000-2016. For the major climate variabilities of ENSO and PDO, associated STE changes are assessed in detail using a composite analysis. The model validation shows that the model well captures the OMI-observed tropospheric column ozone (TCO) abundances (r~0.55), especially around the tropical Pacific (r~0.8). It is shown that in the tropics there is upward O_3 transport to the stratosphere (troposphere to stratosphere transport, TST) while in the extratropics, O_3 transport is downward (stratosphere to troposphere transport, STT), consistent with the Brewer-Dobson circulation in the stratosphere. Although geographical distributions of vertical and meridional STE fluxes are not changed largely by ENSO or PDO, the STE fluxes are significantly amplified by the ENSO events. Horizontal patterns of STE flux anomaly are found to be similar with respect to the El Niño episodes and the PDO warm phases (STT increased by 21% and 10%, respectively, in the northwest Pacific). These anomalies are reversed during the La Niña and PDO cold phases (STT decreased by 16% and 3%, respectively, in northeast Pacific). The anomaly of global net STE O_3 flux is interpreted as several key factors using a multiple-regression analysis. The result shows that the STE anomaly is explained largely by the combination of ONI, PDO, QBO, and global mean surface temperature (R^2~43%). Contributions of ONI and PDO to STE anomaly are estimated to be 22.3% and 23.1%, respectively. This study quantitatively reveals the possible connection between climate condition and STE.

Keywords: Stratosphere-Troposphere Exchange (STE), Ozone, chemistry climate model, chemistry-climate interaction, climate change, Budget of tropospheric ozone

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Thu. May 30, 2019 10:45 AM - 12:15 PM JST | Thu. May 30, 2019 1:45 AM - 3:15 AM UTC | 106 1F

[A-CG36] Earth & Environmental Sciences and Artificial Intelligence

convener:Tomohiko Tomita(Faculty of Advanced Science and Technology, Kumamoto University), Ken-ichi Fukui(Osaka University), Daisuke Matsuoka(Japan Agency for Marine-Earth Science and Technology), Satoshi Ono(Kagoshima University), Chairperson:Tomohiko Tomita(Kumamoto University, Faculty of Advanced Science and Technology)

In recent years, we have been required to explore the gigantic environmental data leading global environmental studies of modern meteorology, oceanography, and hydrology to accomplish Society 5.0 and Sustainable Development Goals (SDGs). Such environmental data, which are typical "big data," include the reliable long-term observatory data, ground radar data, satellite observation, oceanographic observation, global objective analysis data, and so on. However, it is hard to say that such big data are fully utilized, or nobody may have examined many of them. Therefore, to examine the global environment more faithfully, we need to apply the techniques of artificial intelligence/machine learning on such big data, that is, spatiotemporal data modeling of artificial intelligence, prediction and detection by machine learning, techniques of automated data mining, and so forth. Only cross-cutting diagnosis of the gigantic environmental data could resolve a wide variety of environmental problems including measures against global warming. In addition, the application of artificial intelligence/machine learning on the big data would raise us to the 4th paradigm of science (the 1st paradigm, observation/experiment; 2nd, theory; 3rd, simulation; 4th, data driven). This session sincerely invites various research initiatives that accelerate the application of artificial intelligence/machine learning on such gigantic environmental data.

10:45 AM - 10:50 AM JST | 1:45 AM - 1:50 AM UTC

Introduction

10:50 AM - 11:20 AM JST | 1:50 AM - 2:20 AM UTC

[ACG36-01] Recent Progress in Deep Neural Network Architectures and their Applications

★Invited Papers

*Shinichi Shirakawa[1] (1.Yokohama National University)

11:20 AM - 11:35 AM JST | 2:20 AM - 2:35 AM UTC

[ACG36-02] Improving performance of oxidant prediction using machine learning by optimizing input data based on atmospheric science knowledge

*Tomohiro Sato[1], Peijiang Zhao[1], Koji Zettsu[1] (1.National Institute of Information and Communications Technology)

11:35 AM - 11:50 AM JST | 2:35 AM - 2:50 AM UTC

[ACG36-03] Spatiotemporal Climate Forecasting with ConvLSTM

*Ekasit Phermphoonphiphat[1], Tomohiko Tomita[3], Masayuki Numao[2], Ken-ichi Fukui[2] (1.Graduate School of Information Science and Technology, Osaka University, 2.The Institute of Scientific and Industrial Research, Osaka University, 3.Faculty of Advanced Science and Technology, Kumamoto University)

11:50 AM - 12:05 PM JST | 2:50 AM - 3:05 AM UTC

[ACG36-04] Deep-Learning Based Short-Term Prediction Method for Sea Ice Concentration Using Explanatory Variables

*Issei Kawashima[1], Toru Kouyama[1], Ryu Sugimoto[1], Ryosuke Nakamura[1] (1.National Institute of Advanced Industrial Science and Technology)

12:05 PM - 12:15 PM JST | 3:05 AM - 3:15 AM UTC

Discussion

Recent Progress in Deep Neural Network Architectures and their Applications

*Shinichi Shirakawa[1]

1. Yokohama National University

A deep neural network (DNN) is a powerful machine learning model that shows remarkable performance in various artificial intelligence domains such as computer vision and natural language processing. A DNN is composed of a number of non-linear, differentiable units that have tunable parameters. In the training phase, DNN parameters (called connection weights) are trained so as to minimize training loss. After training the DNN, we expect it to be able to produce the generalized rule for the target task, i.e., the trained DNN is expected to return the ideal outputs from inputs for unknown data.

Researchers in the deep learning community are actively proposing a novel DNN architecture (i.e., the network structure of DNNs) to improve the performance and applicability of DNNs. For instance, a convolutional neural network (CNN) is frequently used as the network model for computer vision tasks, and the recurrent connection and long short-term memory (LSTM) cell is suitable for treating time series and sequential data. Besides these network structures, many extended network modules and architectures have been developed.

In this talk, we provide an overview of the recent progress in deep neural network architectures and their amazing applications. We also overview how to handle multimodal data in DNNs and present several studies on modality translation such as image-to-text (image captioning) and text-to-speech.

Although a lot of DNN architectures have been proposed so far, the selection and design of the architectures are still the users' task. Such a task is not trivial because the appropriate architecture heavily depends on the target problem and dataset, meaning that trial and error and expert knowledge are required for users. The second topic of this talk is the automatic design of DNN architectures, called neural architecture search (NAS). Recent studies show that NAS can improve the performance of DNNs depending on the dataset. Particularly, we present the computationally efficient NAS methods that can work on a single GPU with reasonable computational time.

At the end of this talk, we would like to discuss the applicability of deep neural networks to the field of global environmental science.

Keywords: Deep Learning, Deep Neural Network, Machine Learning, Artificial Intelligence

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Improving performance of oxidant prediction using machine learning by optimizing input data based on atmospheric science knowledge

*Tomohiro Sato[1], Peijiang Zhao[1], Koji Zettsu[1]

1. National Institute of Information and Communications Technology

[Background] Air pollution was the cause of 3.7 million premature deaths globally in 2012 (WHO, 2014). In Japan, the amount of oxidant (Ox) keeps high level or has been still increasing, although other air pollutants, such as NO_2 and $PM_{2.5}$. has been decreasing. High level of Ox affects human health and crop yields (e.g., Zheng et al., 2018). There are many factors for Ox generation, such as precursors especially NO_2 and VOC, sunlight and wind. They are non-linearly connected, thus, modeling of physical and chemical processes for Ox amount prediction is difficult and requires large calculation costs. There are many studies for Ox prediction using machine learning (ML) as an alternative of traditional modeling. Keller et al., (2017) showed that the random forest demonstrated the GEOS-Chem model calculation of ozone (O_3), major component of Ox, within an error less than 10% during the first 10 days with a 1/100 calculation cost. Other ML methods have been tested for O_3 prediction, Multi Linear Regression, Artificial Neural Network (Pires and Martins, 2011), Gene Expression Programming (Samadianfard et al., 2013).

[Aim] Previous studies of air pollution prediction by ML have well developed the model algorithm. Guennec et al., (2016) reported that improvement of input data, such as data augmentation, also increased the prediction performance. In this study, we approached to improve the Ox prediction using ML technique by optimizing the input data.

[Dataset and Method] Ox, especially O_3, is formed via photo-chemical reaction. The O_3 amount increases after the sunrise (e.g., $NO_2 + hn \rightarrow NO + O$, $O + O_2 + M \rightarrow O_3 + M$), takes a maximum during the day, and decreases during the night due to collision with surface and other species. This O_3 trend is observed throughout a year with a variation depending on whether, season and human activity. In this study, we compared the predicted results of Ox amount using two types of input data; in case 1, the Ox amount data itself (V_{obs}) and case 2, difference ($DeltaV = V_{obs} - V_{diurnal}$) from the reference diurnal variation ($V_{diurnal}$). We used data of amounts of major air pollutants (such as Ox, NO_2, SPM, $PM_{2.5}$, SO_2, CO), temperature, humidity, and wind at 16 points in Fukuoka city in 2014 to 2016 (Atmospheric Environmental Regional Observation System). The reference diurnal variation $V_{diurnal}$ was mean in each local hour and year. The ML model that we employed was a Convolutional Recurrent Neural Network (CRNN) based on a Convolutional Neural Network (CNN) and Long Short-Term Memory (LSTM) (Zhao and Zettsu, 2018). The value of measurement at each point was translated into 2-D map based on the longitude and latitude in the CNN part and the spatial features was extracted. A short-term prediction was performed by the LSTM part. We used the data for the last 24 hours as an input. The output was mean value of Ox amount in all points after six hours.

[Results and Discussion] We demonstrated the Ox prediction using the CRNN model with two types of input data (V_{obs} for Case 1 and DeltaV for Case 2). Root mean squared error and accuracy for the two predictions were compared; Case 1: 10.3 ppb/75.4%, Case 2: 6.7ppb/84.7% (in 2014), Case 1: 11.0 ppb/72.7%, Case 2: 8.3ppb/79.6% (in 2015), Case 1: 9.4 ppb/76.7%, Case 2: 8.6ppb/79.4% (in 2016). Using DeltaV, the accuracy was increased at most 10%. We also compared the predictions in terms of time in a day. In case 1, the model overestimated the Ox amount during the night and underestimated during the day. This bias was significantly improved in case 2 for all years.

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[Conclusion and remarks] We demonstrated an optimization of input data for Ox prediction using the CRNN model. Our approach showed the accuracy of the Ox prediction was improved at most 10% using a difference from the reference diurnal variation instead of using a raw data. This study indicates an importance to optimize input data based on atmospheric science knowledge for air pollution prediction by ML.

Keywords: Air pollution, Oxidant, Machine learning, Optimization, Short-term prediction

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Spatiotemporal Climate Forecasting with ConvLSTM

*Ekasit Phermphoonphiphat[1], Tomohiko Tomita[3], Masayuki Numao[2], Ken-ichi Fukui[2]

1. Graduate School of Information Science and Technology, Osaka University, 2. The Institute of Scientific and Industrial Research, Osaka University, 3. Faculty of Advanced Science and Technology, Kumamoto University

Recent years, climate forecasting techniques with machine learning have been developing to get high accuracy result, unlike physical simulation that uses the techniques of ensemble mean and has already been employed by JMA (Japan Meteorological Agency) which cannot perform well for long term prediction because climate data is a very high non-linear relationship. Machine learning techniques can build a forecasting model by learning patterns from prior data while maintaining the spatial correlation that very important for climate data because the variable from one area could affect other areas. In this paper, we studied the spatial-temporal pattern of machine learning techniques can improve the forecasting result. The experiment compares 3 forecasting models. Linear regression model is a simple forecasting linear model that try to produce linear formula from the training dataset, we use this model with non-spatial correlation setup. CNN (Convolutional Neural Network) is a class of deep learning, the key idea is convolutional layer that is able to maintain spatial correlation through the network. ConvLSTM (Convolutional Long Short-Term Memory) is the improvement version of Fully Connected Long Short-Term Memory that combines convolution operator inside every gate (the control unit that measures how much information will pass through) in the memory cell; therefore, spatial correlation is preferably maintained on the arbitrary of times. We run the experiment to forecast temperature at 2 meter height of the Japan area, we used the monthly mean data of ERA-Interim dataset that started from 1979 to the present. The result has shown that ConvLSTM performs the best accuracy compares to CNN and non-spatial correlation setup linear regression model.

Keywords: Climate Forecasting, ConvLSTM, Spatial Correlation

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Deep-Learning Based Short-Term Prediction Method for Sea Ice Concentration Using Explanatory Variables

*Issei Kawashima[1], Toru Kouyama[1], Ryu Sugimoto[1], Ryosuke Nakamura[1]

1. National Institute of Advanced Industrial Science and Technology

Importance of short-term future and middle-term future prediction techniques of sea ice concentration (SIC) has been significantly increasing for navigation of vessels which uses the Northern Sea Route. High frequent updating of the short-term prediction for adopting to SIC is required and thus its calculation load is an important issue same as the accuracy of the prediction. We have been developing a deep-learning based sea ice prediction method and adopting it to Sea of Okhotsk where sea ice coverage dramatically changes during a season. The proposed method can predict SIC immediately once we have sufficient observation or simulation data and the calculation time is very short. In addition, we have confirmed that the predicted SIC has basically good correlation with actual SIC, even though this method only uses previous and current observed SIC by AMSR2. However, considering actual applications, such as navigation for vessels, it is necessary to improve the accuracy of the proposed method as much as possible.

In this study, we proposed a new short-term prediction method for temporal variation of SIC. The new method uses not only SIC but also other variables which can be obtained from observations and/or simulations. The new method can improve the prediction accuracy than that in the previous method.

Keywords: Sea Ice Concentration, Deep Learning, LSTM

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Thu. May 30, 2019 1:45 PM - 3:15 PM JST | Thu. May 30, 2019 4:45 AM - 6:15 AM UTC | 104 1F

[A-CG36] Earth & Environmental Sciences and Artificial Intelligence

convener:Tomohiko Tomita(Faculty of Advanced Science and Technology, Kumamoto University), Kenichi Fukui(Osaka University), Daisuke Matsuoka(Japan Agency for Marine-Earth Science and Technology), Satoshi Ono(Kagoshima University), Chairperson:Tomohiko Tomita(Kumamoto University, Faculty of Advanced Science and Technology)

In recent years, we have been required to explore the gigantic environmental data leading global environmental studies of modern meteorology, oceanography, and hydrology to accomplish Society 5.0 and Sustainable Development Goals (SDGs). Such environmental data, which are typical "big data," include the reliable long-term observatory data, ground radar data, satellite observation, oceanographic observation, global objective analysis data, and so on. However, it is hard to say that such big data are fully utilized, or nobody may have examined many of them. Therefore, to examine the global environment more faithfully, we need to apply the techniques of artificial intelligence/machine learning on such big data, that is, spatiotemporal data modeling of artificial intelligence, prediction and detection by machine learning, techniques of automated data mining, and so forth. Only cross-cutting diagnosis of the gigantic environmental data could resolve a wide variety of environmental problems including measures against global warming. In addition, the application of artificial intelligence/machine learning on the big data would raise us to the 4th paradigm of science (the 1st paradigm, observation/experiment; 2nd, theory; 3rd, simulation; 4th, data driven). This session sincerely invites various research initiatives that accelerate the application of artificial intelligence/machine learning on such gigantic environmental data.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[ACG36-05] Remote sensing of cloud using the deep learning based on three-dimensional radiative transfer

*Hironobu Iwabuchi[1], Ryosuke Masuda[1], K. Sebastian Schmidt[2,3], Alessandro Damiani[4], Rei Kudo[5] (1.Graduate School of Science, Tohoku University, 2.Department of Atmospheric and Oceanic Sciences, University of Colorado, 3.Laboratory for Atmospheric and Space Physics, University of Colorado, 4.Center for Environmental Remote Sensing, Chiba University, 5.Meteorological Research Institute, Japan Meteorological Agency)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[ACG36-06] Time series of cloud cover during the night derived from an omnidirectional camera

*Karin miyabe[1], Kazunori Ogohara[1] (1.University of Shiga Prefecture)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[ACG36-07] Time series prediction of cloud cover using whole-sky images and meteorological elements

*Kazunori Ogohara[1], Teppei Sonoda[2] (1.School of Engineering, University of Shiga Prefecture, 2.Graduate School of Engineering, University of Shiga Prefecture)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[ACG36-08] Fundamental investigation about the inductive prediction of precipitation based on the time series data

*Naoki Matsumoto[1], Tomohiko Tomita[1], Kenichi Fukui[2] (1.Kumamoto Univ., 2.Osaka Univ.)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[ACG36-09] Identification of ships image on SAR data using machine learning

*Takashi Sonoke[1], Hirohide Demura[1] (1.University of Aizu)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

Discussion

Remote sensing of cloud using the deep learning based on three-dimensional radiative transfer

*Hironobu Iwabuchi[1], Ryosuke Masuda[1], K. Sebastian Schmidt[2,3], Alessandro Damiani[4], Rei Kudo[5]

1. Graduate School of Science, Tohoku University, 2. Department of Atmospheric and Oceanic Sciences, University of Colorado, 3. Laboratory for Atmospheric and Space Physics, University of Colorado, 4. Center for Environmental Remote Sensing, Chiba University, 5. Meteorological Research Institute, Japan Meteorological Agency

Remote sensing is a field of active research to which the machine learning techniques are applied. Machine learning models can be trained to detect characteristics and estimate properties of spatial and temporal variations of geophysical features. The deep learning uses a deep neural network and is rapidly developing in wide areas of industrial applications and scientific research. The deep neural network generally offers high capabilities of automatic feature extraction from multi-variate, multi-modal data and a good approximation of non-linear functions. If a deep learning model is trained well, its advantages are high accuracy with reasonable speed of calculation, which is suitable for practical applications to processing a large amount of data.

We will present a few applications of the deep learning to remote sensing of cloud from satellite- and ground-based optical measurements. In optical remote sensing of clouds, three-dimensional (3-D) radiative transfer effects are a major source of retrieval errors. Radiative interactions operate across spatial elements of the cloudy atmosphere at a wide range of spatial scales. Radiance measured at each pixel of an image taken by a satellite-based imager or ground-based camera is influenced by not only cloud density and microphysical properties along the line of sight but also the spatial distribution of clouds in a wide domain surrounding the line of sight. Although the retrieval of cloud properties is usually based on the independent pixel approximation assuming a plane-parallel, homogeneous cloud for each image pixel, the 3-D radiative interaction makes it difficult to retrieve cloud properties at pixel level if one uses single-pixel radiances solely. Thus, use of multiple pixels looks attractive, offering a great potential to accurately retrieve cloud properties from an image. Convolutional neural networks (CNNs) naturally traces the 3-D radiative effects that appear across image pixels, which traditional single-pixel approaches cannot capture. We have thus developed deep learning models to estimate the spatial distribution of cloud properties from multi-spectral, multi-pixel cloud retrieval from satellite imagery and images taken by a ground-based digital camera. Training data of pseudo-observation radiances are made from simulations using a Monte Carlo 3-D radiative transfer model for cloud fields simulated by a large eddy simulation model with high spatial resolution. In this case, the deep learning model is trained to learn the multi-scale spatial structure of clouds in addition to the complicated relationships between cloud properties and radiances. Deep CNNs show high retrieval accuracy for cloud properties such as cloud optical thickness and effective droplet radius from multi-spectral images of visible, near-infrared, and shortwave infrared channels, efficiently deriving the spatial distribution of cloud properties at multiple pixels all at once from radiances at multiple pixels. By using multi-scale features in the images, it is possible to recover the information lost in 3-D radiative transfer. Results show significantly better accuracy compared with traditional approaches.

Keywords: deep learning, remote sensing, cloud, radiative transfer

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Time series of cloud cover during the night derived from an omnidirectional camera

*Karin miyabe[1], Kazunori Ogohara[1]

1. University of Shiga Prefecture

Surrounding atmospheric environment have a big influence on our lives. For example, fog causes various accidents due to poor isibility. Leisure facilities must be stopped when wind speed is high. Meteoropathy tends to increase depending on perature or weather. Therefore, environmental prediction with higher temporal and spatial resolution than that of daily ather forecast is needed. Cloud cover (CC) will have a large impact on prediction of environmental changes in other tities (e.g. temperature, humidity, wind speed and direction). The method for deriving CC from RGB images taken by an omnidirectional camera has been investigated so far. However, it was not applicable to nighttime images, which is usually grayscale images, due to low SN and low brightness. Therefore, we develop a method for deriving CC from grayscale images taken by an omnidirectional camera during the night using deep learning. Also, we investigate he distortion of the whole-sky images because CC measured in the celestial sphere has a different value from that measured in whole-sky images.We separate cloud areas from sky areas in the whole-sky images using a deep learning technique for semantic segmentation, U-net. U-net is a encoder-decoder type of convolutional neural network. Area under an ROC curve (AUC), which is an evaluation index commonly used in the discipline of machine learning, for nighttime images is 0.985 and that for rainy images during the night is 0.984. However, that for evening and morning images is lower than them, 0.952. Therefore, the proposed method may not be applicable to evening and morning images.

Keywords: Cloud cover

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Time series prediction of cloud cover using whole-sky images and meteorological elements

*Kazunori Ogohara[1], Teppei Sonoda[2]

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Prediction of the sky conditions is becoming important in several sectors of society. The most typical codition of the sky is cloud cover (CC). CC should have a correlation to air temperature, ground temperature, humidity, and solar radiation, etc. Therefore, prediction of CC is highly significant from the perspective of social application and should have a large impact on accuracy of time-series prediction of other variables.
We have developed a novel method for segmentation of cloud areas in whole-sky images using an encoder-decoder based convolutional neural network to derive CC from images observed by an omnidirectional camera. F-measure for cloud obtained by 10-fold cross validatoin was 0.86. We could generate time series of daytime CC for 1.5 years using the proposed method.
We have tried to predict CC after one hour based on time series of CC itself and solar radiation using recurrent neural network. RMSE of CC between the observed and predicted time series is 0.022 and the predicted time series of CC is more accurate than the persistence model. However, predicted CC tends to get close to 0.4-0.5 and the phase shift like the persistence model is partially seen.

Keywords: time-series prediction, image segmentation, deep learning

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Fundamental investigation about the inductive prediction of precipitation based on the time series data

*Naoki Matsumoto[1], Tomohiko Tomita[1], Kenichi Fukui[2]

1. Kumamoto Univ., 2. Osaka Univ.

This work applied the artificial neural network (ANN) to observatory data and conducted a fundamental investigation about improving the prediction accuracy in precipitation. Especially, this work focused on the improvement of training data for the short-term prediction in precipitation.
The used data were precipitation, temperature, pressure, vapor pressure, wind speed, and wind direction with hourly interval edited by the Japan Meteorological Agency, and the ANN prediction model was constructed based on multilayer perceptron. Using these data and the ANN prediction model, this work tentatively predicted the time variation of hourly precipitation at Kumamoto, Japan. Then, through systematic changes of the training data, this work investigated how the accuracy of short-term predicton was improved. Especially, the contributions of each observation parameter and of increase of observatories were investigated. For the evaluation of prediction, this work emploied the verification by comparing the peak values between prediction and observation and the appearance time of the peak that are both important for heavy rainfall prediction, and the sum of squared errors between predicted and real values.
This work found that setting the data to the west into the training data is effective for predicting Kumamoto's hourly precipitation. This work also found that the peak value in prediction was greatly improved from 30% to 80% by deleting the data at the time when no precipitation occurs in the training data. Then, the contribution of vapor pressure increases. We will continue to investigate how the precipitation prediction can be improved through the changes of parameters, observatories, and forecast lead times in the training data.
The results of this work will contribute to the construction of a simple precipitation prediction scheme at the location where sophisticated observation data can not be obtained.

Keywords: artificial neural network, prediction of hourly precipitation

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Identification of ships image on SAR data using machine learning

*Takashi Sonoke[1], Hirohide Demura[1]

1. University of Aizu

SAR(Synthetic Aperture Radar) has been popular in Earth remote sensing because this is available for all-weather and night time, unlike optical sensors. The identification of ships has been remarked from viewpoints of coast guard such as finding and monitoring marine accidents and poaching boats without Automatic Identification System (AIS). Current monitoring such situations still has been a visual inspection. This brings some difficulties such as too huge area, too time-consuming processes and so on to monitor them. So, screening candidates of ships have been required for helping the watchers. Machine learning is one of the best solutions because usual visual inspections have been substituted by the recent AI trend.
This research adopts the Convolutional Neural Network (CNN) because this is the most popular approach in image analysis. We have many uses with CNN in image recognition. This research verifies whether a ship image on SAR can be identified by CNN. This research used SAR images of PALSAR2/ALOS2 with a resolution of 10 m/pixel, polarization is HV (horizontal transmitting, vertical receiving) for the identification of ships. This machine learning needs a set of labeled data with positive/negative. The label is given to ship image on SAR using AIS. Results with PALSAR 2 data with a resolution of 10 m / pixel showed high accuracy of 95%. This research showed the availability of a method to discover ships from SAR images using CNN. In the future, this research will classification of ships not only identification. This research will examine how the change of SAR image due to marine weather affect machine learning. I would like to discuss with marine weather experts at JpGU.

Keywords: SAR, Deep learning, CNN, Ship

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Thu. May 30, 2019 9:00 AM - 10:30 AM JST | Thu. May 30, 2019 12:00 AM - 1:30 AM UTC | 303 3F

[A-CG37] Science in the Arctic Region

convener:NAOYA KANNA(Arctic Research Center, Hokkaido University), Masashi Niwano(Meteorological Research Institute), Tetsu Nakamura(Faculty of Environmental Earth Science, Hokkaido University), Shunsuke Tei(Arctic Research Center, Hokkaido University), Chairperson:Tetsu Nakamura(Faculty of Earth Environmental Science, Hokkaido University), Shunsuke Tei(Arctic Research Center, Hokkaido University)

The Arctic and circumpolar region is the key area for the study of global change because the anthropogenic impact is projected to be the largest in this area due to the complicated feedback processes of the nature. A number of international and interdisciplinary research projects have been conducted for the studies on the land-atmosphere-ocean system. In order to understand the feedback processes occurring in the Arctic and to project the global warming in the future, we need to establish the intense observational network and to exchange the knowledge and information by combining the different scientific communities under the common interest of the Arctic. The objectives of this session are 1) to exchange our knowledge on the observational facts and integrated modelling and 2) to deepen our understanding on wide range of natural sciences related to the Arctic and the circumpolar region. Studies on humanities, social sciences, and interdisciplinary fields are also welcomed.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[ACG37-01] Arctic midlatitude linkage modulated by the QBO

*Jinro Ukita[1], Kazuhiro Hoshi[1], Meiji Honda[1], Tetsu Nakamura[2], Koji Yamazaki[2] (1.Niigata University, 2.Hokkaido University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[ACG37-02] Interhemispheric synchronization between the AO and the AAO

*Yoshihiro Tachibana[1], Yusuke Inoue[1], Kensuke K komatsu[1], Tetsu Nakamura[2], Meiji Honda[3], Koto Ogata[1,4], Koji Yamazaki[2] (1.Mie University, 2.Hokkaido University, 3.Niigata University, 4.Japan Meteorological Agency)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[ACG37-03] Marginal ice zone sea ice observations in the refreezing Chukchi Sea

*Takehiko Nose[1], Tsubasa Kodaira[1], Takuji Waseda[1], Jun Inoue[2] (1.The university of Tokyo, 2.National Institute of Polar Research)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[ACG37-04] Prediction of wildfire and air pollution with machine learning over the five domains of Eastern Eurasia

*Teppei J Yasunari[1,2], Ichigaku Takigawa[3], Kyu-Myong Kim[4], Arlindo M da Silva[4] (1.Faculty of Engineering, Hokkaido University, 2.Arctic Research Center, Hokkaido University, 3.Graduate School of Information Science and Technology, Hokkaido University, 4.NASA Goddard Space Flight Center)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[ACG37-05] Hydrological Changes in the Four Largest Siberian Arctic River Basins

*Kazuyoshi Suzuki[1], Tetsuya Hiyama[2], Kazuhito Ichii[3], Yoshihiro Iijima[4], Koji Matsuo[5], Dai Yamazaki[6,1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Institute for Space-Earth Environmental Research, Nagoya University, 3.Chiba University, 4.Graduate School of Bioresources, Mie University, 5.Geospatial Information Authority of Japan, 6.Institute of Industrial Sciences, The University of Tokyo)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[ACG37-06] Mapping thermokarst subsidence in Central Yakutia using L-band SAR interferometry

*Takahiro Abe[1], Go Iwahana[2,3], Takeo Tadono[1] (1.Earth Observation Research Center, Japan Aerospace Exploration Agency, 2.International Arctic Research Center, University of Alaska, Fairbanks, 3.Arctic Research Center, Hokkaido University)

Arctic midlatitude linkage modulated by the QBO

*Jinro Ukita[1], Kazuhiro Hoshi[1], Meiji Honda[1], Tetsu Nakamura[2], Koji Yamazaki[2]

1. Niigata University, 2. Hokkaido University

We examined an observed relationship between the BKS sea ice variability and the midlatitudes cold anomaly and found that this relationship is highly dependent on the QBO phase, easerly (QBO-E) or westerly (QBO-W). For the QBO-E winters midlatitude cold (warm) anomalies appear significantly under the low (high) sea ice condition. On the other hand, such a relationship is not found in the QBO-W winters. This dependence is a robust feature. Atmospheric circulation anomalies related to the high and low sea ice conditions are also different between the two QBO phases. In the troposphere, stationary Rossby wave propagation from the BKS region and the negative NAO appear in QBO-E, along with weakened stratospheric polar vortex and downward propagation of the signals. For QBO-W, such tropospheric and stratospheric signals are mainly absent. Our results may provide an explanation for why some simulations suggest the presence of Arctic sea ice impacts on midlatitude surface temperature while others do not. The most important implication is that in the Arctic-midlatitudes climate linkage tropics also plays a key role.

Keywords: Arctic, QBO, sea ice, stratosphere, polar vortex

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Interhemispheric synchronization between the AO and the AAO

*Yoshihiro Tachibana[1], Yusuke Inoue[1], Kensuke K komatsu[1], Tetsu Nakamura[2], Meiji Honda[3], Koto Ogata[1,4], Koji Yamazaki[2]

1. Mie University, 2. Hokkaido University, 3. Niigata University, 4. Japan Meteorological Agency

Abstract

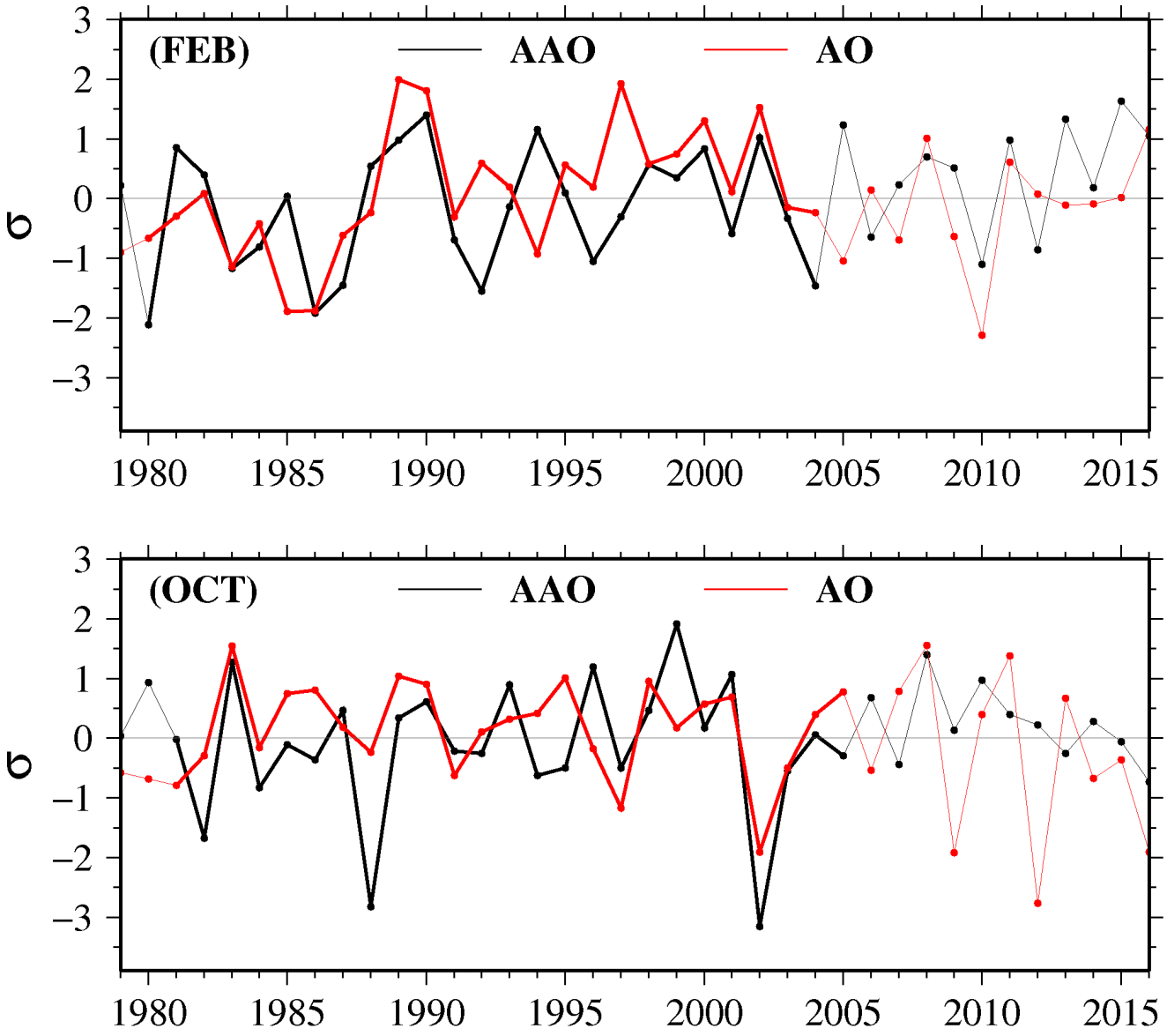
Teleconnections between lower and higher latitude regions are widely known in both the Northern and Southern Hemispheres. To broaden our view of these teleconnections, we searched a reanalysis dataset for evidence of a teleconnection between the Arctic Oscillation (AO) and the Antarctic Oscillation (AAO), two widely separated circumpolar phenomena. Statistical analysis of the Japanese 55-year reanalysis dataset showed significant in-phase synchronization between the AO and AAO, particularly in October and February, with a vertical structure extending from the troposphere to the stratosphere. This vertical structure may suggest a stratospheric control, and we did not find a significant signature indicating a tropical ocean control. We also observed decadal-scale modulation of the synchronicity. Observational evidence implies that the stratospheric meridional circulation may be responsible for AO–AAO synchronization. This paper was published in ***GRL,*** 45, DOI:10.1029/2018GL081002 by Tachibana et al., 2018.

Plain Language summary

The Arctic Oscillation (AO) and the Antarctic Oscillation (AAO) are dominant atmospheric variability patterns in the Northern and Southern hemispheres, respectively. Each is a pressure seesaw between the pole and the midlatitudes that remotely affects weather, climate, and environment around the world. We showed interhemispheric in-phase synchronization between the AO and AAO in October and February, and we also found decadal-scale variation of the synchronicity. Because the vertical structure of the AO–AAO synchronization extends from the troposphere to the stratosphere, stratospheric variations may be responsible for the synchronization. This finding of AO–AAO synchronization points the way to a better understanding of past, present, and future pole-to-pole climatic relationships and improvements in long-term weather forecasts.

Keywords: Arctic Oscillation, Antarctic Oscillation, sudden stratospheric warming

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Marginal ice zone sea ice observations in the refreezing Chukchi Sea

*Takehiko Nose[1], Tsubasa Kodaira[1], Takuji Waseda[1], Jun Inoue[2]

1. The university of Tokyo, 2. National Institute of Polar Research

Regions in the Arctic Ocean that were inaccessible in November are now open for navigation, even for non-icebreakers, and R/V Mirai, a Polar Class 6 vessel, carried out a late autumn voyage in 2018. It conducted a 12-day sea ice observation campaign during the 9th–20th of November along a fixed Marginal Ice Zone (MIZ) transect in the eastern Chukchi Sea and obtained first-hand observations at a time when research vessels are rarely in the sea. Satellite sea ice data were compared with the shipboard observations and compared relatively well. A sequence of events to describe the observations are grouped and described in four phases: 9th–13th, “Sea ice growth under relatively calm wind conditions”; 14th–16th, “the on-ice wave event, sea ice break up, and subsequent sea ice advance”; 17th–18th, “sea ice retreat or a mass shift under moderate easterly winds”; and 19th–20th, “warming sea surface temperature (SST) under strengthening cold off-ice winds and air temperatures below -10 ˚C”. Shipboard and ERA5 reanalysis data were analysed to identify physical processes that affect the Chukchi Sea refreezing process. Sea ice conditions during the first two phases appear to be influenced primarily by surface winds whereas the analysis suggests a driver of sea ice conditions in the latter phases were due to ocean interior processes. The MIZ transect waters became heavily ice covered within five days after R/V Mirai began its return voyage, so the observation period covered most of the refreezing process along the transect water.

Keywords: R/V Mirai, Marginal Ice Zone, sea ice, refreezing ocean, the Chukchi Sea

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Prediction of wildfire and air pollution with machine learning over the five domains of Eastern Eurasia

*Teppei J Yasunari[1,2], Ichigaku Takigawa[3], Kyu-Myong Kim[4], Arlindo M da Silva[4]

1. Faculty of Engineering, Hokkaido University, 2. Arctic Research Center, Hokkaido University, 3. Graduate School of Information Science and Technology, Hokkaido University, 4. NASA Goddard Space Flight Center

Under the ongoing global warming, necessity of better forecasting on wildfires and its air pollutions is increasing. In the last year, we carried out a preliminary wildfire prediction using the areal-averaged monthly mean data over a large Siberian domain (Yasunari et al., 2018, presented at AGU Fall Meeting 2018: http://bit.ly/2PG1bmK). Here we extend our previous analysis of machine learning and prediction into the five separated domains over the Arctic and sub-Arctic regions over Eastern Eurasia including Siberia, East Asia, Far East, etc. We use the same monthly mean dataset during 2003-2017 as we did in the last year above (i.e., NASA's FEER fire data, MODIS Snow Cover Fraction, SCF, Modern-Era Retrospective analysis for Research and Applications, Version 2, MERRA-2). The time periods of 2003–2014 and 2015–2017 focus on learning and prediction. Areal averaged data for objective (i.e., wildfire and air pollution variables) and explanatory variables (i.e., snow, temperature, wind, surface soil wetness, precipitation, geopotential height, etc.) over the defined five domains over Eastern Eurasia (Domain 1: 57°–70°N, 60°–90°E; Domain 2: 57°–70°N, 90°–140°E; Domain 3: 60°–70°N, 140°–180°E; Domain 4: 42.5°–57°N, 60°–90°E; Domain 5: 42.5°–57°N, 90°–140°E) are calculated, together with producing monthly time-lagged data for explanatory variables up to six months (i.e., total 174-month data available during 2003 and 2017). In addition, we made different areal-averaged fire pixel count data in which some smaller fires were removed with defined thresholds to remove expected human-made fires such as bonfires (i.e., assumed natural fire cases). If the areal-averaged fire data under the thresholds on a specific month showed no fire, we replaced that data to zero (i.e., used for our analyses but treated as zero fire data on that month).
Using Random Forest Regression, for example, in the machine learning, except for Domain 5, all the fire-included case showed the worse prediction score than those of the assumed natural fire cases. This implies that smaller fire cases, which were likely ignited by human activities or others, would be one of the causes for making wildfire predictions worse. However, over Domain 5, all the fire-included case showed the best probably because the assumed natural fire case was probably affected by the unusual large-scale wildfire events (i.e., outliers). These significantly large-scale wildfire cases also likely to make predictions worse because of not enough such cases existing in the training data (i.e., not frequent). In addition, these outliers might happen under unusual climatic and environmental conditions. How to include more large-scale fire cases in training data would be one of the important future targets on wildfire prediction with machine learning. On the day of the presentation, we'll also show the results for air pollution prediction.

Keywords: Arctic, wildfire, air pollution, PM2.5, machine learning, Siberia

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Hydrological Changes in the Four Largest Siberian Arctic River Basins

*Kazuyoshi Suzuki[1], Tetsuya Hiyama[2], Kazuhito Ichii[3], Yoshihiro Iijima[4], Koji Matsuo[5], Dai Yamazaki[6,1]

1. Japan Agency for Marine-Earth Science and Technology, 2. Institute for Space-Earth Environmental Research, Nagoya University, 3. Chiba University, 4. Graduate School of Bioresources, Mie University, 5. Geospatial Information Authority of Japan, 6. Institute of Industrial Sciences, The University of Tokyo

The Arctic freshwater budget affects global climate and is critical for understanding the climate in polar regions. However, the hydrology of the largest Eurasian Arctic rivers is still not understood well. In this paper, we analyze spatiotemporal variations in hydro-climatological factors related to four of the largest Siberian Arctic river basins (Ob, Yenisey, Lena, and Kolyma). To examine recent hydro-climatological changes in these river basins, we utilize monthly observation-based gridded meteorological and evapotranspiration data, Moderate Resolution Imaging Spectroradiometer (MODIS)-based products such as the snow area fraction (SAF) and normalized vegetation index (NDVI), global land data assimilation system products, and Gravity Recovery and Climate Experiment (GRACE) data from 2000 to 2016. Combining these with river runoff data, we identify how river runoff shifted from June to May during the study period. River runoff in May significantly increased although there was no clear trend in annual discharge. In addition, SAF decreased drastically in April and this is evidence that spring snow coverage in Siberian basins is shrinking and snowmelt is shifting toward earlier. On the other hand, we found the positive trend in summer NDVI. Focusing on permafrost distribution, this paper will discuss the correlation in the temporal lag between the water cycle and vegetation activity.

Keywords: Snow, Vegetation, Premafrost

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Mapping thermokarst subsidence in Central Yakutia using L-band SAR interferometry

*Takahiro Abe[1], Go Iwahana[2,3], Takeo Tadono[1]

1. Earth Observation Research Center, Japan Aerospace Exploration Agency, 2. International Arctic Research Center, University of Alaska, Fairbanks, 3. Arctic Research Center, Hokkaido University

Thermokarst is an irreversible phenomenon with geomorphological change, resulted from the thawing of ice-rich permafrost or the melting of massive ice. The formation of large depressions in the ground surface by thermokarst processes results in surface inundation, and causes damages on infrastructure. Central Yakutia in Eastern Siberia is one of the regions where ice-rich permafrost is broadly distributed. The remarkable surface subsidence due to thermokarst has been observed in recent years, which could cause destruction of building and infrastructure in this area (Shiklomanov et al., 2017; Hjort et al., 2018). The thermokarst settlement are frequently observed in continuous permafrost zones in arctic regions, especially in Alaska and the Northeastern Siberia. However, it is so difficult to know where and how surface deforms in vast permafrost zones.

Remote sensing technique, especially Interferometric Synthetic Aperture Radar (InSAR), has a great potential to monitor the thermokarst subsidence, and seasonal permafrost melting and heaving. SAR sends microwave toward ground, and receive the reflected and scatter signals under all-weather and day-and-night condition without any instrument on ground. Thus, InSAR can provide essential information to understand thawing process of ice-rich permafrost and to predict the future stage over arctic permafrost region. Many studies about permafrost dynamics using SAR images have been reported so far (e.g., Liu et al., 2010; Iwahana et al., 2016; Antonova et al., 2018; Strozzi et al., 2018), but there is no study using SAR in Central Yakutia.

In this study, we used ALOS/PALSAR (2007-2010) and ALOS-2/PALSAR-2 (2014-2018) images to examine ground subsidence caused by thermokarst development. GAMMA software was used to generate Single Look Complex data from Lv1.0 data in ALOS/PALSAR and Lv1.1 data in ALOS-2/PALSAR-2. ALOS world DEM derived from ALOS/PRISM was used to simulate and remove topographic effect. We generated many interferograms, selected some of them, and applied stacking procedure weighted on period between two SAR data acquisition time, estimating the mean change rate along line of sight (LOS). Assuming ground displacement is only vertical component, the LOS change was converted to vertical displacement using incidence angle.

At the last JpGU, we reported ground subsidence in Mayya, on the right bank of Rena River, Central Yakutia, derived from ALOS/ALOS-2 InSAR stacking. To validate the InSAR signals, we carried out the ground observation in Mayya at the end of September, 2018. As a result, the subsidence rate of 2-3 cm/yr was obtained at the two measurement points in 2017-2018. The result of ground observation is consistent with that of InSAR result from ALOS-2. We also went to some places where there are subsidence signals in the ALOS-2 results. As a consequence, the two large subsidence signals were found in alasses. Alas is considered as a final geomorphological stage of old thermokarst development. Significant amount of the subsidence may be due to consolidation settlement associated with soil desiccation under recent dry climate conditions. However, judging from new developments of polygonal subsidence in the bottom areas of alasses, ground ice still remains under the alasses, which may cause further thermokarst progress.

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Moreover, we extended our target to other cities, Amga, and Churapcha, where thermokarst has been also developing (e.g., Saito et al. 2018). The similar subsidence signals were obtained in the two cities, where it is in area of many polygons. It suggests that the signals be presumably due to thermokarst development.

Keywords: Permafrost, Thermokarst, Synthetic Aperture Radar (SAR), SAR Interferometry, ALOS-2, ALOS

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Thu. May 30, 2019 10:45 AM - 12:15 PM JST | Thu. May 30, 2019 1:45 AM - 3:15 AM UTC | 303 3F

[A-CG37] Science in the Arctic Region

convener:NAOYA KANNA(Arctic Research Center, Hokkaido University), Masashi Niwano(Meteorological Research Institute), Tetsu Nakamura(Faculty of Environmental Earth Science, Hokkaido University), Shunsuke Tei(Arctic Research Center, Hokkaido University), Chairperson:Shunsuke Tei(Arctic Research Center, Hokkaido University), Masashi Niwano(Meteorological Research Institute)

The Arctic and circumpolar region is the key area for the study of global change because the anthropogenic impact is projected to be the largest in this area due to the complicated feedback processes of the nature. A number of international and interdisciplinary research projects have been conducted for the studies on the land-atmosphere-ocean system. In order to understand the feedback processes occurring in the Arctic and to project the global warming in the future, we need to establish the intense observational network and to exchange the knowledge and information by combining the different scientific communities under the common interest of the Arctic. The objectives of this session are 1) to exchange our knowledge on the observational facts and integrated modelling and 2) to deepen our understanding on wide range of natural sciences related to the Arctic and the circumpolar region. Studies on humanities, social sciences, and interdisciplinary fields are also welcomed.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[ACG37-07] Spatiotemporal variation of thaw subsidence and frost heave of permafrost caused by wildfire around Batagay, East Siberia

*Kazuki Yanagiya[1], Masato Furuya[2] (1.Graduate School of Science, Hokkiado University, 2.Faculty of Science, Hokkaido University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[ACG37-08] Influence of recent climate change on permafrost coast dynamics in the Kara Sea, Russian Arctic Ocean

*A. Kioka[1,2], V. S. Isaev[2], A. V. Koshurnikov[2], A. Pogorelov[2], R. M. Amangurov[2], O. Podchasov[2], D. O. Sergeev[3], S. N. Buldovich[2], D. M. Aleksyutina[4], E. A. Grishakina[5] (1.Institut für Geologie, Leopold-Franzens-Universität Innsbruck, Austria, 2.Department of Geocryology, Lomonosov Moscow State University, Russia, 3.Sergeev Institute of Environmental Geoscience, Russian Academy of Science, Russia, 4.Research Laboratory of Geoecology of the Northern Territories, Lomonosov Moscow State University, Russia, 5.Vernadsky Institute of Geochemistry and Analytical Chemistry, Russian Academy of Science, Russia)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[ACG37-09] Ice front variations of Heilprin Glacier in northwestern Greenland controlled by the ocean and glacier bed geometries

*Izumi Asaji[1,2], Daiki Sakakibara[3], Takuto Ando[3], Shin Sugiyama[1] (1.Institute of Low Temperature Science, Hokkaido University, 2.Graduate School of Environmental Science, Hokkaido University, 3.Arctic Research Center, Hokkaido University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[ACG37-10] Meltwater discharge and flooding of the outlet stream of Qaanaaq Glacier, northwestern Greenland

*Ken Kondo[1,2], Daiki Sakakibara[3,2], Shungo Fukumoto[1,2], Shin Sugiyama[2] (1.Graduate School of Environmental Science, Hokkaido University, 2.Institute of Low Temperature Science, Hokkaido University, 3.Arctic Research Center, Hokkaido University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[ACG37-11] Occurrence frequency of lee-side downslope winds near Siorapaluk in northwest Greenland

*Akihiro Hashimoto[1], Tetsuhide Yamasaki[2], Teruo Aoki[3,1], Masashi Niwano[1], Satoru Yamaguchi[4] (1.Meteorological Research Institute, 2.Avangnaq, 3.The Graduate School of Natural Science and Technology, Okayama University, 4.Snow and Ice Research Center, National Research Institute for Earth Science and Disaster Resilience)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[ACG37-12] Impacts of clouds on the Greenland ice sheet surface melt and mass balance

*Masashi Niwano[1], Akihiro Hashimoto[1], Teruo Aoki[2] (1.Meteorological Research Institute, 2.Graduate School of Natural Science and Technology, Okayama University)

Spatiotemporal variation of thaw subsidence and frost heave of permafrost caused by wildfire around Batagay, East Siberia

*Kazuki Yanagiya[1], Masato Furuya[2]

1. Graduate School of Science, Hokkiado University, 2. Faculty of Science, Hokkaido University

Thawing permafrost release soil organic carbon as a greenhouse gases, and it can be positive feedback on global warming (Shuur et al. 2015). To estimate terrestrial carbon budget precisely, permafrost degradation should be observed in the entire circumpolar region. However, it is impractical to perform field observation over all the permafrost areas in northern hemisphere. Especially in Siberia, observation sites by the international network (e.g. GTN-P, CALM) is very few despite the largest area in terms of permafrost distribution. Therefore, remote sensing techniques to cover wide areas are indispensable. Observing ground deformation by InSAR (Interferometric Synthetic Aperture Radar) can tell us the state of permafrost with high spatiotemporal resolution. Some previous studies are conducted in a part of Alaska, Canada and Siberia that can be easy to compare with field work (Liu et al. 2010; Short et al. 2011; Antonova et al. 2018).

We focused on East Siberia, where no previous studies by InSAR are conducted. Study area is around Batagay town (67’ 39N, 134’ 39E). At ~10 km southeast of Batagay, there is a well-known and one of the largest slump terrains caused by thawing of permafrost (Murton et al. 2017). Processing ALOS and ALOS2 InSAR images, we found the deformation signal due to wildfire at the hill to the 20 km northwest of Batagay. Loss of surficial vegetation layer by wildfire accelerates permafrost thawing, and the degradation continues for several years to decades after a fire (Yoshikawa et al. 2002). Furthermore, given the fact that the frequency and intensity of wildfires are increasing in the Arctic region with global warming (Alexander et al. 2018; Gibson et al. 2018; Masrur et al. 2018), it is important to reveal the spatiotemporal variation of the ground deformation in the post-wildfire area.

Here, we report our detection of the post-wildfire ground deformation in the place where the fire occurred in 2014. We used SAR images obtained from ALOS 2 (L-band) and Sentinel-1 (C-band) satellites from 2014 to 2018. Secular deformation is detected by ALOS2 data. The results indicated that thawing subsidence up to 10cm in the satellite line of sight direction continued after 2-3 years after the fire. Seasonal deformation from 2017 to 2018 is detected and compared with both satellites data. The magnitude and spatial patterns of subsidence and uplift was consistent in both satellites. Especially, short-term InSAR images with Sentinel-1 data revealed detailed temporal variation from the start to the end of thawing and freezing. Estimation of permafrost thawing amount from ground deformation amount detected by InSAR can contribute to reducing uncertainty of terrestrial carbon budget. Those physical models are under discussion (Liu et al. 2014; Hu et al. 2018; Molan et al. 2018). In this study, we verified the Molan model in our study area, and developed it taking into account the deformation in the slope direction.

Keywords: permafrost, InSAR, ALOS2, Sentinel-1, wildfire, Batagay

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Influence of recent climate change on permafrost coast dynamics in the Kara Sea, Russian Arctic Ocean

*A. Kioka[1,2], V. S. Isaev[2], A. V. Koshurnikov[2], A. Pogorelov[2], R. M. Amangurov[2], O. Podchasov[2], D. O. Sergeev[3], S. N. Buldovich[2], D. M. Aleksyutina[4], E. A. Grishakina[5]

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Recent years of increasing air temperature in the Arctic have known to lead a significant increase in the retreat speed of permafrost coast, which has threatened livelihoods and infrastructure along the coasts. The Kara Sea hosts more than 25% of the total length of Arctic coasts. Despite many works for more than six decades, little is known about how the Kara Sea coasts, affected by permafrost and sea-ice, may have changed through time and what the climatic and environmental drivers are. To understand the dominant climatic factors influencing the dynamic processes along the permafrost and sea-ice affected coastline, we study dynamics of permafrost coast along the Baydaratskaya Bay of Kara Sea, Western Siberia, during the rapidly retreated period 2005–2016, by handheld differential GPS mapping, satellite imagery, measurements of ground temperature and subsurface resistivity, and meteorological data. These multidisciplinary data reveal that the activity of wind-driven ocean wave during the sea ice-free (open water) days influences the magnitude of coastal retreat in the study area, while that recent temperature rise less contributes to enhancing coastal retreat during the study period. This suggests that the magnitude of wave activity over the sea ice-free days controls the quantities of the eroded sediment and the associated release of nutrient to the nearshore zone, which might result in influencing infrastructure along the permafrost coast and marine ecosystem in the proximal ocean.

Keywords: Permafrost coast, Kara Sea, Sea ice, Wind-driven ocean wave

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Ice front variations of Heilprin Glacier in northwestern Greenland controlled by the ocean and glacier bed geometries

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The Greenland ice sheet is losing mass under the influence of increasing surface melting and ice discharge from marine-terminating outlet glaciers. Better understanding of mechanisms controlling ice dynamics of marine-terminating glaciers is crucial for predicting future mass loss from the ice sheet. However, processes controlling rapid retreat of the glaciers are not well explained. As many Greenlandic glaciers thinned recent years, ice thickness near the current front position is possibly close to the hydrostatic equilibrium condition. Therefore, we hypothesize that a possible cause of recent rapid retreat of marine-terminating glaciers is surface lowering below the flotation level (ice surface elevation at which buoyancy and gravitational forces balance). Validation of this hypothesis requires detailed ice surface and bed elevation data near the calving front.

In this study, we measured bed topography and surface elevation of Heilprin Glacier in northwestern Greenland. Heilprin Glacier has a 6 km-wide terminus, which is currently separated to three calving fronts. The front position advanced by 800 m from 1990 to 2000, and retreated by 1 km from 2000 to 2009. We measured the ocean bed topography near the one of the calving front situated in the north, using a sonar fixed on a boat from 13 to 15 August, 2018. The surface elevation change from 2001 to 2012 was analyzed by using digital elevation models generated from satellite images acquired by an optical sensor ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) mounted on the Terra satellite. We computed the flotation level from the bed elevation, and compared it with glacier surface elevation before and after the rapid retreat.

Near the studied glacier front, the fjord is deeper in the northern side of the glacier, and the maximum water depth in the region was 340 m. The glacier retreated by 1 km over this deepest area from 1998 to 2008. Analysis of the data showed that the glacier surface near the front in 2000 was 10 m below the flotation level, suggesting significant ice thinning prior to the rapid retreat. It is likely that the retreat of northern front of Heilprin Glacier was driven by thinning and ice flotation at the deepest area of the fjord.

Keywords: Greenland, Calving glacier, Bed topography

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Meltwater discharge and flooding of the outlet stream of Qaanaaq Glacier, northwestern Greenland

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Glacial meltwater discharge is increasing in Greenalnd under recent warming climate. As a consequence, floods and damages on infrastructures are reported at outlet streams of land terminating glaciers. For instance, discharge from Qaanaaq Glacier in northwestern Greenland rapidly increased on 21 July 2015 and 2 August 2016, leading to floods of a proglacial stream and destruction of a road between a settlement and Qaanaaq Airport. To better understand the mechanisms of the flood events at Qaanaaq Glacier, we investigated meteorological conditions during the 2015 and 2016 events by using AWS operated on the ice cap at 944 m a.s.l. (SIGMA-B) (Aoki et al., 2014). We performed field measurements in the summer 2017 and 2018 to investigate melting process of Qaanaaq Glacier and the response of the outlet discharge. These data were combined with surface mass balance of Qaanaaq Glacier observed from 2012 to 2018 to analyse the cause of floods in 2015 and 2016.

Surface mass balance was significantly more negative in 2015 and 2016 as compared to the other years. Glacier wide mass balance was −0.76±0.13 m w.e. in 2014/2015 and -0.28±0.7 m w.e. in 2015/2016. Before the floods, daily mean temperature rose above 5 ˚C for 5 days in 2015 and above freezing for almost a month in 2016 at SIGMA-B. Such warm conditions caused intensive melting over the entire glacier, resulting in saturation and disappearance of snowpack from the glacier below 950 m a.s.l. In addition to large exposure of ice surface, heavy rainfall (90 mm d^{-1}) occurred on the date of the flood in 2016. we assume that the exposed ice surface helped immediate runoff of a large amount of rainwater. These analyses suggested the loss of snow cover played a key role in the flood events in 2015 and 2016.

We measured discharge from Qaanaaq Glacier from 21 July to 3 August 2017. Stream discharge rapidly increased on 28 July 2017, leading to a peak value of 8.11 m^3 s^{-1}. From 21 to 28 July, snowline elevation rose from 500 to 650 m a.s.l. after intensive melting. Runoff measured before the peak discharge accounted for only 60 % of the estimated total glacier melt, indicating the rest of meltwater remained in snowpack on the glacier. These data suggested snowpack was saturated with meltwater, and rapidly released water during the period of rapid melting and upglacier snowline migration. Together with data obtained by similar measurements in 2018, we conclude that saturation and disappearance of snowpack are the key to predict rapid increase in stream discharge and flooding.

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Keywords: Glacier, Greenland, Surface mass balance, Freshwater runoff

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Occurrence frequency of lee-side downslope winds near Siorapaluk in northwest Greenland

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In early April 2018, Niwano et al. (2018) conducted the scientific traverse expedition “Snow impurity and glacial microbe effect on the abrupt warming in the Arctic (SIGMA) Traverse 2018”. The expedition crews had initially planned to depart Siorapaluk on April 2, 2018. However, their departure was delayed by four days because of strong winds and snow blocking the way. Numerical experiment showed that the strong wind had characteristics of a lee-side downslope wind (Hashimoto et al., 2018). Matoba and Yamasaki (2018) reported a sea ice outflow event and its damage to fishery along the coast of Qaanaaq (50-km southeast of Siorapaluk) in early December 2016, which was the first time experience for residents of Qaanaaq over the last 30 years. They assumed that northeasterly winds of more than 30 ms^{-1} on 6-hour average dispersed sea ice from the coast, based on observation data at Qaanaaq airport.

These strong wind events seriously affected the scientific activity and residents’ living, which motivate the authors to study occurrence characteristics of strong winds in the northwest Greenland. According to observation performed during 2016-2017 and 2017-2018 winter seasons in Siorapaluk, strong winds more than 15 ms^{-1} occur in several times. These winds are always from the north-northeast to the observation point, which means that these winds blow beyond the ridgeline in the north of Siorapaluk. Year-round observation in Qaanaaq shows that strong winds appear also in summer as well as in winter. Some strong wind events are found to occur simultaneously in Siorapaluk and Qaanaaq. Numerical simulations are conducted for the period from May 2017 to April 2018 by using the Japan Meteorological Agency’s non-hydrostatic model (JMA-NHM) with the 1-km horizontal resolution to reveal temporal and spatial distributions of strong winds and mechanisms causing them. Statistical features of strong winds and dynamical connections between synoptic and local wind systems will be presented in the meeting.

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Acknowledgements

This work was partly supported by the Joint Research Program of the Institute of Low Temperature Science, Hokkaido University, Japan, and JSPS KAKENHI Grant Numbers, JP15H01733, JP16H01772, and JP17K12817.

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Keywords: Greenland, lee-side downslope wind, Non-hydrostatic model

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Impacts of clouds on the Greenland ice sheet surface melt and mass balance

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Clouds have been recognized to enhance surface melt on the Greenland Ice Sheet (GrIS). However, quantitative estimates of the effects of clouds on the GrIS melt area enhancement and resultant ice-sheet-wide surface mass balance modulations are still lacking. Here we assessed the effects of clouds with the state-of-the-art regional climate model NHM-SMAP (Niwano et al., 2018), conducting a numerical sensitivity test in which clear-sky downward radiations and adiabatic atmospheric conditions were assumed, although the precipitation rate was the same as in the control all-sky simulation. By including or excluding cloud effects, we quantified time-integrated feedbacks for the first time. We found that the surface melt area extent increased by 3.1%, 0.3%, and 0.7% (of the total GrIS area) by the presence of clouds during summer (June to August) in 2012, 2013, and 2014, respectively. During the same periods, clouds reduced solar heating and thus daily runoff by 1.6, 0.8, and 1.0 Gt day^{-1}, respectively: clouds did not enhance the GrIS surface mass loss. In the ablation area, the presence of clouds results in a reduction of downward latent heat flux at the snow/ice surface so that much less energy is available for the surface melt, which highlights the importance of indirect effects of clouds.

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Keywords: Greenland ice sheet, surface mass balance, NHM-SMAP, clouds

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Thu. May 30, 2019 3:30 PM - 5:00 PM JST | Thu. May 30, 2019 6:30 AM - 8:00 AM UTC | 303 3F

[A-CG37] Science in the Arctic Region

convener:NAOYA KANNA(Arctic Research Center, Hokkaido University), Masashi Niwano(Meteorological Research Institute), Tetsu Nakamura(Faculty of Environmental Earth Science, Hokkaido University), Shunsuke Tei(Arctic Research Center, Hokkaido University), Chairperson:Naoya Kanna(Arctic Research Center, Hokkaido University)

The Arctic and circumpolar region is the key area for the study of global change because the anthropogenic impact is projected to be the largest in this area due to the complicated feedback processes of the nature. A number of international and interdisciplinary research projects have been conducted for the studies on the land-atmosphere-ocean system. In order to understand the feedback processes occurring in the Arctic and to project the global warming in the future, we need to establish the intense observational network and to exchange the knowledge and information by combining the different scientific communities under the common interest of the Arctic. The objectives of this session are 1) to exchange our knowledge on the observational facts and integrated modelling and 2) to deepen our understanding on wide range of natural sciences related to the Arctic and the circumpolar region. Studies on humanities, social sciences, and interdisciplinary fields are also welcomed.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[ACG37-13] Introduction of the IASC project "T-MOSAiC"

Masaki Uchida[1], *Tetsuo Sueyoshi[1] (1.National Institute of Polar Research)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[ACG37-14] Estimation of ice thickness and volume in the Sea of Okhotsk using ICESat and CryoSat-2 data

*Sohey Nihashi[1], Nathan T. Kurtz[2], Takenobu Toyota[3] (1.National Institute of Technology, Tomakomai College, 2.NASA GSFC, 3.Institute of Low Temperature Science, Hokkaido University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[ACG37-15] Arctic Sea Ice Changes in the DAMIP experiments using the MRI Earth System Model

*Takuro Aizawa[1], Masayoshi Ishii[2], Naga Oshima[2], Seiji Yukimoto[2], Hiroyasu Hasumi[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Meteorological Reseaerch Institute)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[ACG37-16] **Oceanographic Observation in the Refreezing Warm Chukchi Sea during 2018 Mirai Cruise**

*Tsubasa Kodaira[1], Takehiko Nose[1], Takuji Waseda[1], Jun Inoue[2] (1.The University of Tokyo, 2.National Institute of Polar Research)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[ACG37-17] **Observed Waves in the refreezing eastern Chukchi Sea during 2018 Mirai Cruise**

*Takuji Waseda[1], Takehiko Nose[1], Tsubasa Kodaira[1], Alison Kohout[2], Johannes Gemmrich[3], Hui Shen[4], Jun Inoue[5] (1.The University of Tokyo, 2.National Institute of Water and Atmospheric Research, 3.University of Victoria, 4.Bedford Institute of Oceanography, 5.National Institute for Polar Research)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[ACG37-18] Mooring measurement near a marine-terminating glacier in Bowdoin Fjord in northwestern Greenland

*Yoshiki Fujishi[1,2], Yasushi Fukamachi[1,3], NAOYA KANNA[3], Shin Sugiyama[1,3] (1.Institute of Low Temperature Science, Hokkaido University, 2.Graduate School of Environmental Science, Hokkaido University , 3.Arctic Research Center, Hokkaido University)

Introduction of the IASC project "T-MOSAiC"

Masaki Uchida[1], *Tetsuo Sueyoshi[1]

1. National Institute of Polar Research

Terrestrial Multidisciplinary distributed Observatories for the Study of Arctic Connections (T-MOSAiC) is one of the IASC (International Arctic Science Committee) projects. T-MOSAiC has been formulated as a research and synthesis project to provide an integrated, cross-disciplinary evaluation of how the changing Arctic Ocean affects terrestrial environments, from the coastal zone to the continental interior. The project will focus on connecting studies which take place throughout the Arctic and across disciplines in order to generate new findings into Arctic geosystems, ecosystems and human systems. There are key aspects to be addressed include connectivity, gradients, discontinuities, thresholds, extreme events and emergent properties, with specific questions that bridge sites and disciplines. Data sets will be available via open access repositories. T-MOSAiC will run in parallel to the ocean-based project Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC), with temporal overlap in 2019-2020 and exchange of data sets such as climate observations from land and ocean stations.

Participating in T-MOSAiC has several advantages to your research. Join an international project across disciplines that targets key physical, ecological and societal issues affecting the Arctic and the world, at this critical time of rapid change and international decision-making. Contribute to fill key observational data in gaps identified by the T-MOSAiC Science Plan. Assure laboratory and project visibility at the international level. Benefit from T-MOSAiC and IASC grants for early career researchers for networking. Link with large T-MOSAiC partners such as MOSAiC (https://www.mosaic-expedition.org/), INTERACT (https://eu-interact.org/), Sentinel North (https://sentinelnorth.ulaval.ca/en), Nunataryuk (https://nunataryuk.org/) and others. Develop new collaborations, including across disciplines. Please visit the T-MOSAiC web site and get more information (https://www.t-mosaic.com/).

Keywords: Arctic, Terretrial, Observations, International Collaborative Study

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Estimation of ice thickness and volume in the Sea of Okhotsk using ICESat and CryoSat-2 data

*Sohey Nihashi[1], Nathan T. Kurtz[2], Takenobu Toyota[3]

1. National Institute of Technology, Tomakomai College, 2. NASA GSFC, 3. Institute of Low Temperature Science, Hokkaido University

Sea-ice thickness in the Sea of Okhotsk is estimated from freeboard derived from satellite altimeter data. Ice thickness is estimated by assuming densities of sea ice, snow, and seawater based on in-situ observations (Toyota et al., 2007; Ohshima et al., 2001). Snow depth is assumed 10% of ice thickness by referring to in-situ observation (Toyota et al., 2007). Ice freeboard (thickness) derived from a laser altimeter GLAS on ICESat is used for 2004-08 (Nihashi et al., 2018). After 2011 to 2018, data from radar altimeter SIRAL-2 on CryoSat-2 is used. CryoSat-2 freeboard is obtained by a method of Kurtz et al. (2014). Comparison with ice thickness observed hourly aboard icebreaker Soya by visual observation suggests that ice thickness derived from ICESat and CryoSat-2 are almost consistent. Total ice thickness (ice thickness including snow depth) in February and March, when the sea-ice area is maximum, averaged over the entire sea-ice zone ranges from 77.5 cm (2008) to 123.0 cm (2017). The mode of total ice thickness ranges from 50-60 cm (2007; 2008; 2017) to 90-100 cm (2013). Ice volume in the Sea of Okhotsk is estimated from the total ice thickness and ice concentration derived from AMSR-E (2004-11), SSMI (2012), and AMSR2 (2013-18). Ice volume is estimated by interpolating these sea-ice datasets onto an NSIDC polar stereographic grid at a spatial resolution of about 12 km. The maximum ice volume is 8.3×10^{11} m^3 (2016), while the minimum is 5.4×10^{11} m^3 (2015). The interannual variability is shown to be mainly determined by the sea-ice area, although ice thickness seemed to be effective in 2008. It has been shown that the maximum sea-ice area and ice production in the Sea of Okhotsk can be explained from atmospheric and oceanographic conditions (e.g., Ohshima et al., 2006; Nakanowatari et al., 2010; Kashiwase et al., 2014). Based on these studies, we compare the ice volume with the atmospheric and oceanographic data. And then we find that the ice volume can be explained to some extent by the air temperature in the northwest and north of the sea just before the freezing season (November-December), the air temperature in the northwest of the sea during active freezing period (February-March), and the wind toward the offshore during the ice advance season (January-March). Multiple regression analysis is performed on the ice volume using these atmospheric conditions. And we try to reproduce the ice volume in the Sea of Okhotsk since the 1950s when the satellite data does not exist from the atmospheric data by using the regression line.

Keywords: Sea of Okhotsk, sea-ice thickness, satellite altimeter

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Arctic Sea Ice Changes in the DAMIP experiments using the MRI Earth System Model

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1. Atmosphere and Ocean Reseaerch Institute, The University of Tokyo, 2. Meteorological Reseaerch Institute

Arctic sea ice decreases rapidly with a temperature rise by Arctic amplification which is caused by an increase of the greenhouse gases. According to some studies, the Arctic Ocean is projected to become ice-free Ocean in the nature future. As sea ice melts due to the effect of sensible heat, it has a close relationship with air temperature. Although the historical temperature in the Arctic is well known by the previous observational studies, the historical sea ice variability hasn’ t still understood sufficiently because of the lack of observations in pre-satellite era. Therefore, the modeling study will greatly contribute to the understanding of the Arctic climate change.

Meteorological Research Institute (MRI) has developed a new version of MRI Earth System Model (MRI-ESM2) for participating in the various Model Intercomparison Project (MIP), especially CMIP6 (Coupled Model Intercomparison Project Phase 6). We conducted the CMIP6 historical experiment (1850-2014) and the DAMIP (Detection and Attribution MIP) experiments by MRI-ESM2. The DAMIP experiments consist of hist-GHG (Well-mixed greenhouse-gas-only historical simulations), hist-aer (Anthropogenic-aerosol-only historical simulations) and hist-nat (Natural-only historical simulations). The DAMIP experiments make it possible to the clarify the impacts of anthropogenic and natural forcing on the global warming. And the experiment will be able to estimate how the sea ice variability was influenced by the external anthropogenic and the natural forcing. The decadal to multi-decadal variability of the Arctic sea ice is seen in all experiments, but each experiment indicates some characteristic changes. The hist-GHG experiment shows a strongly decrease in the sea ice extent due to the rapid increase of the greenhouse gases. The hist-aer experiment indicates an expansion in the summer sea ice extent over the period to 1980 when the concentration of sulphate aerosols is peak out, which lead to the global and Arctic cooling. But over the period from 1980 to now, the summer sea ice extent shows a decrease. The hist-nat experiment shows a weakly decrease in the summer sea ice extent over the period from 1880 to 1940, since then the summer sea ice extent remains at the same level. Thus, our simulations show the historical summer Arctic sea ice extent and the contributions of the external anthropogenic and the natural forcing to the sea ice changes.

Keywords: Arctic sea ice change, Global warming, Aerosol

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Oceanographic Observation in the Refreezing Warm Chukchi Sea during 2018 Mirai Cruise

*Tsubasa Kodaira[1], Takehiko Nose[1], Takuji Waseda[1], Jun Inoue[2]

1. The University of Tokyo, 2. National Institute of Polar Research

In November 2018, R/V Mirai entered Chukchi Sea to conduct observations with special attention to the Marginal Ice Zone (MIZ). Based on satellite SST measurements over Chukchi Sea, it is found that Chukchi Sea has a clear warming trend in the last decade. The warm Chukchi Sea enabled R/V Mirai to conduct rare observations in November to measure the refreezing ocean. The preliminary results of the hydrographic and velocity observation are presented. The repeated measurements along an observation line toward MIZ north of Hana Shoal showed temperature and salinity changes largely over the Chukchi slope compared to the shallow shelf.

Keywords: R/V Mirai, MIZ

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Observed Waves in the refreezing eastern Chukchi Sea during 2018 Mirai Cruise

*Takuji Waseda[1], Takehiko Nose[1], Tsubasa Kodaira[1], Alison Kohout[2], Johannes Gemmrich[3], Hui Shen[4], Jun Inoue[5]

1. The University of Tokyo, 2. National Institute of Water and Atmospheric Research, 3. University of Victoria, 4. Bedford Institute of Oceanography, 5. National Institute for Polar Research

The sea ice in the Pacific side of the Arctic Ocean starts to melt in August, retreats the most in September, and advances again in October. In November, in typical years, most of the Chukchi Sea is covered by ice. Waves generated in the open waters is largest in October. During the R/V Mirai (JAMSTEC) expedition in November 2018 (MR18–05C, PI J. Inoue), anomalously warm surface waters delayed freezing of Chukchi Sea providing a unique opportunity to observe ocean waves in the freezing period. A drifting wave buoy, ship-borne wave gauge, and satellite synthetic aperture radar data were analyzed to characterize the waves during that period. The drifting wave buoy was deployed at the edge of the Marginal Ice Zone, gradually migrated to the west, and eventually got trapped in the sea ice. During this period, the largest significant wave height observed by a buoy was 2.6 m. Once trapped in ice, the buoy-detected wave energy significantly reduced from the open water wave height detected by ship-borne wave gauge. The possible generation, decay, and propagation of waves in the ice-covered sea for on-ice and off-ice conditions will be discussed in conjunction with the obtained satellite SAR images.

Keywords: wave-ice interaction, Marginal Ice Zone, Chukchi Sea, R/V Mirai, SAR

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Mooring measurement near a marine-terminating glacier in Bowdoin Fjord in northwestern Greenland

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Submarine melting of calving glaciers is considered as an important process in the mass loss of the Greenland ice sheet (Straneo et al., 2013). Moreover, freshwater runoff has been increasing in recent years and its impact on marine ecosystem is recognized. Bowdoin Glacier, a marine-terminating outlet glacier in northwestern Greenland, has experienced rapid retreat since 2008 (Sakakibara et al., 2018). However, oceanographic observations are sparse in Greenlandic fjords, especially near the calving front of glaciers. The lack of a long-term in-situ data makes it difficult to quantify submarine melting. To better understand seasonal variability in current, temperature, and salinity in this proglacial fjord, mooring measurement was performed in Bowdoin Fjord, a 20-km-long fjord in front of Bowdoin Glacier.
Two moorings were deployed in Bowdoin Fjord, one at 17 km from the glacier front (BF17) and another at approximately 1 km from the glacier front (BF01), respectively. The ocean depth was 540 m at BF17 and 186 m at BF01. The moorings were equipped with a pressure sensor (DEFI2-D50HG, JFE Advantech), thermistors (NWT-SN, Nichiyu Giken and SBE56, Seabird), current meters (INFINITY-EM, JFE Advantech) and conductivity-temperature sensors (SBE-37SM, Seabird). At BF17, a current meter and a conductivity-temperature sensor were at the depths 527 m and 530 m, respectively. A pressure sensor and seven thermistors were at 220 m and 222, 246, 268, 318, 368, 418, and 468 m, respectively. At BF01, a current meter and a conductivity-temperature sensor were at the depths of 167 m and 170 m, respectively. The instruments were operated from August 2016 to July 2018 at BF17 and from July 2017 to July 2018 at BF01.
At BF17, temperature near the bottom was lower during northward current (towards the glacier). Temperature variations corresponded well with that of salinity throughout the year, i.e. temperature increased when salinity decreased. From August to October, we observed fortnightly temperature variations suggesting the influence of tide on water exchange in the fjord. In early August, water near the bottom at BF01 flowed towards the glacier and temperature near the bottom rapidly decreased. This event occurred when the daily mean air temperature measured at Qaanaaq Airport exceeded 0 ˚C, indicating the initiation of subglacial discharge. Temperature variations near the bottom at BF01 correlated with salinity, i.e. temperature and salinity increased at similar timings. Both at BF17 and BF01, temperature variations were small in winter and spring, which we attribute to sea ice cover usually observed in Bowdoin Fjord from November to June. Our data suggested that tide plays a key role in water exchange in the fjord, whereas water property near the glacier front was strongly influenced by meltwater discharge. In the presentation, water property variations and fjord circulation are discussed with weather conditions, and the data obtained at BF17 are compared with those at BF01.

ACKNOWLEDGEMENTS
This research was funded by the Arctic research project Arctic Challenge for Sustainability (ArCS).

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Keywords: Greenland, Fjord, Marine-terminating glacier

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[J] Oral | H (Human Geosciences)：H-DS Disaster geosciences

Thu. May 30, 2019 1:45 PM - 3:15 PM JST | Thu. May 30, 2019 4:45 AM - 6:15 AM UTC | 106 1F

[H-DS15] Human environment and disaster risk

convener:Tatsuto Aoki(School of Regional Development Studies, Kanazawa University), Hisao Kondo(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Chairperson:Tatsuto Aoki(金沢大学地域創造学類)

This session discusses disaster risks being inherent in the natural and human environment, which sometimes happen to appear at a disaster, from the viewpoint of not only natural sciences but also social and human sciences. Examples of discussion subjects are as follows: uncertainty of forecasting disaster and problems of huge disaster with low frequency that raised from the 2011 Tohoku earthquake, the methodology for improving hazard maps, national recovery plans considering probable changes or sustainability of the society, international cooperation for disaster mitigation, problems of active faults or liquefaction, adjusting disaster mitigation plan to the regional characteristics, technical development for supporting disaster prevention, education for the disaster mitigation.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[HDS15-01] Influence of inhomogeneous structure in surficial reclaimed body traced by aerial photos and delineated by near surface geophysical survey at Makuhari-Kaihin Park liquefied by the 2011 off the Pacific coast of Tohoku earthquake.

*Tomio INAZAKI[1], Takanori Ogahara[1] (1.Public Works Research Institute, Tsukuba Central Institute)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[HDS15-02] Distribution morphology of deformed reclaimed valley associated with the 2018 Hokkaido Eastern Iburi Earthquake

*Takayuki Nakano[1], Satoshi Fujiwara[1], Hiroshi Une[1] (1.GSI of Japan)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[HDS15-03] Liquefaction risk evaluation using relative height data of natural levee

*Mamoru Koarai[1], Kouta Uchiyama[1], Takayuki Nakano[2] (1.Earth Science course, College of Science, Ibaraki University, 2.Geospatial Information Authority of Japan)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[HDS15-04] **Spatial Analysis of Social Vulnerability to large-scale flood: a case study on the Katsushika Ward, Tokyo**

*LIAN XIAO[1] (1.University of Tsukuba)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[HDS15-05] Importance and method of visualization of future occurrence possibilities of giant earthquakes along the Nankai trough

*Yo Fukushima[1] (1.International Research Institute of Disaster Science, Tohoku University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[HDS15-06] Investigation of efficient tsunami evacuation using real-time disaster information

*Yusuke Oishi[1,2,3], Takashi Furumura[2], Fumihiko Imamura[3], Yoshiteru Mihara[4], Fumiyasu Makinoshima[3], Yamashita Kei[3], Takao Higashiyama[5], Tomonori Goto[5], Makoto Oomura[4], Mitsuyuki Nagayama[4] (1.Fujitsu Laboratories Ltd., 2.Earthquake Research Institute, the University of Tokyo, 3.IRIDeS, Tohoku University, 4.Kawasaki City, 5.Fujitsu Ltd.)

Influence of inhomogeneous structure in surficial reclaimed body traced by aerial photos and delineated by near surface geophysical survey at Makuhari-Kaihin Park liquefied by the 2011 off the Pacific coast of Tohoku earthquake.

*Tomio INAZAKI[1], Takanori Ogahara[1]

1. Public Works Research Institute, Tsukuba Central Institute

We reanalyzed the comprehensive geoscientific investigation data obtained at a site where outstanding liquefaction took place just after the 2011 off the Pacific coast of Tohoku earthquake. The studied site, Makuhari-Kaihin Park, Chiba Prefecture, faces the Tokyo Bay and is situated on a reclaimed land constructed through 1973 to 1987. The field surveys were composed of high-resolution seismic surveys along two short lines, core boring at 4 points, suspension PS logging, CPTs at 7 points, and dynamic cone penetration tests. Core descriptions and detailed grain size analyses were quite helpful to discriminate man-made strata from natural layers and classify them into wet deposits, dry soils and surface cover soils. A time series of aerial photos of the site was interpreted to reconstruct the reclamation process of the site. Our interpretation is as follows; 1) Northern block was first reclaimed since 1973 and the southern block was followed since 1976. Reclamation was completed till 1987 and then the surface was covered with improved soils to form a loan park surrounded by a planted zone. The boundary between the reclamation blocks was buried in the northern part of the park. Aerial photos clearly recorded dendritic sand dunes in the southern block spread by using aligned sand pipes. Wet deposits were overlain with 1 to 2 m thick dry soils toward the offshore.
Based on the time and spatial history of the reclamation process at the site, we implemented a geoscientific interpretation of liquefaction process of the site. 1) The cover soils acted as a cap layer which controlled the mode of occurrence of the surface fissures and sand boil chains caused by liquefaction. 2) Sand dominant parts in the wet deposits first liquefied during the earthquake, and it caused segmentation of man-made strata into several fragments and differential oscillations during the earthquake. Liquefaction resulted in fluidization of fine-grained parts in the wet deposits. No trace of liquefaction was recognized in the underlying natural layers. In contrast, characteristic structure associated with liquefaction and fluidization was obvious in the wet deposits in the whole points of the site. It means that the surface fissures and sand boil chains were inappropriate to explain liquefaction process because liquefaction inherently takes place in the subsurface.

Keywords: 2011 off the Pacific Coast Tohoku Earthquake, reclaimed land, liquefaction, fluidization, near surface geophysics, aerial photo interpretation

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Distribution morphology of deformed reclaimed valley associated with the 2018 Hokkaido Eastern Iburi Earthquake

*Takayuki Nakano[1], Satoshi Fujiwara[1], Hiroshi Une[1]

1. GSI of Japan

1. Introduction

In the 2018 Hokkaido Eastern Iburi Earthquake (M6.7) that occurred on September 6, 2018 (Japan Society of Erosion Control Engineering, 2018 etc.), the fluidization phenomenon of filled land caused by liquefaction etc. in reclaimed valley on Kiyota Ward, Sapporo City seriously damaged residential land and social infrastructures (Japanese Geotechnical Society and Japan Society of Civil Engineers, 2018 etc.). In order to discuss this fluidization phenomenon of reclaimed valley, it is necessary to know the reclaimed valley distribution morphology. Therefore, we disclosed the distribution morphology of the reclaimed valley created by the difference between the pseudo DEM generated from aerial photos using the SfM-MVS technique and the post-construction DEM. Also, we extracted the surface deformation in this area from SAR interferogram and compared it with reclaimed valley distribution.

2. Target area and study method

Reclaimed valley distribution maps were created in Kiyota Ward, Sapporo City (Kiyota site) and Atsuma Town (Atsuma site). Pre-construction DSMs were generated from 44 aerial photos of the 1960s and 1970s taken by the GSI of Japan, respectively. The DSMs were generated by using the SfM-MVS technique and the DSMs were converted to a pseudo DEM by filtering (Nakano, 2017). On the SfM analysis, we established 35 and 20 ground control points (GCPs) respectively. A 5-m grid DEM of the fundamental geospatial data was used for the post-construction DEM. The used SAR interferogram is an image by a pair of August 23, 2018 and September 6, 2018 analyzed by the GSI of Japan using the ALOS-2 data of JAXA.

3. Result & Discussion

We acquired the reclaimed valley distribution map more detail than the past distribution map in the Kiyota site. The reclaimed thickness at the Satozuka district where ground damage was serious in the Kiyota site was ca. 15 m at the maximum. Since the RMSE of vertical residual of GCPs on the SfM analysis was ca. 1.2 m, the value of reclaimed thickness has an error equivalent to that. Comparing this reclaimed valley distribution map with the SAR interferogram, we could identify surface deformations moving away from the satellite or non-interference areas in the reclaimed valley area. This non-interference areas correspond the serious damage areas and the surface deformations area has the potential to show the subsidence or sliding-like deformation of reclaimed valley.

In the Atsuma site, we confirmed small reclaimed valley which the thickness is less than 10 m. The RMSE of vertical residual of GCPs on the SfM analysis was ca. 0.8 m. Surface fissures in this site were discovered on site (Iiba and Nagai, 2018 etc.), and it is estimated that the sliding-like deformation of reclaimed valley occurred.

4. Challenges

We identified the reclaimed valley distribution morphology easily and quickly by using SfM-MVS and filtering analysis with aerial photo. Also, InSAR indicated the possibility of quickly detecting the surface deformation immediately after the disaster. However, we should be careful since the pseudo DEM created from DSM generated by the SfM analysis will have large errors when the area was forest land before construction. It is necessary to examine a more effective and prompt filtering method. Finally, I would like

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to offer my sincere sympathy to the people living in the damaged regions by the earthquake.

Acknowledgements: PALSAR-2 data are provided from JAXA through joint cooperative agreement between GSI and JAXA. The ownership of PALSAR-2 data belongs to JAXA.

References:

Iiba and Nagai (2018): Damage investigation report of the Hokkaido Eastern Iburi Earthquake (prompt report), foundation ground related.
Japanese Geotechnical Society and Japan Society of Civil Engineers (2018): Liquefaction damage by the Hokkaido Eastern Iburi Eartuquake.
Nakano (2017): Research result report of KAKENHI, 15K16288.

Keywords: The 2018 Hokkaido Eastern Iburi Earthquake, reclaimed valley, SfM-MVS, InSAR

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Liquefaction risk evaluation using relative height data of natural levee

*Mamoru Koarai[1], Kouta Uchiyama[1], Takayuki Nakano[2]

1. Earth Science course, College of Science, Ibaraki University, 2. Geospatial Information Authority of Japan

The liquefaction risk evaluation of the natural levee has been divided in two by a border of relative height 5m in the liquefaction evaluation standard of Nakano et.al. (2015).But it is necessary to reconsider evaluation division, because almost no natural levee with over 5m relative height exists in the Naka River low land and the Tone River downstream.
In this study, land condition map, 5m grid DEM and liquefaction occurrence area by The 2011 off the Pacific coast of Tohoku Earthquake in downstream of the Tone River were overlaid by GIS. The relative height of natural levee was calculated from an elevation of the natural levee liquefaction generated and an elevation of other neighbor landform such as back marsh, coastal plain and delta.
After the liquefaction occurrence rate of the natural levee was calculated every relative height difference of the 0.5m unit, the liquefaction occurrence rate decreased suddenly between 1.5 m-2.5 m of relative height or the liquefaction occurrence rate gradually decreased over 1.5 m-2.5m of relative height. It is appropriate to establish a border of relative elevation of a natural levee by 2m or 3m.

Keywords: liquefaction hazard map, natural levee, relative height

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Spatial Analysis of Social Vulnerability to large-scale flood: a case study on the Katsushika Ward, Tokyo

*LIAN XIAO[1]

1. University of Tsukuba

Due to global climate change, the scalability and frequency of flooding is increasing. On the other hand, population aging and family structural changes, as well as the lack of adaptation measures, accelerate vulnerability to flooding. It is necessary to reduce the vulnerability to floods and to accelerate adaptive capacity. Therefore, assessing social vulnerability to flooding disasters is an important step in reducing flooding vulnerability and accelerating resilience.

In this study, we refer to the MOVE framework (a disaster vulnerability assessment framework) and analyze social vulnerability from three perspectives: exposure to a flood, susceptibility, and resilience. We subsequently develop an index system to evaluate the social vulnerability using 14 indicators. Spatial distribution of the social vulnerability of floods in the Katsushika Ward, Tokyo, is revealed based on the collected data using the information entropy method and geographic information system (GIS).

Keywords: GIS, large-scale flood, Social Vulnerability

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Importance and method of visualization of future occurrence possibilities of giant earthquakes along the Nankai trough

*Yo Fukushima[1]

1. International Research Institute of Disaster Science, Tohoku University

Earthquakes occur in a diverse fashon and we can only make probabilistic forecasts on their occurrence. In a future, we might be able to make deterministic forecasts for certain earthquakes, but at the current status we do not foresee a realization of such a type of forecast.

Currently, discussion on how to take countermeasures on the anticipated giant Nankai trough earthquakes based on forecast information is going on in Japan, led by a Japanese governmental working group. On the giant Nankai trough earthquakes, it has been known mainly from historic documents and seismological observations that 1) the mean recurrence interval of giant Nankai trough earthquakes is 100–150 years, 2) there are two segments, west and east of the Kii peninsula, and they tend to generate earthquakes one after another with a short time interval (within a few years) or rupture simultaneously, 3) normally there are few interplate earthquakes along the Nankai subduction.

Based on such current knowledge, the report by the governmental working group issued in December 2018 emphasizes on the case where a magnitude ~8 earthquake rupturing only one side (west or east) and another earthquake is strongly anticipated on the other side. The report also mentions the cases where a smaller earthquake (magnitude ~7) or an unusual slow slip occur, but with conservative descriptions on the countermeasures for such cases. In short, the report focuses on relatively certain and presumably impending case of what to do in case of the “half-rupture”.

While, at the standpoint of the national government, the framework of the report is appropriate, there seems to be potential motivation on local government, public organizations and private companies to make own flexible decisions depending on their circumstances. There may be cases where some anomalous geophysical phenomenon, even without an eventual occurrence of a giant earthquake, would lead to social reactions and the organizations should take some countermeasures. It seems thus useful for the organizations to understand the possibilities of anomalous natural phenomena that might lead to an earthquake (and social phenomena that follows). Event tree diagrams used in volcanology and other fields can be useful for that purpose. It would be important that experts collaborate with the stakeholders (potential users) and know their needs and opinions in developing them.

Keywords: Nankai Trough Giant Earthquakes, Earthquake Forecast

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Investigation of efficient tsunami evacuation using real-time disaster information

*Yusuke Oishi[1,2,3], Takashi Furumura[2], Fumihiko Imamura[3], Yoshiteru Mihara[4], Fumiyasu Makinoshima[3], Yamashita Kei[3], Takao Higashiyama[5], Tomonori Goto[5], Makoto Oomura[4], Mitsuyuki Nagayama[4]

1. Fujitsu Laboratories Ltd., 2. Earthquake Research Institute, the University of Tokyo, 3. IRIDeS, Tohoku University, 4. Kawasaki City, 5. Fujitsu Ltd.

1. Introduction

In recent years, due to the expansion of the offshore tsunami observation network in Japan and the development of high-speed analysis techniques to utilize the observed data, it is becoming possible to transmit more detailed real-time disaster prediction information. Just after the 2011 Tohoku-Oki Earthquake occurred, while the majority of voice calls were regulated, packet communication continued to be relatively connected and smartphones played an important role in information sharing. Therefore, it is expected that real-time disaster information obtained through smartphones can realize safer evacuation in the near future. In this study, in order to evaluate the effect and the challenge of providing real-time disaster information through smartphone in tsunami evacuation, a demonstration experiment was carried out.

2. Tsunami evacuation demonstration experiment

In the demonstration experiment conducted in the opportunity of the Kawasaki city’s annual tsunami evacuation drill on December 9, 2018, we set up points where passing through was not permitted due to assumed damages caused by strong shake of earthquake, e.g., building collapse, fire, liquefaction, etc., and staff members were located with panels that said “impassable”. When participants of the demonstration experiment encountered the impassable points, they posted the location of these points through a smartphone application, and the posted information was shared in real time on the application screen of other participants. The smartphone application was developed for this experiment and was distributed before the experiment. The number of participants who used the provided smartphone application was 84.

Evacuation behaviors were measured as time series data of position information by the position measurement function of smartphones. In the experiment, in order to evaluate the effect of real-time disaster information about the locations of above-mentioned impassable points on evacuation behaviors, 24 participants from the organizations conducting the demonstration experiment were divided into two groups. One of the two groups were not provided the posted information. As a result, in the group with disaster information, multiple evacuees succeeded in choosing an efficient evacuation route by reducing the number of encounters to the impassable points, and the effectiveness of the real-time disaster information was confirmed. However, when comparing the average value for each group, although the evacuation distance was slightly shorten in the group with the information, it did not lead to reduction in evacuation time, because the average walking speed was slower than the group without the information. The average walking speed that takes the standstill time into account was 4.9 km/h for the group without the real-time disaster information and was 4.7 km/h for the group with the information.

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One of the estimated factors that lower the average walking speed is the standstill time to consider evacuation routes using the smartphone application at the branching points and at the places near the impassable points, or the action to post the impossible points. In the group with the real-time disaster information, among twelve people, nine people stopped for more than 10 seconds during the evacuation action.

3. Future work

One of the reasons why the average evacuation speed was decreased in the group with the real-time information is that the accuracy of the posted information was rather low and the standstill time to consider evacuation route was prolonged. In the questionnaire conducted after the evacuation drill, there were multiple opinions such as "With the wrong information, there were no passible road leading to the evacuation site". Among the 74 postings about the impassable points, 40 posts (54.8% of the whole) were accurate with an error of 20 m or less. In order to realize evacuation effectively utilizing real-time disaster information, it is important to evaluate the quality of information and consider information providing means that are easy-to-understand and lead to immediate determination of the next action.

Keywords: tsunami, evacuation, smartphone application

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[J] Oral | H (Human Geosciences)：H-TT Technology & Techniques

Thu. May 30, 2019 10:45 AM - 12:15 PM JST | Thu. May 30, 2019 1:45 AM - 3:15 AM UTC | 301B 3F

[H-TT23] Geographic Information System and Cartography

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Kazunari Tanka(Department of Civil Engineering and Urban Design, Faculty of Engineering, Osaka Institute of Technology), Kazuhiko Nakamura(The University of Tokyo), Chairperson:Mamoru KOARAI(Ibaraki University), Kazunari Tanaka(大阪工業大学)

This session discusses various methods which acquire, store, analyze and visualize geospatial data, and presents the outcomes of empirical studies using GIS or mapping methods. The session also deals with applications of digital data, GIS, and mapping to various fields of earth and planetary science and human society. All presentations and discussion of this session are made in Japanese.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[HTT23-01] **An analysis of the year-round distribution of $PM_{2.5}$ and Oxidant by (Web)GIS and R**

★Invited Papers

*Junji Yamakawa[1] (1.Graduate School of Natural Science and Technology, Okayama University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[HTT23-02] Development Process and Spatial Structure of Urban Villages in Shenzhen City China

*YARONG LUAN

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[HTT23-03] An analysis on the location characteristic of alley spaces in Tokyo

*Ryo Taniguchi[1], Go Ishikawa[1], Mayumi Oka[2] (1.Tokyo Map Research Inc., 2.Research Organization of Information and Systems The Institute of Statistical Mathematics)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[HTT23-04] Image analysis of night scape using lyrics

*Hiroki Komai[1], Kazunari Tanaka[1] (1.Osaka Institute of Technology)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[HTT23-05] On the Method to Evaluate Signboards based on the Relationship with the Surrounding Space

*Akihiro Kishikawa[1], Kazunari Tanaka[1] (1.Osaka Institute of Technology)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[HTT23-06] ON THE LANDSCAPES ELEMENTS FROM A BIRD’S-EYE VIEW SCAPE

*Nobuaki Tanaka[1], kazunari Tanaka[1] (1.Osaka Institute of Technology)

An analysis of the year-round distribution of $PM_{2.5}$ and Oxidant by (Web)GIS and R

*Junji Yamakawa[1]

1. Graduate School of Natural Science and Technology, Okayama University

The year-round concentration distribution of $PM_{2.5}$ and Oxidant in Okayama City, Okayama Prefecture, Japan were estimated by using the geostatistics method and expressed by the (Web)GIS.

The observed concentration data of those environmental substances were obtained from the Website of the National Institute for Environmental Studies. The target year of $PM_{2.5}$ was 2015, and the year of the oxidant was 2006. GNU R (R core team, 2018) was used for geostatistics analysis. The JPGIS (Geographical Survey Institute, 2018), which is government-based open data, was used for geostatistics analysis. The On-premise type GIS and the WebGIS were used in the research. The QGIS (QGIS Development Team, FOSS4G, 2018), and the jSTAT MAP (Statistics Bureau, Ministry of Internal Affairs and Communications, 2019) were used for the each type of the GIS.

First, the variogram of the observed concentration data of the environmental substances, were calculated for the estimation of the spatial dependence, then the prediction of the concentration distribution on the target area were carried out by using the Kriging method. The estimated concentration data were examined together with other geographic information data using (Web)GIS. The expression scheme of the accuracy of the estimation were investigated on the QGIS. Furthermore, transformation of the coordinates that was required on the using of the jSTAT MAP was also investigated.

The year-round mean concentration distribution of $PM_{2.5}$ and oxidant in Okayama city were estimated with certain accuracy. It was also possible to qualitative analysis of the coefficient of variation of estimated distributions of $PM_{2.5}$ and oxidant by GIS and WebGIS. The minor error on the conversion from the rectangular coordinate system to the regional mesh code requires further consideration.

GIS is effective for analysis and mapping of the global environmental data and geographic information data. WebGIS is also becoming capable of executing these analysis with only by the Web browser. Further utilization is expected in the study field of the Earth and planetary science.

Keywords: GIS, jSTAT MAP, Kriging, FOSS4G, PM2.5, Oxidant

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Development Process and Spatial Structure of Urban Villages in Shenzhen City China

*YARONG LUAN

During the 30 years of the reform and opening-up policy, economically developed cities and regions have expanded rapidly in China. Villages which originally surrounded the city before their expansion were rapidly submerged by the expanded city areas and surrounded by high-rise buildings. They are turned into the "urban villages". In the rapidly urbanized regions, urban villages are common phenomena. This problem becomes extremely serious in the Pearl River Delta region in China.

In the present study, Shenzhen City was selected as the research area. Field work was performed on the 18 sample urban villages selected from total 320 urban villages of Shenzhen City. Based on the changes in their internal spatial structures, the development of the urban villages is divided into three stages, e.g., embryonic stage, growth stage, reformed stage. After analyzing the spatial structures, different characteristic features were found in each stage. And the main factors of the spatial structural changes arising from different stages were summarized.

It was found that the traffic condition was the key factor for the embryonic stage; rental price was the key factor for the growth stage and the regulatory power of the government was the key factor for the reformed stage.

Keywords: Urban Village, Shenzhen City

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An analysis on the location characteristic of alley spaces in Tokyo

*Ryo Taniguchi[1], Go Ishikawa[1], Mayumi Oka[2]

1. Tokyo Map Research Inc., 2. Research Organization of Information and Systems The Institute of Statistical Mathematics

The number of alley spaces in urban areas is rapidly decreasing due to road transportation plans centered on automobiles and large-scale development. In recent years, however, aspects of the alley as a common space are being reconsidered, and town planning with the alley was also promoted throughout the country. The alley is considered to be an important factor characterizing urban spaces, but it is difficult to grasp its location as special information. So than before, we devised "Alley Estimation Logic" which extracts block areas where the existence of allays is presumed by using GIS, and have checked the accuracy of logic through field survey in Tokyo and Tokushima prefectures.
In this study, we conducted "Alley Estimation Logic" for Tokyo and estimated the alley location. For the analysis, we used “Foundation Geographical Data” (scale level 2500) made by Geographical Survey Institute and “ArcGIS Pro 2.2” by Esri. Furthermore, we calculated "Alley Ratio" from the estimation result and considered the location characteristics of the alley through comparison with the number of wooden buildings and the use district etc. In addition, we estimate the "Alley Ratio" of municipalities in Mie prefecture as a whole, and we will verify regional differences due to differences in prefectures.

Keywords: Geospatial information Data, Alleys, GIS

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Image analysis of night scape using lyrics

*Hiroki Komai[1], Kazunari Tanaka[1]

1. Osaka Institute of Technology

Night scape has a beauty that attracts people. In recent years, due to the spread of cameras and SNS, there are many new trends and new popular spots. As a byproduct, this seems to attract tourist. In this research, the characteristics of the night scape were analyzed using the photos and post contents from SNS. As a result, by the analysis to evaluate a part of the values, the examples: the perseverance, the painfulness and the merriment are appeared of the night scape.

Keywords: Image analysis, Night scape, SNS

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On the Method to Evaluate Signboards based on the Relationship with the Surrounding Space

*Akihiro Kishikawa[1], Kazunari Tanaka[1]

1. Osaka Institute of Technology

The street space in the city is an important space to impress visitors with the image of the city.

However, in recent years, miscellaneous and townscapes are being formed due to the enlargement of buildings and the diversification of size, forms and colors of signboards.

The signboard design combines size, color, and letters together to create a signboard.

In this research, we aim at grasping the degree of group signs by checking the placement and colors appropriate to the characteristics of the place for Kyoto city.

Based on these relationships, we try to design a signboard suitable for the street.

Keywords: Outdoor Advertisement, Regulation, Kyoto

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ON THE LANDSCAPES ELEMENTS FROM A BIRD’S-EYE VIEW SCAPE

*Nobuaki Tanaka[1], kazunari Tanaka[1]

1. Osaka Institute of Technology

When it comes to landscapes, beautiful landscapes are formed from local climates such as history and customs by elements such as varying nature and demographic structures. A feature that creates these beautiful landscapes is the linear landscape element. This linear element is characterized as being beautiful because landscape elements that can be continuously viewed form a beautiful landscape such as a building that looks continuous due to the shape and color, in addition to linear landscape elements such as rivers and roads. Hypotheses concerning continuity and image are present not only in urban landscapes, but also in the landscape of rural areas and mountainous regions. Therefore, in this research, focusing on a bird's eye view from high vantage points, we aim to examine urban landscapes by analyzing their elements, shape, view and area. As for the examination method, analyzed and expressed the continuity of streets, rivers, green roads etc, using image analysis and GIS. From the results, extract and consider the relationship between the position and shape of elements with regards to continuity and the beauty of urban landscapes.

Keywords: High-rise building, Bird's eye view Landscape , Continuity

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[J] Oral | H (Human Geosciences)：H-CG Complex & General

Thu. May 30, 2019 9:00 AM - 10:30 AM JST | Thu. May 30, 2019 12:00 AM - 1:30 AM UTC | 101 1F

[H-CG31] Nuclear Energy and Geoscience

convener:Eiji Sasao(Tono Geoscience Center, Japan Atomic Energy Agency), Ryuta Hataya(Central Research Institute of Electric Power Industry), Shinji Takeuchi(Department of Earth and Environmental Sciences, College of Humanities & Sciences, Nihon University), Chairperson:Tadafumi Niizato

Handling of geological hazard assessments represent a major environmental concern in the modern society due to constructing nuclear facilities and their radioactive wastes, and also related to the management of contaminated biosphere after nuclear disasters of Fukushima-Daiichi Nuclear Power Plant. The session rational is to provide a forum to deal with various aspects of scientific and engineering aspects of nuclear power. The session in this year focuses on radioactive waste disposal and covers not only scientific aspect such as characterization of geological environment but also engineering aspects such as microbe-nuclide, mineral-water, and cement-water interactions. In addition to this, themes on seismic hazards at nuclear facilities, environmental behavior of radionuclides emitted from disabled nuclear plants, and volume reduction and reuse of cesium contaminated soils are welcomed. Through these presentations, we aim to promote intercultural communication and collaboration between science, engineering and social science.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[HCG31-01] **Uplift estimation in coastal sea area by extrapolation of the land area model and its uncertainty**

*Ryuta Hataya[1], Takaomi Hamada[1], Yohei Shimizu[1] (1.Central Research Institute of Electric Power Industry)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[HCG31-02] Deep groundwater mobility at costal area estimated by groundwater dating

*Takuma HASEGAWA[1], Kotaro NAKATA[1], Yuichi Tomioka[1], Tomoko Ota[1], Atsunao Marui[2], Isao Machida[2], Reo Ikawa[2], Masahiko Ono[2], Shinji Matsumoto[2] (1.Central Research Institute of Electric Power Industry, 2.The National Institute of Advanced Industrial Science and Technology)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[HCG31-03] Attempt to Estimate permeability of rock mass based on elasticity and resistivity measurement in underground tunnel

*Sota Kawaguchi[1], Tada-nori Goto[1], Koki Kashiwaya[1] (1.Graduate School of Engineering, Kyoto University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[HCG31-04] Study on relationship between pathway of groundwater and mass transport, and cooling process of granitic rock

*Eiji Sasao[1], Takashi Yuguchi[2], Masayuki Ishibashi[1] (1.Tono Geoscience Center, Japan Atomic Energy Agency, 2.Faculty of Science, Yamagata University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[HCG31-05] Fracture characterization in the accretionary complex from the view point of mass transfer

*Shinji Takeuchi[1], Chikara Kurata[1], Masakazu Niwa[2], Tadamasa Ueki[2] (1.Department of Earth and Environmental Sciences, College of Humanities & Sciences, Nihon University, 2.Japan Atomic Energy Agency)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[HCG31-06] Retardation of Cs and Sr leachings by geopolymer matrices with zeolte and titanate adsorbent

*Kazuma Kuroda[1], Soonthornwiphat Natatsawas[1], Chaerun Raudhatul Islam[1], Hnin Wint Wint Two[1], Kanako Toda[1], Yutaro Kobayashi[1], Tsutomu Sato[2], Tsubasa Otake[2] (1.Graduate school of Engineering, Hokkaido University, 2.Faculty of Engineering, Hokkaido University)

Uplift estimation in coastal sea area by extrapolation of the land area model and its uncertainty

*Ryuta Hataya[1], Takaomi Hamada[1], Yohei Shimizu[1]

1. Central Research Institute of Electric Power Industry

1. Introduction

The research meeting of the METI in 2015-2016 discussed research issues of geological disposal in the coastal area [1]. After that, we began this study in August 2016[2]. In this study, finally, we’ d like to estimate the downward erosion under the coastal seafloor.

2. Method

We use the conventional method considering the future preliminary investigation for geological disposal siting [2, 3, 4, 5 etc.]. We drew the distribution map of the late Pleistocene uplift in the land using these data. Then, we construct a model of uplift motion after late Pleistocene in three dimensions on the basis of the uplift distribution and extrapolate it to the sea. Next, we have verified the model by discussing the uplift history from the tertiary to the recent. Furthermore, we’ ve discussed uncertainty of the extrapolation of uplift late from the land to the sea by the sensitivity analysis.

3. Case study

We have conducted the case study on the Miyazaki plain, which is known to have terraces widely distributed and the amount of uplift after the late Pleistocene is relatively large.

(1) Basic uplift model

Our basic model of the uplift in the case study area is a flat plate approximation model, which means monotonous tilting in one direction [2].

(2) Verification of uplift model by discussing the uplift history

The geological structure of the Neogene system shows tilting movement in the ESE direction [6]. The geomorphology and geological distribution of Pleistocene suggest tilting movement in the ENE direction. In addition, it is now rotating counterclockwise in North Kyusu district [7]. From these, the tilting direction in the late Pleistocene is considered to be in the ENE direction.

(3) Discussed uncertainty of the extrapolation of uplift late from the land to the sea

In addition to the basic data set, we have created multiple possible data sets reflecting the uncertainty of the survey. These are saved data of some areas from the basic data set, and some data are replaced based on working hypotheses of terrace chronology. We constructed models from each data set and compare the average uplift rate distribution models of the late Pleistocene of coastal sea area. In this examination, the difference in uplift estimation due to the amount of data was larger than the difference of terrace chronology.

4. Summary and future tasks

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Needless to say, the uplift model in the land depends on the data set of the uplift, and discussion on geological history is useful for verification of the model. Also, in this presentation, we showed how to evaluate the effect of uncertainty deriving from data set and models (working hypothesis). We would like to continue case studies.

Acknowledgments:
This study was conducted as a project of the Ministry of Economy, Trade and Industry. Tono Geoscience Centre of Japan Atomic Energy Agency, DIA Consultant and Kawasaki Geological Engineering greatly helped us. For the survey of the sea area, we used the sea acoustic wave exploration records disclosed by the National Institute of Advanced Industrial Science and Technology. We express our deep thanks to their participants.

Reference:
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[7] Earthquake Research Committee, 2018, Long-term evaluation of active faults in the Kyushu area (Ver.1).

Keywords: high level radioactive waste, geological disposal, coastal area, uplift, Quaternary

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Deep groundwater mobility at costal area estimated by groundwater dating

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1. Central Research Institute of Electric Power Industry, 2. The National Institute of Advanced Industrial Science and Technology

On high-level radioactive waste disposal, “Nationwide map of Scientific Features for Geological Disposal” was published and costal area is the favorable from transportation point of view. To evaluate deep groundwater mobility at coastal area, groundwater was sampled from deep borehole at the order of 1000 m in depth. Major ions, tritium, carbon-14, chorine-36 were measured. Based on these results, the groundwaters were categorized into four groups, which are modern meteoric water, modern seawater, glacial meteoric water, fossil sea water. Meteoric water and seawater was divided by 1900 mg/l of Cl concentration. Modern and old groundwater was divided by 10 pMC of ^{14}C concentration. The type of seawaters was well categorized into modern seawater and fossil seawater by ^{14}C concentration because residence times of modern seawater and fossil seawater are quite different. $^{36}Cl/Cl$ of Modern sea water is equivalent to that of present seawater ($\fallingdotseq 0.7\times10^{-15}$), and that of fossil sea water is higher than that of present seawater. It indicates that $^{36}C/Cl$ of fossil seawater influenced by in-situ production, which takes at least a few ten thousand years. Thus, the category of modern seawater and fossil seawater was validated by not only ^{14}C but also ^{36}Cl. Due to the lack of information, which are shallow groundwater and surface investigation, it could not be confirmed that modern meteoric water and glacial meteoric water was categorized by water isotopes and noble gas temperature. However, it is deduced the origin of Cl of meteoric water is from modern seawater and that of glacial meteoric water is from fossil sea water. It is though that the age of mixing water reflects the groundwater age.

As a result, the deep groundwaters at costal area were categorized into modern meteoric water and modern seawater about 40%, glacial and fossil seawater about 60%.

This study was performed under contracts “Development and Improvement on waste disposal system at coastal area” awarded by the Japanese Ministry of Economy, Trade and Industry.

Keywords: groundwater dating, costal area, radioactive isotopes

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Attempt to Estimate permeability of rock mass based on elasticity and resistivity measurement in underground tunnel

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1. Graduate School of Engineering, Kyoto University

Fracture distribution in the rock has a great influence on the groundwater flow. So, it is necessary to grasp its characteristics for resource exploration and geological disposal of radioactive waste. Previous studies have been attempting to grasp the hydraulic characteristics on a local scale using boreholes and the like, but it is considered difficult to grasp the hydraulic characteristics in undrilled areas. In this study, we tried to estimate the permeability of rocks in deep underground from physical property values like resistivity and Young's modulus in order to grasp macroscopic hydraulic characteristics of rock including fracture. The validity of the present estimation method was examined, by comparing this estimated value with the measured value.

The survey area is the research tunnel exposed bedrock (depth 300 m, 500 m) of the Mizunami underground research labolatory of the Japan Atomic Energy Agency, located in Mizunami-city, Gifu Prefecture. In this area, a lot of logging data is published and the fracture distribution in the gallery is also examined in detail.(eg. Ishibashi et al.,2016) Furthermore, permeability of the same rock is measured in 2015 (Sato, 2015). In this study, we measured resistivity using a small electric surveying device (4 pole method with electrode interval of about 10 cm) in addition to these. Young's modulus was measured using a Schmidt-lock hammer.

In this study, the permeability was estimated using a rock physics model. The resistivity was expressed as follows using modified archie’ s law (Katsube and Hume,1983)(1).

$\sigma_{eff}=a\,\sigma_w\,\Phi^m+\sigma_c c$(1)

Where σ_{eff} is electrical conductivity of rock, $a$is toriosity, σ_w is relectrical conductivity of pore water, $\Phi$is porosity, m is cementation factor, σ_c is clay reistivity.The elasticity of rock, was expressed as follows using Gassmann’ s Relation (Gassmann, 1951) added clay effect (2).

$1/K=1/K_m+\Phi/K_w+c/K_c$(2)

Where K is bulk module of rock, K_m is bulk module of mineral, $\Phi$is porosity, K_w is bulk module of pore water, c is clay content, K_c is bulk module of clay. Where K is bulk module of rock, Km is bulk module of mineral, $\Phi$is porosity, Kw is bulk module of pore water, c is clay content, Kc is bulk module of clay. The porosity and the clay content rate were two unknown parameter, and these were determined from the measured values of resistivity and bulk modulus by Nelder-Mead method. Permeability was estimated from Kozeny-Carman's equation (Carman, 1961) for plane crack (3).

$k=\Phi t^2/8\,\tau^2$

k is permeability, $\Phi$is porosity, t is opening width, τ is tortuosity.

Estimated value of pemeability and measured value are consistent with estimated value and error of about one digit in many rock parts.

We will use other rock physics models like unsaturated pore and data obtained from laboratory experiments and loggingdate to further improve the estimation accuracy of permeability.

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Study on relationship between pathway of groundwater and mass transport, and cooling process of granitic rock

*Eiji Sasao[1], Takashi Yuguchi[2], Masayuki Ishibashi[1]

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Fractures in the crystalline rock (e.g. granite) can act as the pathways for groundwater flow and mass transport. Therefore, understanding of the fracture distribution is an important subject for the disposal of high-level nuclear waste. The authors studied the relation between the formation of fracture and infilling mineral, and geological history from the emplacement to present in the Toki granite, Tono district, central Japan (Sasao et al., 2015). Ishibashi et al. (2016a) found that the micropores are selectively formed in plagioclases due to deuteric alteration and that those have the potential of acting as matrix diffusion paths. These results suggest that the magma cooling process played a significant role for the formation and development of the pathways for groundwater flow and mass transport.

The authors studied cooling process of granitic magma in the Toki granite, distributed in the southwestern part of Gifu Prefecture, central Japan, based on petrological, mineralogical and themochronological methodologies. We also discussed the relationship between magma cooling process, and fracture distribution and alteration of biotite and plagioclase (Yuguchi et al., 2019a, 2019b, 2015, 2012, Ishibashi et al., 2016a, 2016b, 2014). In this study, We present the relationship between formation of the pathway of groundwater and mass transport, and cooling process of granitic rock.

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Keywords: granite, cooling process of granitic magma, fracture, micropore

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Fracture characterization in the accretionary complex from the view point of mass transfer

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1. Department of Earth and Environmental Sciences, College of Humanities & Sciences, Nihon University, 2. Japan Atomic Energy Agency

Introduction
As most of the basement rock of Japan is thought to be composed of accretionary complexes (Kano et al., 1998), accretionary prisms should not be ignored for the site selection of geological disposal of high-level radioactive waste. Because of many discontinuous structures such as faults and fractures formed due to the subduction of the plate in the accretionary complex, radioactive materials may migrate in the discontinuous structure together with the groundwater flow. Therefore, it is important to understand the characteristics of the mass transfer in along the discontinuous structure in the accretionary complex. In this study, we have carried out geological observation, permeability test in the laboratory, etc. using the samples containing discontinuous structures in the Neogene and Pre-Neogene accretionary complex (Takeuchi et al. 2018).

The study areas are Chichibu Belt (Akiruno City, Tokyo) for the Pre-Neogene accretionary complex, and Miura Group Misaki Formation (Miura City, Kanagawa Prefecture) for the Neogene accretionary complex. In the Misaki Formation, plain-less fault (Ijiri et al., 1955) in the mudstone are widely distributed. On the other hand, argillaceous matrix rock in the mélange which characterizes the accretionary complex are widely distributed. An optical microscope, scanning electron microscope (SEM) observation, X-ray fluorescence micro-scanner (XGT) analysis, permeability test, etc. have been were carried out using those samples.

2. Neogene accretionary complex

In the Miura Group Misaki Formation exposed to the southern tip of Miura Peninsula, plain-less faults are widely distributed. It was confirmed by SEM observation and XGT observation that there has been no change in the element distribution, although the host rock was granulated due to a cataclastic fracturing in the fault zone (Takeuchi et al. 2018). The porosity of the host rock and faults has been measured using SEM images. As a result of measurement, the porosity in the fault zone is about 1.2%, and that of the host rock is about 2.7%. In addition, hydraulic conductivity of the host rock without plain-less fault and the specimen perpendicular to the plain-less fault is estimated by the permeability test. As a result, the former is about 6 E - 9 (m / s), and in the latter is about 2E - 8 (m / s). This suggests hydraulic anisotropy in the formation with plain-less fault. From the above results, it is expected that a barrier effect on the mass transfer within the area surrounded by the plain-less fault.

3. Pre-Neogene accretionary complex

As a result of observation of thin sections, scaly cleavage due to shear deformation can be observed in the mudstone. In addition, concentrations of Fe have been confirmed along the cleavage from the XGT analysis. The concentration of Fe (the count number of XGT analysis) perpendicular to the cleavage shows almost restricted to the cleavage part, and diffusion has not been observed in the adjacent area. As a result of permeability test in the laboratory, the hydraulic conductivity parallel to the cleavage is estimated

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about 4E - 8 (m / s), on the other hand, that perpendicular to the cleavage is about 2.5 E-8 (m / s). From the result above, it is assumed that faint hydraulic anisotropy exists in the mudstone matrix part. The reason for the small difference in hydraulic conductivity is thought to be connectivity of the curvature scaly cleavage or the weathering at the surface.

From the above results, it is considered that cleavage planes in the mudstone matrix can be selective migration pathways for mass transfer.

4. Summary

From this study, we have constructed a conceptual model showing the characteristics of material transfer in discontinuous structures in Neogene and Pre-Neogene accretionary complex. In the future, we have to improve the conceptual model from the mass transfer point of view properly by using deeper samples.

Keywords: Geological disposal, Accretionary complex, Neogene, Pre-Neogene, Mass transfer

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Retardation of Cs and Sr leachings by geopolymer matrices with zeolte and titanate adsorbent

*Kazuma Kuroda[1], Soonthornwiphat Natatsawas[1], Chaerun Raudhatul Islam[1], Hnin Wint Wint Two[1], Kanako Toda[1], Yutaro Kobayashi[1], Tsutomu Sato[2], Tsubasa Otake[2]

1. Graduate school of Engineering, Hokkaido University, 2. Faculty of Engineering, Hokkaido University

After the accident at the Fukushima Daiichi Nuclear Power Station (FDNPS) that occurred due to the Tohoku big earthquake in 2011, contaminated water with radioactive nuclides such as cesium (Cs) and strontium (Sr) have been continuously generated due to cooling of fuel debris by water. Zeolite or titanate adsorbents have been used for removing Cs or Sr from the contaminated water. The spent adsorbents would probably be solidified for the safety storage and disposal. Glass and cement have been proposed for solidifying binder. However, they have some disadvantages such as generation of secondary radioactive waste during vitrification and large amount of waste volume limited by bigger free water volume. Recently, geopolymer is considered as new binder which has potential to solve the above disadvantages for safety disposal of the spent adsorbent. Geopolymer has the potential to decrease total volume of solidified substances comparing cement because amount of containing free water is less than that containing cement. Primary phases of geopolymer such as calcium silicate hydrate (C-S-H) or potassium alumino silicate hydrate (K-A-S-H) may have property for sorbing radioactive nuclides. Furthermore, it is possible to obtain the desirable phases by changing the type and ratio of the starting materials. So, the appropriate primary phases could be designed depending on the type of the radioactive nuclide in disposed radioactive waste. However, there are few data about leaching behavior of radioactive nuclides from geopolymer in real disposal condition. In this context, this study was conducted leaching and sorption experiments to understand the leaching behavior from geopolymer with zeolite or titanate containing Cs or Sr.

In this study, geopolymer samples from mixing of KOH, metakaoline and water glass were investigated in leaching experiments. From the leaching experiments of Cs and Sr from geopolymer with titanate, most of Sr was tightly remained after 90 days even without titanate. This means that K-A-S-H matrix formed after the mixing has high capacity for Sr storage. On the other hand, small part of Cs (around 4%) was leached out after 90 days. However, although it is well known that Cs and Sr are easily leached out from cement matrix (A. El-Kamash, et al., 2006, and M. Takaoka, et al., 2015), K-A-S-H matrix is better in terms of Cs and Ss storage. From sorption experiments of Cs and Sr by using powder C-S-H and K-A-S-H samples as matrix components of cement and geopolymer, it is cleared that K-A-S-H has higher sorption capacity than that of C-S-H. From desorption experiment of Cs and Sr using deionized water from the C-S-H and K-A-S-H, it is cleared that almost of Cs was desorbed from C-S-H even for one day, while 90% of Cs was remained in K-A-S-H under the same condition. Consequently, K-A-S-H matrix in geopolymer has higher retention capacity than that of C-S-H matrix in cement. We conducted safety assessment for geopolymer and cement waste form in pit type disposal system using leaching ratio obtained in this study. From results of the assessment, K-geopolymer would be applicable for safety encapsulation and disposal of Cs and Sr as waste form.

Keywords: Geopolymer, Disposal of radioactive waste, Potassium almino silicate hydrate, Calcium silicate hydrate

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[J] Oral | H (Human Geosciences)：H-CG Complex & General

Thu. May 30, 2019 10:45 AM - 12:15 PM JST | Thu. May 30, 2019 1:45 AM - 3:15 AM UTC | 101 1F

[H-CG31] Nuclear Energy and Geoscience

convener:Eiji Sasao(Tono Geoscience Center, Japan Atomic Energy Agency), Ryuta Hataya(Central Research Institute of Electric Power Industry), Shinji Takeuchi(Department of Earth and Environmental Sciences, College of Humanities & Sciences, Nihon University), Chairperson:Shinji Takeuchi

Handling of geological hazard assessments represent a major environmental concern in the modern society due to constructing nuclear facilities and their radioactive wastes, and also related to the management of contaminated biosphere after nuclear disasters of Fukushima-Daiichi Nuclear Power Plant. The session rational is to provide a forum to deal with various aspects of scientific and engineering aspects of nuclear power. The session in this year focuses on radioactive waste disposal and covers not only scientific aspect such as characterization of geological environment but also engineering aspects such as microbe-nuclide, mineral-water, and cement-water interactions. In addition to this, themes on seismic hazards at nuclear facilities, environmental behavior of radionuclides emitted from disabled nuclear plants, and volume reduction and reuse of cesium contaminated soils are welcomed. Through these presentations, we aim to promote intercultural communication and collaboration between science, engineering and social science.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[HCG31-07] Focus points of post-closure monitoring in geological disposal

*Hiroaki Murakami[1], Yusuke Watanabe[1], Kenji Fukuda[1], Teruki Iwatsuki[1] (1.Japan Atomic Energy Agency)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[HCG31-08] 5 years monitoring results for the environmental dynamics of radiocesium in mountainous forest of the Abukuma Mountains, Fukushima

*Tadafumi Niizato[1], Takayoshi Watanabe[1], Yoshito Sasaki[1], Katsuaki Mitachi[2], Satomi Ito[1], Hironobu Abe[1] (1.Japan Atomic Energy Agency, 2.ATOM TRANSPORT SERVICE CO., LTD)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[HCG31-09] Problems of geological disposal based on the contaminated water issues at Fukushima Daiichi NPS

*Naoaki Shibasaki[1] (1.Fukushima University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[HCG31-10] Examination of "Nationalwide Map of Scientific Features" for HLRW geological disposal in case of Niigata Prefecture and fundamental problems in the fair discussion on this task

*Junji Akai[1], Ryuichiro Ohno (1.Emeritus Professor of Niigata University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[HCG31-11] Problems of the "Nationwide Map of Scientific Features for Geological Disposal" in Saitama prefecture and storage method of High-level Radioactive Waste (HLW)

*Kazuaki SEKINE[1], Kazuyuki SUENAGA[2], Tadao KOBAYASHI (1.Saitama Prefectural Chichibu High School, 2.SUENAGA Environmental Geology)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

Discussion

Focus points of post-closure monitoring in geological disposal

*Hiroaki Murakami[1], Yusuke Watanabe[1], Kenji Fukuda[1], Teruki Iwatsuki[1]

1. Japan Atomic Energy Agency

To understand geological-environment stability at the deep underground, it is important to understand the hydrochemical disturbance process and its recovery process due to construction, operation and closure of the underground facility. Monitoring after closure of underground facility is effective method to understand the EdZ recovery process, however few studies have been reported on post-closure monitoring. We considered about focus points of post-closure monitoring by using hydrochemical data of groundwater in/around Mizunami Underground Research Laboratory.

As the groundwater level declined due to the construction and operation of the Mizunami URL, mixing of deep high-salinity groundwater and shallow low-salinity groundwater occurred in the monitoring section of conglomerate layer. In this section, groundwater flow will change again as water pressure recovers after closure of the Mizunami URL. Therefore, we should extract hydrogeologically important sections such as the conglomerate layer and select it as the observation section of post-closure monitoring.

Keywords: Groundwater, Closure of underground facility, monitoring

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5 years monitoring results for the environmental dynamics of radiocesium in mountainous forest of the Abukuma Mountains, Fukushima

*Tadafumi Niizato[1], Takayoshi Watanabe[1], Yoshito Sasaki[1], Katsuaki Mitachi[2], Satomi Ito[1], Hironobu Abe[1]

1. Japan Atomic Energy Agency, 2. ATOM TRANSPORT SERVICE CO., LTD

An understanding of long-term environmental dynamics of radiocesium, which is released by the TEPCO’s Fukushima Dai-ichi Nuclear Power Plant accident, is a key issue for predicting the future radiocesium distribution and forest products radioactivity in a forested environment, especially ^{137}Cs with half-life of 30 years. We compiled the five-years monitoring results of radiocesium input-output budgets in broad-leaved deciduous forests and Japanese cedar evergreen forests of the Abukuma Mountains, Fukushima, Japan. The input-output rates were a few percent of the radiocesium inventory of the monitoring site. In addition, both rates have been decreasing with time. Belowground radiocesium occupied 90% of the total inventory in the Japanese cedar forest on October 2015. The belowground radiocesium was distributed mainly in the topsoil of 0-6 cm depth, approximately 70-80% of the underground inventory on August 2016. These results indicate that the distribution of radiocesium in the forest is similar to the distribution of tree rootlet responsible for absorption of inorganic elements, nutrients, and water. This means long residence time of radiocesium in rooting zone. In the condition of the limited amount of radiocesium input-output rates in the forest, estimation of the migration flux of radiocesium from forest floor to the forest products are considered to be most important issues in the present.

Keywords: TEPCO’s Fukushima Dai-ichi Nuclear Power Plant accident, radiocesium, input-output budgets, mountainous forest

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Problems of geological disposal based on the contaminated water issues at Fukushima Daiichi NPS

*Naoaki Shibasaki[1]

1. Fukushima University

The contaminated water issues at the Fukushima Daiichi Nuclear Power Station (NPS) have not been solved yet even after 8 years since the severe nuclear accident. Many countermeasures against the issues have been implemented, however, the groundwater bypass and frozen soil wall are not effective as expected. This is due to lack of investigations and understanding on the complex geology and hydrogeology at the site. Based on the experience, the author examined the Nationwide Map of Scientific Features for Geological Disposal published in July 2017 by the Ministry of Economy, Trade and Industry, Japan. The map does not show detailed information on groundwater and hydrogeology. The author presents crucial points for geological disposal from the viewpoints of hydrogeology and groundwater flow system.

Keywords: Fukushima Daiichi NPS, contaminated water issues, groundwater, geological disposal, Nationwide Map of Scientific Features for Geological Disposal

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Examination of "Nationalwide Map of Scientific Features" for HLRW geological disposal in case of Niigata Prefecture and fundamental problems in the fair discussion on this task

*Junji Akai[1], Ryuichiro Ohno

1. Emeritus Professor of Niigata University

" Natinalwide Map of Scientific Features" for HLRW geological disposal in Niigata Prefecture region was critically examined from the standpoint of geoscience. Furthermore, Fundamental problems on the fair process of discussion of this task are discussed.

Keywords: High Level Radioactive Waste (HLRW), Nationalwide Map of Scientific Features, Niigata, Fundamental problem, unscientific, fair discussion

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Problems of the "Nationwide Map of Scientific Features for Geological Disposal" in Saitama prefecture and storage method of High-level Radioactive Waste (HLW)

*Kazuaki SEKINE[1], Kazuyuki SUENAGA[2], Tadao KOBAYASHI

1. Saitama Prefectural Chichibu High School, 2. SUENAGA Environmental Geology

The "Nationwide Map of Scientific Features for Geological Disposal" was announced by the Agency for Natural Resources and Energy in 2017. Candidate sites for suitable places and inappropriate places for geological disposal are shown by each color. In Saitama prefecture, the linear yellow part extending from the northwest end to the southeast direction is the most prominent unsuitable place. Other areas are mostly suitable.

In the northern part of Saitama Prefecture, there is the Kanto Plain Northwest Rim Fault Zone. The main one is the fault zone represented by the Fukaya fault and the fault zone represented by the Ayasegawa fault. This fault zone is evaluated as follows. The dip is southwest inclination of 50 ˚to 70 ˚(depth less than 500 m) , the width is about 20 to 25 km, the average slip speed is 20 to 40cm / 1,000 years, The latest activity period is after 6,200 years ago, before about 2,500 years ago. When this fault caused an earthquake, the predicted seismic intensity is the maximum magnitude 8.0 (The Headquarters for Earthquake Research Promotion Committee,2005).

The length of the Fukaya fault system is about 80 km (Sugiyama, 2000). According to the criteria of the "Nationwide Map of Scientific Features for Geological Disposal", since the inappropriate place related to the active fault is one hundredth of the length of the fault, the width of the inappropriate area of the Fukaya fault system is about 800 m. Since there is a possibility that the dip of the fault plane is 50 ˚, considering the horizontal spread, there is no sufficient basis for the width of the inappropriate area.

The depth of the epicenter of the earthquake caused by the Fukaya fault and the Ayasegawa fault is estimated to be 17 to 19 km and the magnitude of the earthquake is to be the maximum magnitude of 8.0. The area with seismic intensity of 7 is distributed in Honjo City, Yoshimi Town, etc. Also the intensity 6 is expected to be distributed in wide area in the prefecture. These areas are much wider than the areas that are regarded as inappropriate in the "Nationwide Map of Scientific Features for Geological Disposal". Since the depth of the epicenter is expected to be 17 to 19 km, there is a high possibility that a wide area suffers a strong shake.

Since the geological disposal site could be kept for more than tens of thousands of years, there is a possibility that a new active fault will destroy the site. As a result, the radioactive material leaks out and it is possible that it can be carried to the ground by groundwater. It is pointed out that groundwater flow is the most important requirement for geological disposal of radioactive waste (IAEA, 1977) , but the matter of groundwater flow is not reflected in the " Nationwide Map of Scientific Features for Geological Disposal ". Since the behavior of groundwater is not well understood in deep underground, classification of suitable sites by the "Nationwide Map of Scientific Features for Geological Disposal" requires detailed study of groundwater.

As the "Nationwide Map of Scientific Features for Geological Disposal" has many problems, construction

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of the geological disposal site is not carried out until sufficient safety and understanding of the people are obtained, and it is appropriate to temporarily keep the radioactive waste on the ground etc. (Science Council of Japan, 2012). It seems necessary to seriously consider options other than geological disposal.

Keywords: Nationwide Map of Scientific Features for Geological Disposal, Kanto Plain Northwest Rim Fault Zone, groundwater, storage method

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[J] Oral | H (Human Geosciences)：H-CG Complex & General

Thu. May 30, 2019 3:30 PM - 5:00 PM JST | Thu. May 30, 2019 6:30 AM - 8:00 AM UTC | 202 2F

[H-CG34] Education and research for rehabilitation of agriculture against harmful rumors in nuclear disaster areas

convener:Masaru Mizoguchi(Graduate school of Agricultural and Life Sciences, The University of Tokyo), Chairperson:Masaru Mizoguchi(The University of Tokyo), Kousuke Noborio(School of Agricultural Science, Meiji University)

Since the eastern Japan earthquake, various universities are carrying out educational programs that take students to the field and let the students recognize the importance of picking up on-site needs from the real field. This session convener also went to Iitate Village in Fukushima Prefecture three months after the nuclear accident, and continues a unique activities in cooperation with NPO and farmers. In this session, university's teachers will report changes in student's consciousness observed through on-site education and field research, and discuss social value of university.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[HCG34-01] Education and research for rehabilitation of agriculture against harmful rumors in nuclear disaster areas

*Masaru Mizoguchi[1] (1.Graduate school of Agricultural and Life Sciences, The University of Tokyo)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[HCG34-02] Towards the reborn of Iitate village 'Agriculture'

★Invited Papers

Makoto Sugisoka[2], *Masaru Mizoguchi[1] (1.Graduate school of Agricultural and Life Sciences, The University of Tokyo, 2.Division of Reconstruction Measures, Iitate Village)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[HCG34-03] Difference among crop species by radiocesium absorption from different soil fractions

*Nihei Naoto[1], Yoshimi Ohmae[1], Makoto Furukawa[1], Syuichiro Yoshida[1] (1.The University of Tokyo, Graduate School of Agricultural and Life Sciences)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[HCG34-04] Wild vegetables and mushrooms retrieving agriculter in Iitate Village, Fukushima Prefecture

*Kosuke Noborio[1], Yudai Fukuyama[2], Satoko Fujita[1], Hiroaki Sugino[2], Masaru Mizoguchi[2] (1.Meiji University, 2.the Univewrsity of Tokyo)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[HCG34-05] Effect of Study Tour toward Participants' Attachment on the Study Site - Case Study of University Student Tour to
Iitate Village, Fukushiima Prefecture -

*Natsumi Ebitani[1], Masaru Mizoguchi[1], Hiroaki Sugino[1] (1.Graduate school of Agricultural and Life Sciences, The University of Tokyo)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

Discussion

Education and research for rehabilitation of agriculture against harmful rumors in nuclear disaster areas

*Masaru Mizoguchi[1]

1. Graduate school of Agricultural and Life Sciences, The University of Tokyo

Since the eastern Japan earthquake of 2011, various universities are carrying out educational programs that take students to the field and let the students recognize the importance of picking up on-site needs from the real field. This session convener also went to Iitate Village in Fukushima Prefecture three months after the nuclear accident, developed a unique agricultural land decontamination method in cooperation with NPO corporations and farmers, and has been experimentally cultivating crops. Also, since 2012, we have held students' field tours and have witnessed changes in student's awareness before and after the local visit. Through these experiences, we have come to the idea that it is necessary to nurture young people who will challenge the creation of a new Japanese type agriculture in Fukushima. "Educational research program for revitalizing agriculture and elimination of bad rumor in Iitate village" is being carried out at the Ministry of Education, Culture, Sports, Science and Technology's "Fukushima Innovation Coast Concept Promotion Project. In this session, members of the Japanese Society of Soil Physics will report changes in student’s consciousness observed through on-site education and field research, and discuss social value of university.

Keywords: nuclear disaster, agriculture reborn, against harmful rumor

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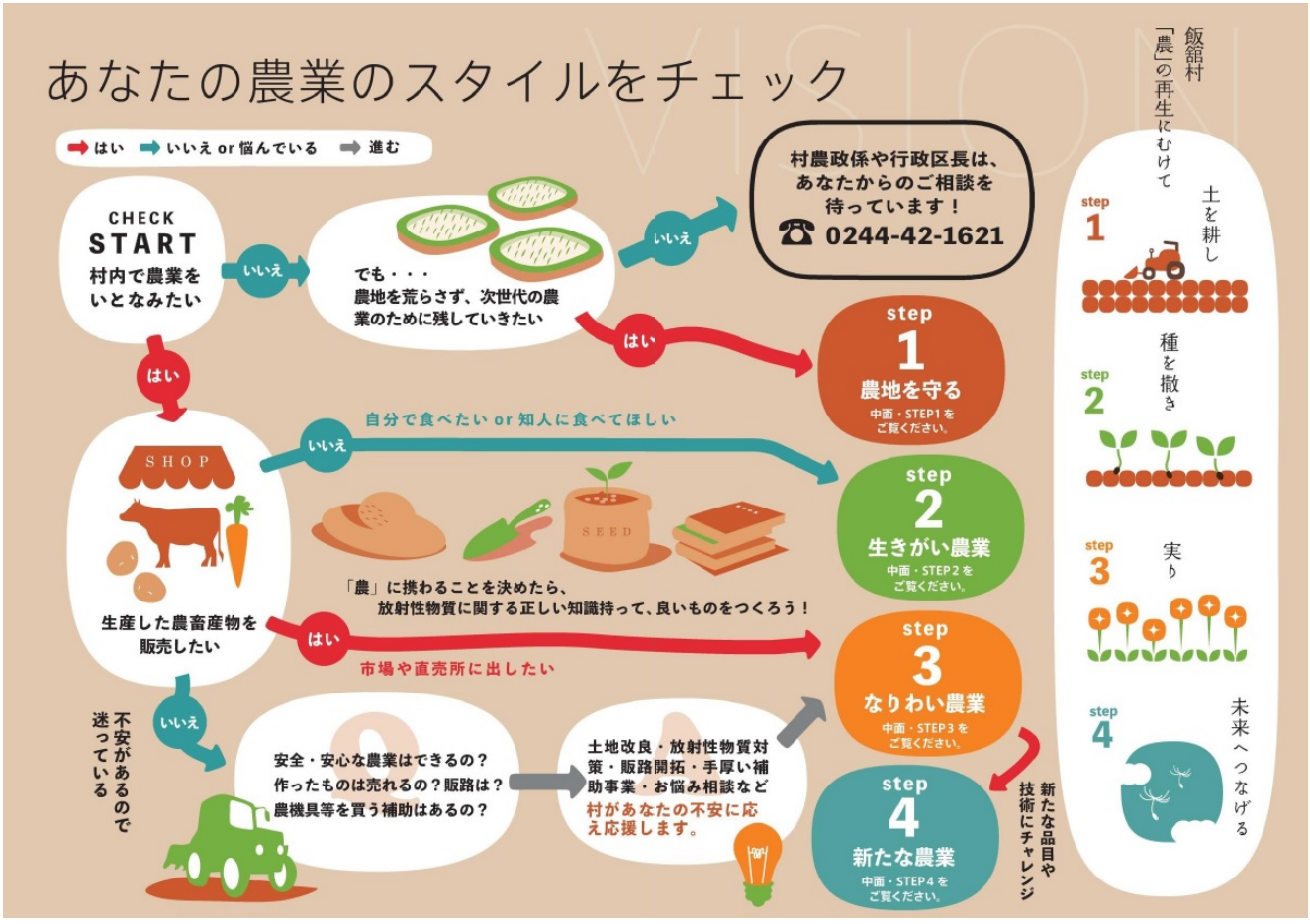
Towards the reborn of Iitate village 'Agriculture'

Makoto Sugisoka[2], *Masaru Mizoguchi[1]

1. Graduate school of Agricultural and Life Sciences, The University of Tokyo, 2. Division of Reconstruction Measures, Iitate Village

In Iitate Village where all villagers were evacuated due to the accident of TEPCO Fukushima Daiichi Nuclear Power Plant, evacuation order were canceled in March 2017 except for some areas. Because of lack of living environment and anxiety about radioactivity in the environment, the number of people who actually settle in Iitate village is less than 10%. However, the Iitate Village Office has proposed four agricultural plans (For protecting agricultural lands, For fun-to -live, For livelihood, For challenging new agriculture) according to the wishes of farmers, and is striving for the revival of "agriculture". In this presentation, I will introduce such efforts.

Keywords: Iitate Village, agriculture, reborn



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Difference among crop species by radiocesium absorption from different soil fractions

*Nihei Naoto[1], Yoshimi Ohmae[1], Makoto Furukawa[1], Syuichiro Yoshida[1]

1. The University of Tokyo, Graduate School of Agricultural and Life Sciences

Radioactive cesium (137 Cs) contaminated widely due to Fukushima Daiichi Nuclear Power Plant accident. The presence form of 137 Cs in soil can be divided into a fraction (adsorbed to ion exchange state or organic matter, defined as f 1 fraction) which crops are considered to be easy to absorb and utilize, and the another fraction (strong acid extraction and total decomposition component by hydrofluoric acid, defined as f2 fraction) which crops are considered to be difficult to absorb and utilize.

If we know how much 137 Cs will be absorbed from which soil fraction, we can grasp the Cs absorption characteristics of a crop. However, there has been no research report on a method showing 137 Cs absorption from each soil fraction. In this study, to grasp the soil fraction absorbing 137 Cs of the crop, the transfer factor (defined as TFf 1 and TFf 2) from each soil fraction were investigated by using the naturally occurring stable isotope cesium (133 Cs) . In addition, absorption ratios (defined as λ 1 and λ 2) in crops derived from each soil fraction were calculated.

Soybean, buckwheat and rice were cultivated for 30 days in a pot, and the 133 Cs and 137 Cs concentrations in the aerial part were measured. Contaminated soil (137 Cs approx 22 kBq / kg, 133 Cs approx. 3.4 mg / kg) obtained by topsoil stripping due to decontamination in Fukushima prefecture was used for soil. The soil after cultivation was successively extracted (ammonium acetate extraction, hydrogen peroxide decomposition, nitric acid decomposition, total decomposition by hydrofluoric acid), and the concentrations of 133 Cs and 137 Cs contained in each fraction were measured. In order to simplify the calculation, the soil fraction was set to two fractions of f1 (ammonium acetate extraction, hydrogen peroxide decomposition) and f2 (nitric acid decomposition, total decomposition by hydrofluoric acid). Measurement of 133 Cs was measured by ICP mass spectrometer (Perkin Elmer, Nex ION 350 S), measurement of 137 Cs by NaI scintillation counter (Perkin Elmer, Wizard). Judgment of each soil fraction absorbed by crops was calculated by 133 Cf 1 ×TFf 1 + 133 Cf 2 ×TFf 2 = 133 Ccrops, 137 Cf 1 ×TFf 1 + 137 Cf 2 ×TF f 2 = 137 Ccrops.

Cf1 or Cf2 is the Cs concentration of the soil in f1 or f2 fraction, TFf1 or TFf2 is Cs transfer factor from f1 fraction or f2 fractionation soil to crop, and Ccrop shows Cs concentration of crop.

TFf 1 and TFf 2 were different depending on the crop, soybean had higher absorption from f 2 fraction than buckwheat. Absorption from f1 fraction in 137 Cs of crops was 66% for soybean, 89% for buckwheat, 76% for rice, confirming the difference between crops. Furthermore, the effect of suppressing Cs absorption by potassium fertilization was shown to be different for each crop. By devising and defining these indices, it was possible to grasp the absorption capacity of crops.

Keywords: Radiocesium, soil fraction, soybean

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Wild vegetables and mushrooms retrieving agriculter in Iitate Village, Fukushima Prefecture

*Kosuke Noborio[1], Yudai Fukuyama[2], Satoko Fujita[1], Hiroaki Sugino[2], Masaru Mizoguchi[2]

1. Meiji University, 2. the Univewrsity of Tokyo

Wild vegetables and mushroom at mountaineous slopes could be key agricultural products in Iitate Village in the future. Radiocesium fallout from the Fukushima Daiichi Nuclear Powerplant contaminated surface soils in its vicinities. Removal of contaminated surface soils was recently completed in agricultural fields, but not in forest areas where wild vegetables and mushrooms were grown. Pine mushroom is one of the precious wild mushrooms in Japan because it has not been successfully grown under controlled environments. We thought pine mushroom could be a key agricultural product for retrieving agriculture in Iitate Villege. Soil and air temperatures in a litter layer were measured to know environmental condidition of growing pine mushroom. We report the preliminary results of the environmental conditions.

Keywords: pine mushroom, sensing environmental factors, soil environment

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Effect of Study Tour toward Participants' Attachment on the Study Site - Case Study of University Student Tour to Iitate Village, Fukushiima Prefecture -

*Natsumi Ebitani[1], Masaru Mizoguchi[1], Hiroaki Sugino[1]

1. Graduate school of Agricultural and Life Sciences, The University of Tokyo

Reconstruction in the affected areas of the Great East Japan Earthquake is progressing, but now there have been many people who feel less interested in understanding of the current situation and remained damage. In order to advance the further development after the basic reconstruction with lessons learned from the disaster, it is necessary to communicate the charm of the area to people outside of the affected area and make opportunities for rural exchange. Therefore, the authors are considering regularly holding study tours to the affected area. This presentation introduces a one-night two-day study tour as a case study for Iitate Village in Fukushima Prefecture held three times from October to November 2018. Before and after the tour, we conducted a questionnaire survey on a total of 44 participants (university students) who are mainly majoring in agriculture, and analyzed the obtained data by co-occurrence network analysis and factor analysis. In the end, this study discusses the effect of the tour on students' attachment to the tour site, and examined how future study tours should be.

Keywords: study tour, rural exchange, place attachment

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Thu. May 30, 2019 1:45 PM - 3:15 PM JST | Thu. May 30, 2019 4:45 AM - 6:15 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-SS12] Crustal Structure

convener:Kazuo Nakahigashi(Tokyo University of Marine Science and Technology), Chairperson:Yoshio Murai(Hokkaido University), Genti Toyokuni(東北大学)

The aim of this session is to cover seismological and geophysical studies on the Earth's crust. Contribution on seismological and geophysical structure of the crust, processes that develop in the crust which include earthquakes, volcanoes and geological descriptions of the crust are welcomed. We also welcome theoretical and methodological studies that will serve as basics in such explorations.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SSS12-01] Shrinking and draining continental lower crust: its binary effects of stress and fluid on crustal activities

*Takehito Koyama[1] (1.Institute of Industrial Science, the University of Tokyo)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SSS12-02] Seismic velocity structure in southern Hokkaido deduced from ocean-bottom seismographic and land observations

*Yoshio Murai[1], Kei Katsumata[1], Tetsuo Takanami[2], Tomoki Watanabe[3], Tadashi Yamashina[4], Ikuo Cho[5], Masayuki Tanaka[6], Ryosuke Azuma[7] (1.Institute of Seismology and Volcanology, Faculty of Science, Hokkaido University, 2.Department of Terrestrial Magnetism, Carnegie Institution of Washington, 3.Marine Works Japan LTD, 4.Kochi University, 5.National Institute of Advanced Industrial Science and Technology, 6.Meteorological Research Institute, 7.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SSS12-03] Structural Complexity Associated with Arc-Arc Collision in Hokkaido Island, Japan - Review on Controlled-Source Seismic Researches in Western and Central Hokkaido -

★Invited Papers

*Takaya Iwasaki[1], Noriko Tsumura[2], Tanio Ito[3], Kazunori Arita[4], Hiroshi Sato[1] (1.Eathquake Research Institute, the University of Tokyo, 2.Graduate School of Science, Chiba University, 3.Association for the Development of Earthquake Prediction, 4.Hokkaido Research Center of Geology)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SSS12-04] Seismic imaging of the eastern Japan forearc region using S-net data

*Genti Toyokuni[1], Dapeng Zhao[1], Naoki Uchida[1], Takashi NAKAYAMA[1] (1.RCPEVE, Tohoku Univ.)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SSS12-05] The relationship between the location of the mid crustal reflector and seismicity in Iwaki area, northeastern Japan

*Takashi Iidaka[1], Shin'ichi Sakai[1], Toshihiro Igarashi[1], Kazushige Obara[1], Aitaro Kato[1], Tetsuya Takeda[2], Shigeki Nakagawa[1] (1.Earthquake Research Institute, University of Tokyo, 2.National Research Institute for Earth Science and Disaster Resilience)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SSS12-06] Abnormal Seismic Anisotropy beneath the Tokyo Metropolitan Area (1) Mantle of the Philippine Sea Slab

*Motoko Ishise[1], Shin'ichi Sakai[1], Aitaro Kato[1], Shin Aoi[2], Makoto MATSUBARA[2] (1.Earthquake Reseach Institute, University of Tokyo, 2.National Research Institute for EarthScience and Disaster Resillience)

Shrinking and draining continental lower crust: its binary effects of stress and fluid on crustal activities

*Takehito Koyama[1]

1. Institute of Industrial Science, the University of Tokyo

Basically, the continental crust itself is presumed to be static passive polycrystalline rocks with its ductility in the aseismic deep. However, this ductility seems difficult to explain crustal activities still debated: not only the long-standing stability (the resistivity to the isostatic decay) but also the short-term activities, e.g., inland horizontal compressive state (Zoback, et al. (1989)), intracrustal seismicity (Calais, et al. (2016)), and rare lower crustal earthquakes (Simpson (1999)).

Then, can we rethink the crust, especially its controversial lower? Actually, I presented a possibility of the shrinking and draining of the continental crust through “phase separation or phase demixing” at JpGU in 2012. Thus, I will propose a new lower crust causing the deformation, qualitatively but comprehensively discussing the activities.

As basic components of the lower crust, I consider SiO_2 and H_2O (with other elements and volatiles). Their melt mixtures cause phase separation under lower crustal temperatures and pressures (Kawamoto (2006), Hack, et al. (2007)). Furthermore, melt SiO_2 forms 3-dimensional macromolecular network (Stebbins (2016)). Thus, I regard this process as the volume shrinking of this elastic SiO_2 network separating from an aqueous fluid (Tanaka (2012), Koyama, et al. (2009), Koyama and Tanaka (2018); also the shrinking SiO_2 in Tognonvi, et al. (2011)): This network macroscopically behaves as a phase-separating glass (before crystallization) or an elastically hard self-squeezing wet sponge.

Then, the new lower crust, constructed by the shrinking SiO_2 network draining the H_2O fluid, combines and interacts with the usual upper crust (Figure): The elastic shrinking laterally compress the upper crust from below, bringing the long-term stability and intermittent drained-fluid injections triggering the intra-upper-crustal earthquakes. Importantly, this lower crust, aiming at shrinking, must follow some degree of external compression: the aseismicity or the apparent ductility. However, when the elastic SiO_2 network suffers a large local differential stresses under the stress/fluid interlayer interactions, the brittleness should arise as lower crustal seismicity.

Therefore, assuming the lower crust to be not monistic solid but dualistic solid/fluid coexisting during their phase separation, we can qualitatively explain the crustal movements using the actively shrinkable/drainable lower crust mechanically/materially interacting with the upper crust.

Keywords: Continental crust, Stability, Stress, Seismicity, Phase separation

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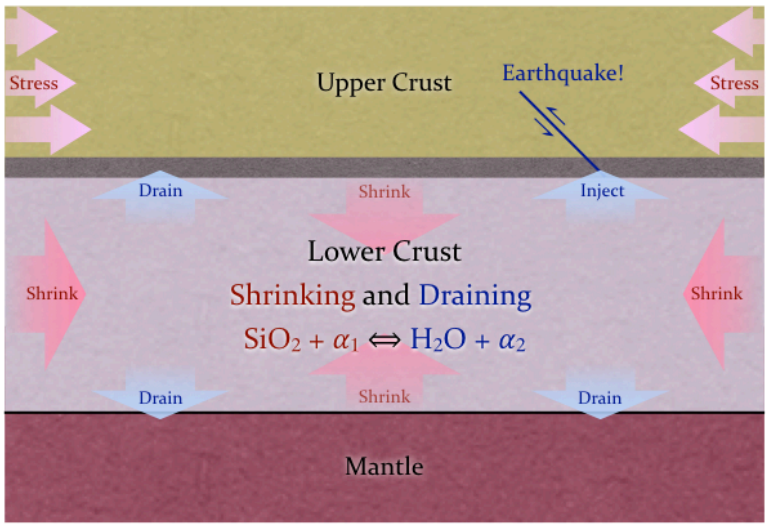


Figure: Self-squeezing lower crust mechanically and materially affecting the static and passive upper crust above.

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Seismic velocity structure in southern Hokkaido deduced from ocean-bottom seismographic and land observations

*Yoshio Murai[1], Kei Katsumata[1], Tetsuo Takanami[2], Tomoki Watanabe[3], Tadashi Yamashina[4], Ikuo Cho[5], Masayuki Tanaka[6], Ryosuke Azuma[7]

1. Institute of Seismology and Volcanology, Faculty of Science, Hokkaido University, 2. Department of Terrestrial Magnetism, Carnegie Institution of Washington, 3. Marine Works Japan LTD, 4. Kochi University, 5. National Institute of Advanced Industrial Science and Technology, 6. Meteorological Research Institute, 7. Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University

The Kuril arc collides with the northeast Japan arc in the southern part of Hokkaido, Japan. Such a collision results in building the Hidaka Mountains and is related to the seismic activity and large earthquake occurrence such as the Urakawa-Oki earthquake (Ms 6.8) on March 21, 1982. It is important to image the three-dimensional crustal structure in order to clarify the collision tectonics and understand the patterns of earthquake occurrence and the mechanism of large earthquake occurrence. A group of seismologists from eleven universities operated a dense temporary network of land stations from 1999 to 2001 in and around the Hidaka Collision Zone [Katsumata *et al.* (2002, Bull. Earthq. Res. Inst., **77**)]. In addition, we conducted ocean-bottom seismographic observations in 1999 and 2000 in the south off Hokkaido region. Murai *et al.* (2003, GRL **30**) estimated P-wave velocity (Vp) structure by the 3-D tomographic inversion [Zhao *et al.* (1992, JGR **97**)] of seismic travel time data obtained from networks of ocean-bottom seismographs (OBSs) and land stations in 1999. However, their spatial resolution was poor for the deep crustal structure and they could not obtain S-wave velocity (Vs) structure because of limitation of the number of data. Murai *et al.* (2016, JpGU) estimated structure of both Vp and Vs by the tomographic inversion of travel time data from OBSs and land stations in 1999 and 2000. We found a problem in the reduction of the travel time residuals due to errors of station corrections in their analysis. Here we estimate Vp and Vs structure again after correcting their errors.

The results from the tomographic analysis are as follows.

1. A high-velocity body seems to be obducted toward the crest of the Hidaka Mountains from east beneath the land area, which is interpreted as the obducted lower crust of the Kuril arc. The high-velocity region extends to the east of the Hidaka Mountains at depths of 15-35 km. A low-velocity region is located to the west of the Hidaka Mountains so as to contact with the high-velocity region at the Hidaka main thrust. It is interpreted as the northeast Japan arc. These results are consistent with those obtained by previous tomographic studies.

2. We found a distinct low velocity region dipping southwestward from beneath the Hidaka Mountains to the source area of the 1982 Urakawa-oki earthquake at depths of 35-45 km which was imaged only by the tomographic analysis using the data from OBSs. It is interpreted as the lower part of the delaminated Kuril arc lower crust, which has an area of about 50 km wide by 50 km long.

3. The colliding low-velocity crustal material disappears in the southeast of Cape Erimo. Moreover many microearthquakes occurred in the low-velocity region whereas the seismic activity was low outside it. These results suggest the effect of arc-arc collision is reduced abruptly in the offshore area as the southeastward extension of the Hidaka Mountains.

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4. The hypocenter of the 1970 Hidaka earthquake (M 6.7) is located at the boundary between the high and low velocity regions. The fault plane of the 1982 Urakawa-oki earthquake is located at the western boundary of the high Vp anomaly faster than 8.0 km/s. Thus these M7 class inland earthquakes occurred at material boundaries, which is consistent with Kita *et al.* (2012, JGR **117**).

5. The overriding plate above the seismogenic asperity of the 2003 Tokachi-oki earthquake (M 8.0) is characterized by high Vp/Vs on the northeast side of Cape Erimo. This result is consistent with Machida *et al.* (2009, Tectonophysics **465**).

Acknowledgments
We thank the crew of the R/V Kofu Maru of the former Hakodate Marine Observatory for their cooperation during deployment of OBSs. We thank D. Zhao for permitting us to use his computer program for 3-D tomographic inversion.

Keywords: ocean-bottom seismograph (OBS), seismicity, tomography, Hidaka Collision Zone, delamination, Hokkaido

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Structural Complexity Associated with Arc-Arc Collision in Hokkaido Island, Japan - Review on Controlled-Source Seismic Researches in Western and Central Hokkaido -

*Takaya Iwasaki[1], Noriko Tsumura[2], Tanio Ito[3], Kazunori Arita[4], Hiroshi Sato[1]

1. Eathquake Research Institute, the University of Tokyo, 2. Graduate School of Science, Chiba University, 3. Association for the Development of Earthquake Prediction, 4. Hokkaido Research Center of Geology

Hokkaido Island has a complicated crustal structure reflecting subduction, accretion and collision processes from Late Jurassic to the present (e.g. Niida and Kito, 1986; Kimura, 1986; Ueda 2016). Central Hokkaido is composed of almost N-S trending geological units of the Sorachi-Yezo Belt (SYB), Hidaka Belt (HB) and Tokoro Belt (TB) from west to east. This region has been highly deformed under the dextral oblique collision between the Eurasia and North America (Okhotsk) Plates and the following westward movement of the Kuril Arc due to the oblique subduction of the Pacific Plate. The latter event has formed the Hidaka Collision Zone (HCZ) with the uplift of the Hidaka metamorphic rocks along the Hidaka Main Thrust (HMT) and the development of the west-verging fold-and-thrust belt with thick sedimentary package on the SYB.

In this paper, we review the previous controlled-source seismic studies in western and central Hokkaido, focusing the structural complexity formed by the arc-arc collision. The first seismic refraction study was undertaken in western Hokkaido in 1968-1969 (Okada et al., 1973). The crust obtained is 20-30 km thick, consisting of 5.9 and 6.6 km/s layers overlying the uppermost mantle of 7.5 km/s. Seismic refraction studies in 1984 and 1992 revealed the complicated structure in central Hokkaido (Iwasaki et al., 1998). The result from the 1984 profile along the Pacific coast is characterized by a rather thick (> 7 km) sedimentary package with a velocity of 2.5-5.5 km/s in SYB. The 1992 refraction/wide-angle reflection profile, which was extended from the western SYB to the eastern TB with SW-NE direction, also show a thick (~8 km) sedimentary package with a velocity of 2.6-5.8 km/s in the southwestern part of SYB, The upper crustal velocity show significant increase from 5.6 km in HB to 5.7-6.15 km in TB.

In 1990’s, several seismic reflection and refraction/wide-angle refraction experiments were undertaken in the southern HCZ (Arita et al., 1998; Tsumura et al., 1999; Ito et al., 2000) and the northern HCZ (Iwasaki et al., 2004, 2016). In the southern HCZ, the crustal delamination by the collision was clearly imaged from the reflection data by applying an advanced method of CRS/MDRS stacking (Tsumura et al., 2014). Namely, the upper 22-23 km crust in the Kuril Arc side is obducted along the HMT, while the lower part of the crust is descending almost to reach the Pacific plate. In the northern part of the HCZ, the detailed structure was obtained along the 227-km profile with E-W direction. In the fold-and-thrust belt of SYB, there exists a very thick (> 10-12 km) sediments including two or three velocity reversals. East of this package, several west-verging events are recognized down to a depth of 7-8 km, probably corresponding to the faults and structural boundaries formed by the collision process. The HMT was well imaged both by seismic reflection processing and refraction/wide-angle reflection analysis, along which the crystalline basement is almost outcropped. Beneath these complicated structures, we succeeded in imaging the NE Japan Arc crust which descends eastward to a depth of about 40 km under the hinterland side.

In the northern HCZ, the clear crustal delamination is not seen. The obduction of the upper Kuril crust starts at a deeper crustal level of at least 27-30 km and more easterly (~20 km) of the HMT as compared

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with the case in the southern HCZ. If the metamorphic rocks outcropped east of the HMT are the same crustal materials at depths shallower than 23 km as in the case of the southern HCZ, the deeper crustal portion originally situated at 23-27~30 km depth must exist in the western side of the present HMT. The very strong and deep reflectors found west of the HMT might result from the mixture of upper crustal (low velocity) materials of the NE Japan Arc and middle/lower crustal (high velocity) materials of the Kuril Arc.

Keywords: crustal and upper mantle structure, Hokkaido Island, Controlled-source seismic experiments, Arc-arc collision, Hidaka, Delamination of crust

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Seismic imaging of the eastern Japan forearc region using S-net data

*Genti Toyokuni[1], Dapeng Zhao[1], Naoki Uchida[1], Takashi NAKAYAMA[1]

1. RCPEVE, Tohoku Univ.

The great 2011 Tohoku-oki earthquake (Mw 9.0) occurred off the Pacific coast of Northeast Japan, where the Pacific plate is subducting beneath the Okhotsk plate. The S-net (the Seafloor observation network for earthquakes and tsunamis along the Japan Trench), initiated in 2016, is a large-scale, permanent, ocean-floor seismograph network with cabled 150 stations, which covers a wide oceanic region off Northeast Japan (Kanazawa, 2013). In this study, we aim to reveal the 3-D seismic velocity structure beneath the forearc region covered by the S-net.

We carefully picked 3754 first P-wave arrival times of 63 local earthquakes (M3.5–6.2) in the Tohoku forearc region from the continuous S-net records. Then, the newly picked data are integrated with the existing arrival-time data (Zhao et al., 2012) of 360 teleseismic and 1,180 local earthquakes recorded at 3,205 Hi-net stations on the Japanese land areas. These combined data are inverted to obtain a new 3-D P-wave velocity (Vp) model beneath the entire Northeast Japan arc by using the seismic tomography method of Zhao et al. (2012).

In this work we focus on the obtained 3-D images at depths < 40 km below the region covered by the S-net. The major results are summarized as follows.
(1) Prominent low-Vp anomalies are revealed in the off-Iwate and off-Fukushima areas. These features are consistent with those revealed by previous works (e.g., Zhao et al., 2011; Huang & Zhao, 2013; Liu and Zhao, 2018), indicating that our hand-picked arrival-time data are quite accurate and robust.
(2) A significant high-Vp anomaly is revealed along the Japan Trench especially beneath the off-Miyagi region where the 2011 Tohoku-oki earthquake (Mw 9.0) occurred, which may reflect that the sedimentary layer is very thin above the subducting Pacific plate.

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Zhao, D. et al. (2012) GJI 190, 816–828.

Keywords: Seismic tomography, Offshore Northeast Japan, S-net, 3-D velocity structure

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The relationship between the location of the mid crustal reflector and seismicity in Iwaki area, northeastern Japan

*Takashi Iidaka[1], Shin'ichi Sakai[1], Toshihiro Igarashi[1], Kazushige Obara[1], Aitaro Kato[1], Tetsuya Takeda[2], Shigeki Nakagawa[1]

1. Earthquake Research Institute, University of Tokyo, 2. National Research Institute for Earth Science and Disaster Resilience

The Tohoku-Oki earthquake occurred on March 11, 2011. After the 2011 Tohoku-Oki earthquake, the seismicity in Japan changed. The seismicity increased in some areas. The seismicity decreased areas also exist. It has been considered that the change of the seismicity is related to the change of the stress field caused by the large slip at the plate boundary. The Iwaki area, northeastern part of Japan, is one of the areas that the seismicity changed. The seismicity in this area increased drastically. Before the 2011 Tohoku-Oki earthquake, the seismicity was very low. But, the seismicity increased after the Tohoku-Oki earthquake. The cause of the changes of seismicity was not clear. It is very important to survey the crustal structure in order to understand the mechanism of the seismicity in this region. The characteristics of the seismicity of the area are following. The earthquakes were occurred within a triangle area. The size of the one side of the triangle was around 50 km. The crustal seismicity in the area divided into two depth range. The seismicity in the shallower area is less than 15 km. The depth range of the other group is 15–25 km.

A temporary dense seismic array (63 seismometers) has been deployed to know the seismicity and mechanism in this area. Usuda (Master thesis 2018) studied the crustal structure using this data. The crustal structure was studied with a reversed VSP (Vertical Seismic Profile) method. The clear two later phases were detected. One of the later phases was the reflected wave at the Moho boundary. The other phase was the reflected phase at the middle of crust. The location of the boundary of the middle of the crust was consistent with that of seismic activity area inside the crust. The amplitude of the reflected wave was very large. It was expected that the reflected wave was caused by the reflector with fluid.

We researched that the relationship between the seismicity in this area and location of the mid-crustal reflector. In this area, the seismicity increases from March, 11, 2011. The seismicity started at the southern part the reflector. The seismicity increased in and around reflector area from Mar., 11 to Apr. 10, 2011. At the northern part of the reflector, a relatively low-seismicity area appeared. On the Apr., 11, 2011, the Hamadori earthquake occurred in the low-seismicity area. We suppose that there is some relationship between the seismicity of the area and reflector. If the reflector is caused by the crustal fluid, the increase of the seismicity in Iwaki area might be related to the crustal fluid.
The outline of reflector obtained by Usuda (Master thesis 2018) is related to the location of the temporally seismic stations. In Iwaki region, the earthquakes are located at the north of the reflector. We want to know the true size of the reflector. We researched the waveforms of the seismic stations located in the north of the reflector area. Hi-net and F-net stations were used. The later phase with large amplitude was found at the seismic stations. We found the reflector at the north of the reflector of Usuda (2018).

Keywords: Iwaki area, seismicity, reflector

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Abnormal Seismic Anisotropy beneath the Tokyo Metropolitan Area (1) Mantle of the Philippine Sea Slab

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1. Introduction

The Tokyo metropolitan area is located on a unique convergence zone associated with the North American (NA) plate: beneath the metropolitan area, dual subduction system was formed by the Pacific (PAC) and Philippine Sea (PHS) plates. Furthermore, subduction of the PHS slab brings a collision zone between the NA plate and the Izu-Ogasawara islands arc, which is on the PHS slab, in the vicinity of the metropolitan area. Therefore, the metropolitan area is seismically active and has various types of earthquakes. However, the relationship between the configuration of plates (the NA, PAC, and PHS plates) and the seismicity remains unknown, although seismo-tectonics of the region has been studied from the various points of view, such as earthquake mechanism, hypocenter distribution, and seismic velocity structure. Thus, we focus on seismic anisotropy that could provide useful information on dynamics and tectonic. In this study, we investigate the three-dimensional (3D) structure of P-wave azimuthal anisotropy beneath the Tokyo metropolitan area.

2. Data and Method

The modeling space is the Tokyo metropolitan area (34.7 - 36.8˚N, 138.5 - 141.5˚E, 0 - 150 km). In order to determine 3D P-wave azimuthal anisotropy velocity structure, seismic anisotropy tomography method of Ishise and Oda [2008] was applied to 442960 P wave arrival time data from 1859 local earthquakes recorded at 500 seismic stations, including 296 Meso-net stations. Initial source parameters (location and origin time of earthquake) used in this analysis were determined independently by NIED. The 3D velocity structure in the modeling space is described by velocity parameters assigned to a 3D grid structure. The grid structure was composed of 0.1˚ - 0.2˚ grid spacing in the latitude and longitude directions. In the vertical direction, grid nodes were spaced at 5 - 20 km.

3. Results

As a result of the tomographic analysis, we found a unique anisotropy region in the lower edge of the PHS slab mantle, or rather the contact zone between the PHS and PAC slabs. The region has strong anisotropy, and the fast axes are uniformly oriented in the N-S trending direction. Generally, anisotropy in the slab can be explained by lattice preferred orientation of mantle minerals or alignments of cracks and faults. However, any mechanism cannot explain the N-S trending anisotropy in the PHS slab beneath the study area. It might suggest that the modeling under the assumption of azimuthal anisotropy would be inappropriate for the study area. Alternatively, it is possible that we have to change our basic idea of the subduction zone.

Acknowledgments: We used Hi-net seismological data. This study was supported by the Tokyo metropolitan project.

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Keywords: seismic anisotropy tomography, Tokyo metropolitan area, Philippine Sea slab, Pacific slab

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Thu. May 30, 2019 3:30 PM - 5:00 PM JST | Thu. May 30, 2019 6:30 AM - 8:00 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-SS12] Crustal Structure

convener:Kazuo Nakahigashi(Tokyo University of Marine Science and Technology), Chairperson:Tsuruga Kayoko(Tokyo University of Marine Science and Technology), Yojiro Yamamoto(Japan Agency for Marine-Earth Science and Technology)

The aim of this session is to cover seismological and geophysical studies on the Earth's crust. Contribution on seismological and geophysical structure of the crust, processes that develop in the crust which include earthquakes, volcanoes and geological descriptions of the crust are welcomed. We also welcome theoretical and methodological studies that will serve as basics in such explorations.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SSS12-07] Deep seismic reflection profiling across the Suruga trough, Shizuoka, Japan

*Hiroshi Sato[1], Kayoko Tsuruga[2], Hisatoshi Baba[3], Tatsuya Ishiyama[1], Shinji Kawasaki[4], Yasuhisa Tanaka[4], Toshifumi Hayashi[2], Yoshihiro Sekino[2], Masanao Shinohara[1], Takaya Iwasaki[1], Makoto MATSUBARA[5], Naoshi Hirata[1,5] (1.Earthquake Research Institute, The University of Tokyo, 2.Tokyo University of Marine Science and Technology, 3.Tokai Univerisity, 4.JGI Inc., 5.National Research Institute for Earth Science and Disaster Resilience)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SSS12-08] Multi-channel seismic profiling in the northern part of Suruga bay using the Shiyomaru-vessel of Tokyo University of Marine Science and Technology (Preliminary report)

*Kayoko Tsuruga[1], Hiroshi Sato[2], Hisatoshi Baba[3], Yoshihiro Sekino[1], Toshifumi Hayashi[1], Hayato Kondotec[1], Chiharu Aoyama[1], Tetsutaro Aikawa[1], Tatsuya Ishiyama[2], Masanao Shinohara[2], Shinji Kawasaki[4], Yasuhisa Tanaka[4] (1.Tokyo University of Marine Science and Technology, 2.University of Tokyo, 3.Tokai University, 4.JGI, Inc.)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SSS12-09] Crustal structure refraction survey using Airgun-OBS in the northern part of Suruga Bay -Fujikawa fault zone- (Preliminary Report)

*Hisatoshi Baba[1], Kayoko Tsuruga[2], Hiroshi Sato[3], Tatsuya Ishiyama[3], Masanao Shinohara[3], Takahito Nishimiya[4], Shintaro Abe[5] (1.Department of Marine and Earth Science, Tokai University, 2.Tokyo University of Marine Science and Technology, 3.Earthquake Research Institute, University of Tokyo, 4.Meteorological Research Institute, Japan Meteorological Agency, 5.Association for the Development of Earthquake Prediction)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SSS12-10] 3D seismic attenuation profiling for imaging an active fault in Uchiura wan

*Tetsuro Tsuru[1], Shio Shimizu[1], Mayu Ogawa[1], Jin-Oh Park[2], Seishiro Furuyama[1], Kosaku Arai[3], Takahiko Inoue[3], Chen Guo[2] (1.Tokyo University of Marine Science and Technology, 2.Atmosphere and Ocean Research Institute, The University of Tokyo, 3.National Institute of Advanced Industrial Science and Technology)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SSS12-11] Gravity survey at the extension of the Takahama fault and the Yokosuka fault in Nishio City, Aichi Prefecture

*Tokunosuke Tatsuzawa[1,2], Tatsuya Sumita[2], Shinobu Ito[2], Tomoya Abe[2] (1.Department of Earth Sciences, Resources and Environmental Engineering, Creative Science and Engineering, Faculty of Science and Engineering, Waseda University, 2.National Institute of Advanced Industrial Science and Technology)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SSS12-12] Subduction geometry and seismicity around northern Ryukyu subduction zone

*Yojiro Yamamoto[1], Tsutomu Takahashi[1], Yasushi Ishihara[1], Koichiro Obana[1], Seiichi Miura[1], Shuichi Kodaira[1], Yoshiyuki Kaneda[2] (1.Japan Agency for Marine-Earth Science and Technology (JAMSTEC), 2.Kagawa University)

Deep seismic reflection profiling across the Suruga trough, Shizuoka, Japan

*Hiroshi Sato[1], Kayoko Tsuruga[2], Hisatoshi Baba[3], Tatsuya Ishiyama[1], Shinji Kawasaki[4], Yasuhisa Tanaka[4], Toshifumi Hayashi[2], Yoshihiro Sekino[2], Masanao Shinohara[1], Takaya Iwasaki[1], Makoto MATSUBARA[5], Naoshi Hirata[1,5]

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An onshore-offshore seismic data set was collected across the Suruga bay in 2018 to determine the deep structure of the subducting Philippine Sea plate (PHS), whose upper surface is estimated to be a seismogenic source fault of the Fujikawa fault system. Three-component of land seismometers (GSX) were deployed with a spacing 100 –200 m from the southern range of Akaishi Mountains to Yui and western part of Izu Peninsula along the seismic lines using total 300 seismometers along the 40-km-long seismic lines. Three-component of ocean bottom seismometers (OBSs) were deployed with spacing of 1 km on the sea bottom deeper than 500 m along the 18 km-long marine part. Five shallow marine ocean bottom seismometers (OBXs) were deployed at the shallow marine western part of Suruga Bay along the 2-km-long interval. They recorded seismic shots generated from four, 200 kg dynamite shots and air gun array with a total volume of 1950 cu. inch. Total number of shots by air gun array was 1479 and shot spacing was 25 m. Data quality is good, allowing the identification of clear refraction by air gun array in the integrated shot gathers. Multi-channel seismic data were also collected towing a 600-m-long streamer cable with 96-ch hydrophones (Tsuruga et al., 2019 JpGU). The redatumed seismic data were produced using interferometric OBS imaging method (Shiraishi et al., 2016). All seismic data were processed according to a standard common-midpoint (CMP) stacking and a post stack time migration. We used refraction tomography to determine the P-wave velocity structure, that revealed down to 10 km in depth beneath the central part of the seismic line. Obtained post-migrated time section portrays the west-dipping reflectors from 3.5 sec (TWT) to 7 sec beneath the eastern part of the Suruga bay, from 5 to 11 sec beneath thesouthern range of Akaishi Mountains. The migrated time section was depth converted using the velocity structure obtained by earthquake tomography based on Hi-net data. On the depth section the depth to an estimated upper surface of PHS is 7 km beneath Yui, western coast of Suruga bay, and 15 km in beneath the central part of land seismic line in the Shizuoka side. The p-wave velocity structure deduced by refraction tomography reveal the wedge-shaped low-velocity area beneath the western part of Suruga bay. The velocity structure accords well to the subduction of PHS and distribution of hypocenters.

The onshore-offshore seismic survey was performed under the Integrated Research Project on the Fujikawa-kako fault zone funded by MEXT. This survey also supported by the research fund of ERI, Univ. Tokyo.

Keywords: plate boundary megathrust, deep seismic reflection profiling, Izu collision zone

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Multi-channel seismic profiling in the northern part of Suruga bay using the Shiyomaru-vessel of Tokyo University of Marine Science and Technology (Preliminary report)

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There is few detail observations and studies about the subduction structure in Suruga trough area as a plate boundary between the Philippine sea plate and Eurasia plate. It is very important to understand the detail structure of Fujigawa fault system to prevent and reduce earthquake disaster by future Tokai earthquake. We have been trying to clarify a shallow structure in this important area by means of both seismic reflection and refraction surveys since 2016 and 2017 (Tsuruga *et al.*, 2016, 2017, 2018). In this report, we show the preliminary results of the seismic reflection and refraction surveys in Suruga Bay, Central Japan, conducted by Shiyomaru-vessel of Tokyo University of Marine Science and Technology (TUMSAT) cooperated with University of Tokyo and Tokai University.

We conducted the 2-D seismic reflection and refraction survey with air-guns and streamer cable system in Suruga Bay, from Oct. 1 to 9, 2018, along three surrey lines (*i.e.*, H30-L00/R00, H30-L01 and H30-L02 lines) which were located in the northern part of Suruga bay with the length of 19.5 km, 20.0 km and 16.1 km, respectively. We used two Bolt air-gun source systems of 'Tri-Gun' 1500LL (350 cu.in x 3) and 1500LL (300cu.in x 3) with a total air volume of 1,950 cu.in for H30-L00/R00 and H30-L02 survey lines with a shot interval of 50 m while we used Tri-Gun 1500LL (350cu.in x 3) with a volume of 1050cu.in with a shot interval of 25 m along H30-L01 line. Total shot number was 2717. Hydrophone receivers array consisted of Hydroscience digital streamer cable including 96 channel sensors with an interval of 6.25 m inside a cable of 600 m long, and a small tailbouy. TUMSAT research vessel 'Shinyomaru' has the following principle specifications: length, beam, and gross tonnage are 65 m, 12.5m, and 986 tons, respectively. Details of the refraction survey across a land area and oceanic area will be shown by Sato *et al.* and Baba *et al.* (in this meeting, 2019).

Preliminary results show some important features as follows: Reflection section of H30-L00 indicates a continuous west-tilting reflection phase which may be located around an upper boundary of the sedimentary layers over the subducting oceanic plate toward west. These reflection phases might be continued to the those along H29-L02 located in the northern area and H30-L02 and H28-L03 located in the southern area. We have not found the dominant characteristics of subduction boundary in these observations. Along H30-L01 we might find an interesting feature as a boundary between Honshu block and Izu peninsula. The details of our result will be shown in the presentation.

This study was supported by fond from the Ministry of Education, Culture, Sports, Science and Technology. We appreciate the big cooperation by Shizuoka prefecture Federation of Fisheries Cooperative Associations and many Fishery Cooperatives around Suruga Bay to understand our study. We thank Tokai University for helping us in an ocean by a vessel 'Hokuto'. Finally, we greatly thank Shinyomaru's crews and many staffs of our university for their encouragement and helps.

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Keywords: Plate boundary, Seismic reflection and refraction survey, Suruga Trough

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Crustal structure refraction survey using Airgun-OBS in the northern part of Suruga Bay -Fujikawa fault zone- (Preliminary Report)

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As part of the exploration of the crustal structure of the Ministry of Education, Culture, Sports, Science and Technology "Priority investigation observation in the Fujikawa fault zone" (Sato et al., 2019 (the present Society); Tsuruga et al., 2019 (the present Society)), in Suruga Bay Reflection and refraction seismic survey by the Tokyo University of Marine Science and Technology, practice ship "Shinyo Maru (986 tons)" was carried out at a survey line of about 19 km (H30 - L00 main line) traversing north to east and west. In this our presentation, we present a preliminary report on the outline of Airgun-OBS structure exploration (refraction seismic survey) and the results obtained.

The H30 - L00 main line starts at the water depth of 485 m in Shizuoka, Shimizu, Okitsu City coastal area, the deepest part is 1320 m in the vicinity of the central part of Suruga Trough and the eastern end is over 500 m in the coastal area of Numazu, Heda City. It is a survey line of trough topography sandwiched by slopes. Since the distance between east and west distances in the northern part of Suruga Bay is short and the coastal area is also a fishing ground, the length of the survey line is limited to about 19 km.

For the refraction seismic survey in the main line, two sets of Tri-Gun by Bolt Co., Ltd. (total capacity 1950 in^3) were towed, and at about 50 m intervals (since the shooting points were adjusted so as to be interposed between practically approximately blast occurred at intervals of 25 m), 18 sets OBS were deployed at about 980 m intervals. Typhoon 24 passed around Suruga Bay on the day of the exploration, so six of the 18 OBSs caused abnormal floating and so on, and they stranded to the coast (Nakao et al., 2019 (the present Society)), so data could not be obtained near the Suruga trough central axis. However, good records were obtained with 12 OBS.

Analysis is ongoing. Looking at the state of each Record Section obtained, the first arrival data can be clearly confirmed throughout the survey line, but a complex structure is presumed because it is also a line surrounding the plate boundary. The earliest layer of apparent velocity is about 6.8 km / sec, and the velocity structure model is estimated to be roughly 5-layer structure. The sedimentary layer of the first, the second and the third layer (acoustic basement layer) are inclined to the west side towards the Suruga Bay central axis, and the reflection cross section (Tsuruga et al., 2019 (the present Society)) and Match. Detailed structure model results will be reported in this presentation.

We have greatly cooperated and inconvenienced the Yui Port Fishery Cooperative Association, Shimizu Fisher Cooperative Cooperative Association and Toda Fisher Cooperative Cooperative Association for the establishment of OBS.

Keywords: Suruga Bay, OBS, Crustal Structure

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3D seismic attenuation profiling for imaging an active fault in Uchiura wan

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We tested seismic attenuation profiling (SAP) to image active faults on a mini-3D seismic reflection dataset observed at Uchiura wan in 2018. Seismic reflection surveys are often conducted to investigate not only geological structures but also development of faults in sedimentary basins, because the past activities of faults are recorded as offsets of geological formations at their locations. However, it is sometimes difficult to specify the existence of faults within highly faulted/fractured areas because seismic reflections are inherently invisible there. SAP has been, therefore, applied to image faults as well as fractures and investigate their activities in poorly reflective areas: the igneous oceanic crust and volcanic areas.

SAP is a method to map seismic attenuation property using seismic reflection data. The authors use the spectral ratio method to estimate Q from seismic reflection data in frequency domain, because the method can be robustly applied in poorly reflective area. Reversely, Q-estimation methods in time domain are not stable in such areas because no reliable amplitude information is available there. However, SAP using the spectral ratio method has not been applied to image faults and fractures developed in sedimentary units (e.g. Tsuru et al, 2017; 2018), because the accuracy in Q-estimation decreases due to spectrum distortions. The spectrum distortions are mostly caused by interruption between primary reflections and interbed multiples within the sedimentary layers. Shimizu (2019) investigated the influences of several Q-estimation methods to interbed multiples by numerical experiments and then improved some processing parameters in the estimation of Q in the frequency domain. As a result, the authors successfully imaged a trend of an active fault on SAP time-slices (Q-slices) from a mini-3D seismic reflection dataset.

A high-resolution mini-3D seismic survey was conducted at Uciura wan in Suruga Bay on August 7th in 2018, by chartering R/V Daini Ikoi Maru of Oki Seatec Co., Ltd. During the survey, twenty of seismic lines were collected with sampling rate of 1 ms. An underwater speaker was adopted as an energy source in consideration of mitigating impact on marine ecosystem. Shot records were collected every 10 s (equivalent to about 10 m with the vessel speed of 2 knots) with a streamer cable of 16 channels. The source and the streamer cable were towed at 0.5 and about 1 m depths, respectively.

As a result of seismic data processing, including band-pass filter, NMO corrections and stacking with one velocity of 1500 m/s, a 3D seismic cube was created. The seismic cube was used for input data of SAP analysis. The data processing was conducted by MATLAB. On the other hand, as a result of the SAP analysis, a 3D cube of average Q was created. An active fault, which cuts seafloor, was clearly demonstrated over several seismic reflection profiles. However, its trend was not clear on seismic time-slices. Reversely, the trend of active fault was clearly figured out on several Q-slices as high attenuation anomalies. In this paper, we would like to show the results of SAP analysis from the mini 3D seismic reflection data observed in Uchiura wan.

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Keywords: seismic attenuation, active fault, 3D seismic data

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Gravity survey at the extension of the Takahama fault and the Yokosuka fault in Nishio City, Aichi Prefecture

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We conducted a gravity survey in Nishio city, Aichi Prefecture to clarify the subsurface structure related to the Takahama fault and the Yokosuka fault (Fig.1). Seismic reflection survey was held in that area in September 2018 (Ito, 2019) and the velocity structure was also obtained by refraction analysis. Then, we consider that we can clarify more detailed subsurface structure by conducting gravity survey on the seismic survey lines and their extensions (Line1 and Line2) and also by comparing gravity survey results with the seismic survey results. We also conducted gravity survey along the Yahagi Furukawa river (Line 3) that is supposed to cross the northern extension of the Yokosuka fault in the active fault map “Gamagori” (Okada et al., 2004) issued by Geospatial Information Authority of Japan and that is also crossing the concealed fault inferred by Sugito and Okada(2004).
In this survey, a total of 150 points of relative gravity was measured by the Lacoste D-type gravimeter (D68) and the Lacoste G-type gravimeter (G304). Measurement distance intervals were about 50m or 100m on Line1 and Line 2, about 30m or 50m on Line 3. The location coordinates of each gravity measurement point were mainly measured by GNSS(network type RTK-VRS), while some points were also measured by Total Station. Gravity anomaly was calculated by the standard procedure SPECG1988 (GSJ Gravity Survey Group, 1989). We performed terrain correction with 50m mesh DEM (Murata et al., 1996) for the Bouguer anomaly calculation. The contribution of terrain on gravity anomaly is small because the surveyed area is nearly flat. In fact, the maximum difference between simple Bouguer anomaly and the Bouguer anomaly calculated with 50m mesh DEM is 0.074mGal, and the pattern of the anomaly profile does not differ greatly between them.
As a result of gravity survey, the pattern of the Bouguer anomaly profile on Line1 and Line 2 is well related to the contour line of 3000m/s in P wave velocity section by the refraction analysis. On Line3, the Bouguer anomaly shows significant change around the point where the presence of the concealed fault of the Yokosuka fault was estimated (Sugito and Okada, 2004; Imaizumi et al., 2018). In addition, the Bouguer anomaly shows complex change on the eastern part of Line 2, where the P wave velocity is also lower than surrounding area by the result of the refraction analysis. In the coming months, we are going to make the density structure model by using the reflection boundary of the seismic profile and the gravity anomaly to reveal the details.

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Keywords: active fault, gravity anomaly, subsurface structure, density structure, seismic reflection survey, Lacoste gravimeter

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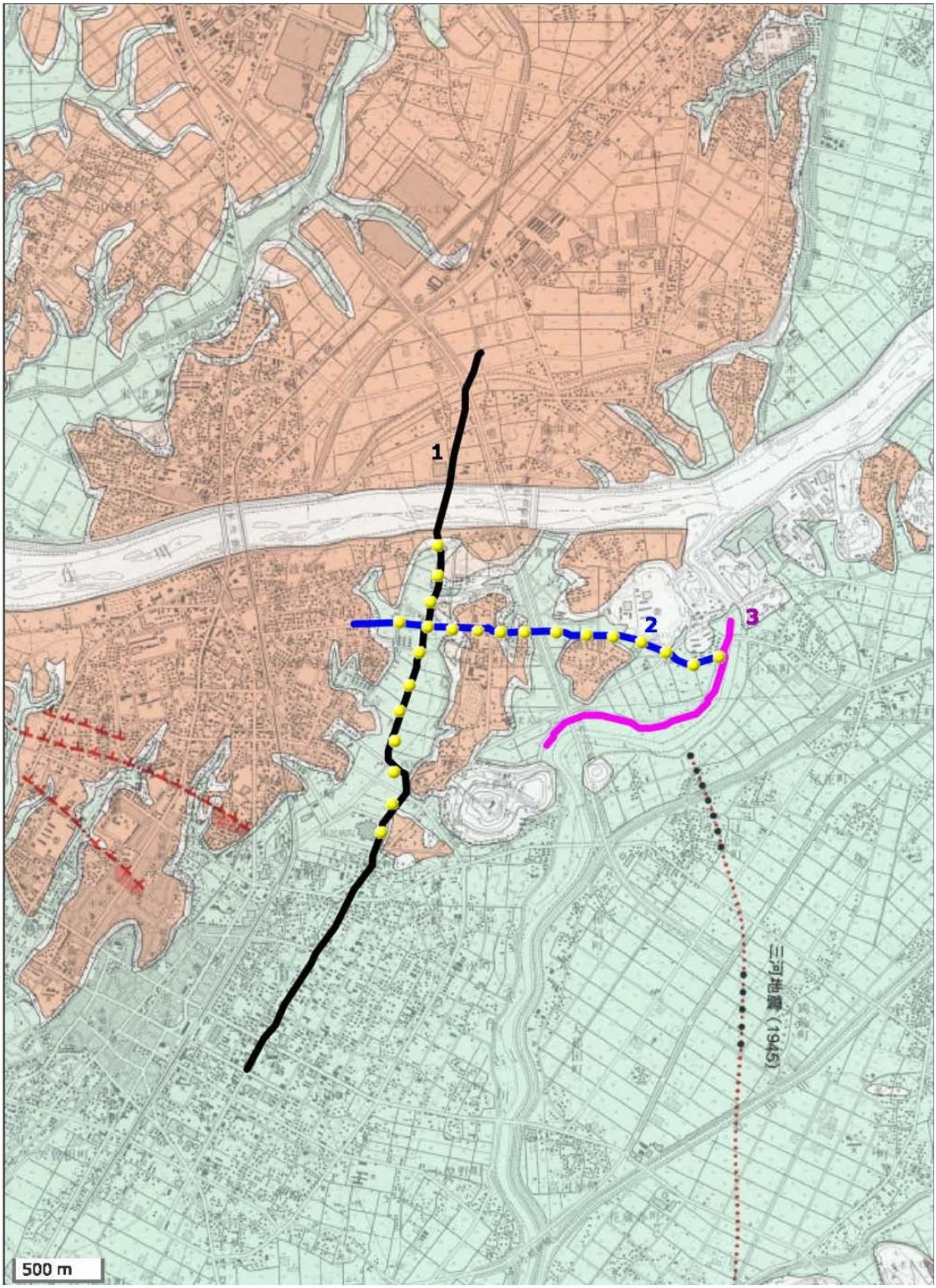


図1　愛知県西尾市における重力探査測線。都市圏活断層図「蒲郡」（岡田ほか、2004）をもとに加工して作成。
黒線が測線1、青線が測線2、紫線が測線3、を示す。測線1及び測線2の一部では反射法地震探査（2019、伊藤）が実施された。黄点線はその地震探査測線を示す。赤線は活断層、赤点は活断層(伏在部)、黒点は地震断層を示す。

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Subduction geometry and seismicity around northern Ryukyu subduction zone

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At the Ryukyu subduction zone, located forearc region of Japan’ s Southwest Islands, the Philippine Sea plate is subducting beneath the Eurasian plate toward northwest direction. Due to the subduction, not only active seismicity but also short-term slow slip event (SSE) (Nishimura, 2014) and low frequency tremor (LFT) activity (Yamashita et al., 2015) were observed in the forearc region of Ryukyu arc. However, the subduction geometry is still unclear since seismic and geodetic stations are limited to the sparsely distributed islands. To know the seismicity, lithospheric structures and subduction geometry, Japan Agency for Marine-Earth Science and Technology (JAMSTEC) launched a series of seismic observations and active-source seismic surveys at the Ryukyu arc from 2013, as a part of research project funded by Ministry of Education, Culture, Sports, Science and Technology, Japan. In FY2016, we have conducted a passive source observation in the northern Ryukyu forearc region. We have deployed 47 seismic stations including 43 ocean bottom seismographs (OBS) and 4 onshore stations at Tanegashima (two stations), Nakano-shima, and Akuseki-jima. The observation period of OBS is about 4 months, from September to December 2016.

In this study, we conduct double-difference seismic tomography (Zhang and Thurber, 2006) to obtain both precious hypocenter location and structural information around plate boundary. We combine 1,303 events detect from our observation data with 454 events from Japan Meteorological Agency (JMA) with our data set. To improve the spatial resolution and ray coverage, we also used the arrival time data at 33 permanent stations from JMA seismic catalogue and dataset of a part of previous OBS observation in Hyuga-nada (Yamamoto et al., 2013; 161 events and 27 OBSs). After the tomographic inversion, we estimate the focal mechanisms by using P-wave first arrival polarity data. Then, we establish the subduction geometry model with reference to the velocity model, distribution of low-angle thrust type earthquakes, previous geometry model based on active source surveys (Nishizawa et al., 2009, 2017; Nakanishi et al., 2018).

Estimated subduction geometry indicates that there is no obvious roughness in this study area. Interplate earthquake, defined as earthquakes within 5 km from plate boundary of this study, is active at depth between 15 and 30 km especially in the southern part. The down-dip limit of interplate earthquakes is corresponding to the high Vp/Vs just above the plate boundary, suggesting that the existence of serpentinized mantle wedge. In addition, LFT, SSE, and interplate earthquake seem to be separately occurred along the plate boundary. Intraslab earthquake is also active. Some of them occurred in the seaward of trench axis. The separation between intraslab earthquakes and plate boundary is larger (25 ~ 30 km) in northern part than that in southern part (15 ~ 20 km). This regionality might be relate to the subduction of Amami Plateau.

Keywords: Ryukyu Trench subduction zone, Philippine Sea Plate, seismicity, tomography

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[J] Oral | S (Solid Earth Sciences)：S-GL Geology

Thu. May 30, 2019 9:00 AM - 10:30 AM JST | Thu. May 30, 2019 12:00 AM - 1:30 AM UTC | A10 TOKYO BAY MAKUHARI HALL

[S-GL27] Geochronology and Isotope Geology

convener:Takahiro Tagami(Graduate School of Science, Kyoto University), Yuji Sano(Division of Ocean and Earth Systems, Atmosphere and Ocean Research Institute, University of Tokyo),
Chairperson:Takahiro Tagami, Yuji Sano

Reliable reconstruction of geohistory is of primary importance to better envision the present and future of the Earth. Geochronology and isotope geology play major roles in the reconstruction. This session offers an opportunity to present the results of fundamental studies, including the developments / improvements of analytical methods and age calibration, as well as applications to the Earth and planetary materials. We particularly focus on: (1) radiometric dating, bio-stratigraphy, magneto-stratigraphy and stable isotopic time series that provide the age information, (2) radioisotopes and stable isotopes widely employed for analyzing the Earth and planetary systems and (3) hypothesis and numerical modeling that utilize / assimilate the age and isotopic data. We also welcome contributions that integrate a variety of relevant disciplines.

9:00 AM - 9:30 AM JST | 12:00 AM - 12:30 AM UTC

[SGL27-01] Terrestrial cosmogenic nuclides as a dating tool of landforms and near-surface materials: applicability and limitations

★Invited Papers

*Yuki Matsushi[1] (1.Disaster Prevention Research Institute, Kyoto University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SGL27-02] Dating of marine erosional terraces using cosmogenic nuclides: A case study of the Hyuga City, Miyazaki Prefecture, southwest Japan (preliminary results)

*Shigeru Sueoka[1], Tetsuya Komatsu[1], Yuki Matsushi[2], Yusuke Yonaga[1], Naomi Sano[1], Noriaki Hirao[1], Tadamasa Ueki[1], Natsuko Fujita[1], Yoko Kokubu[1], Masakazu Niwa[1] (1.Japan Atomic Energy Agency, 2.Disaster Prevention Research Institute, Kyoto University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SGL27-03] Estimation of thermal history of Toki granite over 0.1Myr timescale by Multi-OSL-thermochronometry

*Manabu Ogata[1], Georgina E King[2], Frédéric Herman[2], Shigeru Sueoka[1] (1.Tono Geoscience Center, Japan Atomic Energy Agency, 2.University of Lausanne)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SGL27-04] Depth condition under which OSL signal of quartz gouge experiences coseismic zeroing

*Yuki Minomo[1], Kiyokazu Oohashi[1], Noriko Hasebe[2], Kazumasa Miura[3] (1.Graduate School of science and Technology for Innovation, Yamaguchi University , 2.Institute of Nature and Environmental Technology, Kanazawa University, 3.Kanazawa University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SGL27-05] Result of age determination of samples from Hokuriku Group

*Noriko Hasebe[1], Ryo Kamiguchi[2] (1.Institute of Nature and Environmental Technology, Kanazawa University, 2.Department of Earth Sciences, Kanazawa University)

Terrestrial cosmogenic nuclides as a dating tool of landforms and near-surface materials: applicability and limitations

*Yuki Matsushi[1]

1. Disaster Prevention Research Institute, Kyoto University

This study overviews methodology for application of terrestrial cosmogenic nuclides for dating of diverse types of landforms and near-surface materials. Accumulation of the nuclides in the bedrock or sediment on land surfaces enables us to determine exposure ages of the landform. This methodology targets reconstruction of environmental changes in mountainous areas due to climatic transition, timings of large landslide occurrence, and formation ages of fluvial or marine terraces. In this application, post-event erosion or sedimentation, and/or pre-event irradiation of cosmic rays enlarge uncertainty in the model ages. The nuclide concentration in an eroding bedrock or current sediment reflects residence time of the material near the land surface, which then can be converted to denudation rates of the landform. This application has revealed rates of carbonate denudation as a function of climatic conditions of the sites, soil production and catchment-wide denudation rates in silicate areas, which corresponds to topography of the terrain. For samples of deeply-buried sediments, ratio of paired nuclides in identical mineral grains indicates ages of burying of the debris. The pair of ^{10}Be and ^{26}Al in quartz has been used for dating sediments in caves, for a timescale of 10^6 years. Analysis of such samples provides also a clue to reconstruct paleo denudation rates of the source areas of the debris. In this presentation, applicability and limitations of this method will be discussed with several actual data and outputs from various models of nuclide accumulation.

Keywords: Terrestrial cosmogenic nuclides, Exposure age, Denudation rate, Burial age, Landscape evolution

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Dating of marine erosional terraces using cosmogenic nuclides: A case study of the Hyuga City, Miyazaki Prefecture, southwest Japan (preliminary results)

*Shigeru Sueoka[1], Tetsuya Komatsu[1], Yuki Matsushi[2], Yusuke Yonaga[1], Naomi Sano[1], Noriaki Hirao[1], Tadamasa Ueki[1], Natsuko Fujita[1], Yoko Kokubu[1], Masakazu Niwa[1]

1. Japan Atomic Energy Agency, 2. Disaster Prevention Research Institute, Kyoto University

Uplift rate in an inland region and coastal region in the past 10^4 to 10^5 years can be estimated based on the elevation and emergent age of marine terraces (e.g., Ota and Omura, 1991). Marine depositional terraces in Japan have been dated by using radioactive carbon dating, tephrochronology, and recently developed optically stimulated luminescence dating (especially pIRIR dating for feldspar; e.g., Ito et al., 2015). On the other hand, it is difficult to date marine erosional terraces which lack sedimentary layers on the surfaces to apply these dating methods.

This study attempted to date marine erosional terraces by using terrestrial cosmogenic nuclide (TCN) dating methods, especially ^{10}Be and ^{26}Al methods. The ^{10}Be and ^{26}Al methods can reconstruct an exposure age and/or erosion rate of a rock based on the contents of ^{10}Be and ^{26}Al which are produced by irradiations of cosmic rays to oxygen and silicon in the rock (Wakasa et al., 2004; Matsushi et al., 2007). The production rates of ^{10}Be and ^{26}Al at the surface or at a certain depth depend on the cosmic-ray intensity (related to the latitude and altitude), density of the covering materials, and depth of the rock. The cosmic-ray intensity is computed theoretically, and the density of the covering materials can be also measured or assumed. Therefore, time-depth process of the rock, namely erosion and deposition history at the site, can be constrained by measuring the ^{10}Be and ^{26}Al contents.

We studied marine erosional terraces in Hyuga City, Miyazaki Prefecture, southwest Japan. Three groups of marine terraces were identified in this region, which are hereinafter named M1, M2 and L surfaces, respectively. The elevations of the surfaces are 30-50 m for M1 surface, 19-30 m for M2 surfaces, and sea-level to ~8 m for L surface. Considering the elevation, M1 and M2 surfaces can be correlated to the Sanzaibaru surface and Nyutabaru surface (Nagaoka et al., 2010), respectively, whereas L surface is thought to be the Holocene terraces. We collected rock samples for TCN dating by excavating three pits on M2 surface. The cross-sections of the pits consist of the basement rock, angular to subangular gravel layer interpreted as *in-situ* weathered basement rock, and soil from the base to the top. Rock samples were collected from the top of the gravel layer (depth: ~50 cm to 1 m) which is thought to be the surface of the former wave-cut benches. The lithology of the samples is the granite porphyry of the Osuzuyama acidic rocks formed in the middle Miocene (Nakata, 1978). The samples were processed by following the procedures of Kohl and Nishizumi (1992) and the ^{10}Be and ^{26}Al contents were measured using JAEA-AMS-TONO, an accelerator mass spectrometer at the Tono Geoscience Center, Japan Atomic Energy Agency (Saito-Kokubu et al., 2013).

The ^{26}Al contents measured were rejected because these values were lower than the theoretical values. The ^{10}Be contents yielded ~100 to 70 ka of the minimum exposure ages. More realistic erosion/deposition scenarios were adopted for better dating of the terrace surfaces, in which sedimentary layers were assumed to be deposited at a constant rate after the emergent of the surface. Consequently, M2 surface is thought to be emerged in MIS 5a although the correlated Nyutabaru surface emerged in

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MIS 5c. We are planning to determine more accurate age of the surfaces by tuning model parameters and by obtaining depth profiles of TCN contents.

Acknowledgements: This study was carried out under a contract with METI (Ministry of Economy, Trade and Industry) as part of its R&D supporting program for developing geological disposal technology.

Keywords: cosmogenic nuclide dating, marine erosional terrace

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Estimation of thermal history of Toki granite over 0.1Myr timescale by Multi-OSL-thermochronometry

*Manabu Ogata[1], Georgina E King[2], Frédéric Herman[2], Shigeru Sueoka[1]

1. Tono Geoscience Center, Japan Atomic Energy Agency, 2. University of Lausanne

Estimation of denudation history is important for geological disposal of high-level radioactive waste because denudation influences underground water flow and distance between the surface and underground facility. Terrestrial cosmogenic nuclide (^{10}Be, ^{26}Al) dating is used to evaluate denudation rate in a few meters, whereas low-temperature thermochronology, such as fission-track and (U-Th)/He methods, is applied to estimate denudation histories for a few to several kilometers in the last 10^6-10^8 years. However, the middle-term (10^4-10^5 years) denudation history over several hundred meters is more important for geological disposal because it takes tens of thousands of years to reduce the radioactivity of radioactive waste to the level of that of natural uranium ore.
Recently, multi- OSL-thermochronometry has been proposed as a tool that offers the potential for tight constraint of cooling histories in the low-temperature domain (< 75℃) over recent (0.1-0.2 Myr) timescales. This method determines the timing and rate at which electrons are trapped and thermally released in minerals, in response to in situ radiation and rock cooling. The technique of OSL thermochronometry is able to be used to unravel denudation histories.
Application of OSL thermochronometry is currently limited to regions that have experienced denudation rates higher than 3 mm/year, assuming a general geothermal gradient and surface temperature; luminescence signals saturate before the rocks are exhumed to the surface in a slowly-denuded region. Given such limitations on the cooling/denudation rate, previous researches on OSL themochronometry has focused on tectonically active mountain ranges, such as the Himalayas, the Southern Alps of New Zealand and Hida range in Japan.
We attempt to apply multi-OSL-thermochronometry to the tectonics that have experienced slowly denudation rate using long borehole. We used the borehole MIZ-1 which was drilled at Mino plateau, Gifu, Japan. The denudation rate in this area is expected to be around 0.1 mm/year or less from the denudation rate since ~40 Ma estimated by the apatite fission track method and uplift rate between MIS6 and MIS2 based on elevations and emergent ages of the fluvial terraces. This borehole consists mainly of the Cretaceous Toki granite pluton which is located at the Sanyo Belt in the Inner zone of the South west Japan Arc. The total length of MIZ-1 is about 1,300 mabh (meter along borehole) and Toki granite ranges from 110 to 1,300 mabh. We collected the samples at 159, 449, 751 mabh for multi-OSL-thermochronometry.
Cooling histories of all samples are similar. Their temperatures decreased to the present ambient temperature at each depth before 0.1 Ma and have then been stable. These results correspond to the expected slow denudation rate. Our results indicate that, by using long borehole, multi-OSL-thermochronometry can be applied to slowly-denuded regions.
This study was carried out under a contract with METI (Ministry of Economy, Trade and Industry) as part of its R&D supporting program for advanced research on long-term stability of geological environment.

Keywords: luminescence, thermochronometry, feldspar

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Depth condition under which OSL signal of quartz gouge experiences coseismic zeroing

*Yuki Minomo[1], Kiyokazu Oohashi[1], Noriko Hasebe[2], Kazumasa Miura[3]

1. Graduate School of science and Technology for Innovation, Yamaguchi University , 2. Institute of Nature and Environmental Technology, Kanazawa University, 3. Kanazawa University

Attempts to determine the age of faulting recorded on a fault rock have been made using methods such as the K-Ar dating, FT dating, and ESR dating (e.g., Murakami & Tagami, 2004, GRL). Among the proposed methods, the luminescence dating method has an applicable time range of few decades to few hundred thousand years ago, and hence it is suitable for dating an active fault. Early trial demonstrated a successful determination of the latest earthquake event along the active fault in central Japan (Ganzawa et al., 2013, JGSJ). The slip rate dependence of the condition that optically-stimulated luminescence (OSL) signal of quartz gouge resets was experimentally verified, so that the signal start to decrease from the slip rate of 0.25 m/s and becomes zero at slip rate ≧ 0.65 m/s (Minomo et al., 2018, JPGU). Here we show the clear reduction (zeroing) of OSL signal of quartz gouge after the laboratory experiments and estimate depth condition required to occur age resetting in natural fault zones. In the experiments, we used quartz powder with a particle size of <150 μm which is extracted from Tsushigawa granite, located in Awaji island, Hyogo Prefecture. We irradiated 400 Gy of gamma-ray for the quartz powder before the experiments to simulate natural radiation damage. Friction experiments were conducted under the following conditions in darkroom environment using a rotary-shear, high-velocity friction apparatus in Yamaguchi University; normal stress of 0.5–5.0 MPa and slip rate of 0.65 m/s (constant from starts to finish). To eliminate the effect of crushing on OSL signal, we measured coarse grains (75–150 μm) extracted from recovered sample.As a result of the measurement, OSL signal intensity start to decrease from the normal stress of 0.5 MPa. We found “partial resetting” which is characterized by coexistence of both particles with signal and without signal at normal stress of 0.5 and 1.0 MPa, and then frequency of the signal intensity for each aliquot is bimodal distribution.On the other hand, complete resetting of the signal was observed in all particles at normal stress ≧ 2.0 MPa.. Assuming a coseismic fault slip rate of 0.6 m/s, depth conditions required for operating partial and complete resetting of OSL age expected to be 18~36 m and 72 m respectively.

[Acknowledgements] This work was supported by grants from the Nuclear Regulation Authority (FY 2015-2018).

Keywords: optically-stimulated luminescence, active fault

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Result of age determination of samples from Hokuriku Group

*Noriko Hasebe[1], Ryo Kamiguchi[2]

1. Institute of Nature and Environmental Technology, Kanazawa University, 2. Department of Earth Sciences, Kanazawa University

The Hokuriku Group is distributed from the southern part of Ishikawa Prefecture to the eastern part of Toyama prefecture and deposited in the Neogene period (about 25 Ma to 2.5 Ma). This study reports zircon fission track (ZFT) and U-Pb ages from several volcanic rocks distributed in the Tsurugi district, the southern part of Ishikawa Prefecture, Kanazawa University district, and Uozu area in Toyama prefecture. The Iozen Formation in Tsurugi district show ZFT ages between 12.2 ±1.9 to 15.7 ±2.8 Ma (error, 2 sigma) and U-Pb ages between 17.2 ±0.5 to 21.0 ±0.9 Ma. U-Pb ages coincide with the Japan Sea opening event, and eruption age by ZFT is about 5 mys after zircon crystallization. One sample from Otogawa Formation shows an equivalent age with the Iozen Formation, suggesting a rapid volcanic sedimentation for both formations. The sample from a quarry, which we thought is from TR1 (Ohkubo, 1999), therefore estimated age is about 4.4 Ma (Tamura and Yamazaki, 2004) by the correlation, shows much older age of ZFT 33.2 ±4.6 Ma and U-Pb 65.3 ±2.0 Ma, and further investigation, especially on the sample identification, is necessary. For Uozu area, ZFT ages of 3.4 ±0.7 to 9.7 ±1.4 Ma and U-Pb ages of 2.9 ±0.8 to 71.7 ±2.8 Ma are obtained, and eruption ages are equivalent to tephra found in Yatsuo district (Sumii, 1986)

Keywords: Hokuriku Group, TR1 tephra, Tng tephra

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[J] Oral | S (Solid Earth Sciences)：S-GL Geology

Thu. May 30, 2019 10:45 AM - 12:15 PM JST | Thu. May 30, 2019 1:45 AM - 3:15 AM UTC | A10 TOKYO BAY MAKUHARI HALL

[S-GL27] Geochronology and Isotope Geology

convener:Takahiro Tagami(Graduate School of Science, Kyoto University), Yuji Sano(Division of Ocean and Earth Systems, Atmosphere and Ocean Research Institute, University of Tokyo), Chairperson:Yuji Sano, Takahiro Tagami

Reliable reconstruction of geohistory is of primary importance to better envision the present and future of the Earth. Geochronology and isotope geology play major roles in the reconstruction. This session offers an opportunity to present the results of fundamental studies, including the developments / improvements of analytical methods and age calibration, as well as applications to the Earth and planetary materials. We particularly focus on: (1) radiometric dating, bio-stratigraphy, magneto-stratigraphy and stable isotopic time series that provide the age information, (2) radioisotopes and stable isotopes widely employed for analyzing the Earth and planetary systems and (3) hypothesis and numerical modeling that utilize / assimilate the age and isotopic data. We also welcome contributions that integrate a variety of relevant disciplines.

10:45 AM - 11:15 AM JST | 1:45 AM - 2:15 AM UTC

[SGL27-06] **Geochemical origin/cycle analysis with isotopologues and isotopomers**

★Invited Papers

*Naohiro Yoshida[1] (1.Department of Chemical Science and Engineering, Earth-Life Science Institute, Tokyo Institute of Technology)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SGL27-07] Estimation of Paleoenvironment by sedimentary rocks in Labrador, Cacada

*katsutaka sudo[1], Yuji Sano[1], Tsuyoshi Komiya[1], Bakert David[2], Michael Broadley[2], Bernard Marty[2] (1.University of Tokyo, 2.CRPG-CNRS, Université de Lorraine)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SGL27-08] Hf-W dating of zircons from mesosiderites with high-pressure sintered sample

*Yuta Koyama[1], Naoto Takahata[1], Yuji Sano[1], Naoji Sugiura[1], Mizuho Koike[2], Makiko K. Haba[3], Sakata Shuhei[4], Hideharu Kuwahara[5], Tetsuo Irifune[5] (1.the University of Tokyo, 2.Japan Aerospace Exploration Agency, 3.Tokyo Institute of Technology, 4.Gakushuin University, 5.Geodynamics Research Center, Ehime University)

11:45 AM - 12:15 PM JST | 2:45 AM - 3:15 AM UTC

[SGL27-09] Radiometric ages *vs.* astrophysical ages -with regard to the numerical age in the International Stratigraphic Chart

★Invited Papers

*Ichiro Kaneoka[1] (1.Earthquake Research Institute, University of Tokyo)

Geochemical origin/cycle analysis with isotopologues and isotopomers

*Naohiro Yoshida[1]

1. Department of Chemical Science and Engineering, Earth-Life Science Institute, Tokyo Institute of Technology

Since the 1950's, the stable isotope composition of natural samples has proved to be a unique tool for the study of geological and biological processes, their evolution and effect on Earth's surface environment. However, due to technical and conceptual limitations, the complete set of information potentially contained in the different modes of isotopic substitution remains largely unexplored. In this study, using new methodological developments that allow analysis of more isotopically substituted molecules, we are developing new tracers in 3 modes of isotopic substitution, fully integrated in the study of geological, biological and anthropogenic processes which affect the origin and evolution of the Earth's surface environment.

3 modes of substitution of stable isotopes in a single molecular species are;

1) Position specific isotope abundance (PSIA): Our group has pioneered PSIA of N_2O[1,2] and organic molecules using classic isotope mass spectrometry[3] and nuclear magnetic resonance[4,5]. We have shown that PSIA of hydrocarbons and organic acids allows to distinguish between biological and non-biological processes[4,6].

2) Mass-independent fractionation (MIF): The discovery of MIF of sulfur and oxygen in terrestrial samples has revolutionized environmental geochemistry and our understanding of the evolutionary history of the Earth's environment and life[7-9].

3) Clumped isotopes (i.e. isotopologues and isotopomers with 2 minor isotopes) provide unique information about the temperature history of molecules such as carbonates[10] or organic compounds[11-13].

We are currently developing new and improved tracers of environmental and biogeochemical processes and applying them to the environmental diagnosis. We are establishing and standardizing new methods for the analyses of every 3 complex modes of isotopic substitution, and unifying them to develop ultimate environmental diagnosis.

The development and application of these new isotopic tools to the environment evolution, in modern and more ancient eras, represents an important conceptual advance in Earth and life sciences. This will open new areas of research about, for example, the geological production of some atmospheric gases, metabolic processes and the biological fixation of atmospheric CO_2, the production and cycling of pollutant gas by industrial processes. As a whole, these new tracers will be integrated together for diagnosis of the Earth's environment.

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1)Yoshida & Toyoda, 2000 *Nature*; 2)Yamazaki, Toyoda, Yoshida, et al., 2014 *Biogeosciences*; 3)Yamada, Yoshida, et al., 2002 *RCM*; 4)Gilbert, Yamada, Yoshida, 2013 *Anal. Chem.*, and 5) 2014 *Anal. Chim. Acta*; 6)Gilbert, Yamada, Ueno, Yoshida 2016 *Geochim. Cosmochim. Acta*; 7)Danielache, Ueno, Yoshida et al.,

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2008 *J. Geophys. Res.*; 8)Hattori, Danielache, Ueno, Yoshida et al., 2013 *PNAS*, 9)Ueno, 2015 *Science*; 10) Yoshida, Abe, Yamada et al., RCM, 2013; 11)Tsuji, Yamada, Yoshida et al., 2012 *Sensor;*: 12)Ono et al., 2014 *Anal. Chem.*; 13)Stolper et al., 2014 *Science*.

Keywords: isotopomer, isotopologue, geochemical cycle, light element stable isotopes

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Estimation of Paleoenvironment by sedimentary rocks in Labrador, Cacada

*katsutaka sudo[1], Yuji Sano[1], Tsuyoshi Komiya[1], Bakert David[2], Michael Broadley[2], Bernard Marty[2]

1. University of Tokyo, 2. CRPG-CNRS, Université de Lorraine

In the previous research, we reported isotopic compositions of graphite and carbonate in the 3.95Ga metasedimentary rocks from northern Labrador, Canada (Tashiro et al., 2017). Based on the isotopic shift of 20-30‰, we claimed a carbonate fixation by the Earth’ s earliest life. In this work, we picked up graphite from the very old rocks collected in Labrador and Nuvvuagittuq, and measured volatile isotope compositions by the step-wise heating method. We analyzed nitrogen isotopes to investigate whether the organic carbon was producted by cyanobacteria or methanobacteria, and noble gas (argon, krypton, xenon) isotopes to determine the age of rocks. We have used two types of gas mass spectrometer; VG3600 for nitrogen, Helix-MC for noble gases. The obtained data together with experimental method will be given in the presentation.

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Hf-W dating of zircons from mesosiderites with high-pressure sintered sample

*Yuta Koyama[1], Naoto Takahata[1], Yuji Sano[1], Naoji Sugiura[1], Mizuho Koike[2], Makiko K. Haba[3], Sakata Shuhei[4], Hideharu Kuwahara[5], Tetsuo Irifune[5]

1. the University of Tokyo, 2. Japan Aerospace Exploration Agency, 3. Tokyo Institute of Technology, 4. Gakushuin University, 5. Geodynamics Research Center, Ehime University

Hf-W dating is a chronometer based on the decay of ^{182}Hf to stable ^{182}W with a half-life of 8.9 Myr (Vockenhuber et al., 2004). This radiometric dating method is important for discussing the timing of core formation in protoplanets and meteorites' parent bodies because hafnium is a lithophile element while tungsten is a siderophile one. In-situ analysis of Hf/W ratio on zircon ($ZrSiO_4$) mineral shows several difficulties, whereas meteoritic zircons have been often used to acquire the information of the early solar system due to their high resistance to thermal metamorphism and great aptitude for U-Th-Pb chronology. Generally, in-situ analysis needs standard materials which have well documented concentrations of target elements and the same matrix as the sample in order to avoid the change of sensitivity depending on major components (matrix effects) during an analysis using a secondary ion mass spectrometer (SIMS). There are no available standard zircons which include abundant and homogeneous tungsten because of its incompatibility with zircon crystal. Therefore, the previous studies determining the relative sensitivity factor (RSF) of Hf and W (Hf/W) for Hf-W dating of zircons using SIMS have been based on several assumptions (e.g., Ireland & Bukovanská,2003; Koike et al., 2017). These methods for measuring Hf/W ratios are indirect ways in terms of lacking standard zircons with known amount of W. In this study, we created new standard zircons which have abundant Hf and W concentrations. High purity zircon powder was mixed with hafnium and tungsten oxide. They were well crushed and mixed by a high energy ball mill and solidified by high-pressure sintering method with multi-anvil apparatus (ORANGE-3000, Geodynamics Research Center, Ehime University) in order to establish the direct way to determine the RSF of Hf/W ratio on zircons for in-situ analyses. Moreover, we applied these standards to Hf-W dating of zircons from a couple of mesosiderites with NanoSIMS (Atmosphere and Ocean Research Institute, the University of Tokyo) at approximately 30 μm scale. As a result of these analyses, we obtained the Hf-W age consistent with Koike et al. (2017) for the mesosiderite Asuka 882023.

Keywords: Hf-W dating, zircon, mesosiderite, sintering, NanoSIMS, RSF

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Radiometric ages *vs.* astrophysical ages -with regard to the numerical age in the International Stratigraphic Chart

*Ichiro Kaneoka[1]

1. Earthquake Research Institute, University of Tokyo

In July, 2018, ICS(International Stratigraphy Commission) of IUGS published the new International Stratigraphic Chart (ISC: v.2018/07). The author drew an attention to the public about some issues to be cautioned on the usage of numerical ages in the ISC based on the 2009 version(v.2009/08) at the JpGU before (Kaneoka, 2016). The essential points do not change between the two versions of ISC, but there are some differences in the representation of numerical ages in the new ISC. Here, the author comments some points about them and discuss issues of astrophysical and radiometric ages used in the ISC.

Keywords: International Stratigraphic Chart, numerical age value, effective numerical value, astrophysical age, radiometric age

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[J] Oral | S (Solid Earth Sciences)：S-MP Mineralogy & Petrology

Thu. May 30, 2019 9:00 AM - 10:30 AM JST | Thu. May 30, 2019 12:00 AM - 1:30 AM UTC | 301B 3F

[S-MP32] Deformed rocks, Metamorphic rocks and Tectonics

convener:Yumiko Harigane(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Yoshihiro Nakamura(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Chairperson:Yoshihiro Nakamura(産総研), Yumiko Harigane(産総研)

We invite all researchers who aim to understand the dynamics of the earth's crust and mantle at the plate boundaries, to discuss the latest results from various viewpoints. The scope will include contributions through petrology and structural geology as well as various techniques including rheology and transformation of heat and mass.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SMP32-19] Thermal interaction of the lithosphere and asthenosphere revealed from internal variations of pressure-temperature history in orogenic peridotite complexes

*Kazuhito Ozawa[1], Carlos J. Garrido[2], Karoly Hidas[2], Jean-Louis Bodinier[3] (1.Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo, 2.Instituto Andaluz de Ciencias de la Tierra (IACT), CSIC – UGR, Armilla, Granada, Spain, 3.Geosciences Montpellier, Montpellier, France)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SMP32-20] **Hydration and Ca-metasomatism in Mantle Wedge: An evidence from the Alag Khadny Accretionary Wedge, Western Mongolia**

*OTGONBAYAR DANDAR[1], Atsushi Okamoto[1], Masaoki Uno[1], Noriyoshi Tsuchiya[1] (1.Graduate School of Environmental Studies, Tohoku University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SMP32-21] **Attenuated Total Reflection Infrared (ATR-IR) Spectroscopy of Antigorite, Chrysotile and Lizardite**

*Ilona Talvikki Sakaguchi[1] (1.Nagoya University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SMP32-22] Fabric and petrological characteristics of sheared peridotites in Marion transform fault, Southwest Indian Ridge

*Kakihata Yuki[1], Katsuyoshi Michibayashi[2], Henry Dick[3] (1.Shizuoka University Graduate School of Science, 2.Nagoya University Graduate School of Environmental Studies, 3.Woods Hole Oceanographic Institution)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SMP32-23] Structure and formation mechanism of lithosphere-asthenosphere boundary decoded from Ichinomegata peridotite xenoliths

*Yuto Sato[1], Kazuhito Ozawa[1] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SMP32-24] Metasomatic banding and deformation instability in the metamorphic rocks

*mitsuhiro toriumi[1] (1.Japan agency of marine science and technology)

Thermal interaction of the lithosphere and asthenosphere revealed from internal variations of pressure-temperature history in orogenic peridotite complexes

*Kazuhito Ozawa[1], Carlos J. Garrido[2], Karoly Hidas[2], Jean-Louis Bodinier[3]

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Dynamics of interaction between lithosphere and asthenosphere in their boundary zones (LABZ) plays an important role in transferring heat, material, and momentum from the earth’ s interior to the surface. Orogenic peridotites provide direct and high-resolution information for better understanding mantle processes taking place in the boundary zone. However, their exhumation obscure the information on dynamics operating in LABZ, while they could be driven and affected by processes taking place in and beneath the LABZ. This issue leads to ambiguity in the link between magmatism, relevant to whole-rock chemical characteristics, and exhumation of peridotite complexes, relevant to deformation and subsolidus reactions. Bodinier et al. (2008) actually pointed out two possible formation scenarios for plagioclase peridotites in orogenic peridotite complexes: subsolidus reaction from spinel peridotites and open magmatic processes in the plagioclase peridotite facies in the shallow mantle. In the context of lithosphere-asthenosphere interaction, it is crucial to discriminate these two possibilities. Spatial and temporal changes of pressure and temperature within an orogenic peridotite complex can be used to better constrain its history of decompression and magmatism. By exploiting the advantage of size of orogenic peridotite complexes, these data may provide valuable constraints on the LABZ dynamics.

Here, we examine internal variations of thermal and decompression history of three orogenic peridotite complexes: Ronda, Pyrénées, and Horoman. They exhibit diverse geological and petrologic characteristics providing an excellent chance of comparative study. The common feature of these orogenic peridotites is decompression from the garnet peridotite facies deeper than ~50km. In this study, we focus on garnet-related reaction microstructures, which are powerful tools to resolve pressure-temperature history because of their high hysteresis as compared with suppressed hysteresis of chemical zoning in minerals. Garnet and its breakdown products show contrasting features among the three. (1) Garnet was completely decomposed in both peridotite and pyroxenite lithologies in Horoman with formation of symplectite in slightly depleted peridotites; garnet rarely remains in both peridotite and pyroxenite lithologies with extensive formation of symplectite and kelyphite in Ronda; and garnet is completely decomposed into two-pyroxene spinel symplectite in peridotites but well preserved with partial formation of kelyphite rim and veinlets in pyroxenites in Pyrénées. (2) Coarse-grained granular olivine-plagioclase assemblage in both fertile peridotite and pyroxenites is common in Horoman; formation of olivine-plagioclase assemblage forming fine-grained intergrowth in fertile peridotites and pyroxenites is common with its extent being spatially variable in Ronda; and formation of olivine-plagioclase assemblage rarely in pyroxenites and very rarely in fertile peridotites in Pyrénées. These contrasts suggest: (1) high-temperature decompression path all through its ascent in Horoman; (2) low-temperature in deeper levels but relatively high-temperature decompression path in shallower levels in Ronda; and (3) high-temperature decompression path in deeper levels followed by rapid cooling in shallower levels in Pyrénées. Combined with pressure-temperature path deduced from chemical zoning and microstructure related to exsolution and dissolution in pyroxenes, we propose that the shallow high-temperature decompression of Ronda was caused by heating in the plagioclase peridotite facies and that the

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high-temperature decompression of Horoman by heating over a wide depth range deeper than the plagioclase peridotite facies. Pyrénées is probably intermediate of these two cases. The contrasting modes of thermal perturbation may imply different mechanisms of lithosphere-asthenosphere interaction, such as active upwelling vs. passive upwelling.

Keywords: lithosphere-asthenosphere boundary, pressure-temperature history, orogenic peridotite

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Hydration and Ca-metasomatism in Mantle Wedge: An evidence from the Alag Khadny Accretionary Wedge, Western Mongolia

*OTGONBAYAR DANDAR[1], Atsushi Okamoto[1], Masaoki Uno[1], Noriyoshi Tsuchiya[1]

1. Graduate School of Environmental Studies, Tohoku University

Hydration and metasomatic reactions of mantle wedge play important roles on global material circulation and changes in physical properties along the plate interface within the subduction zone. Metasomatism is caused by specific components of fluids such as silica; however, our understanding on the relationship between hydration and metasomatism in mantle wedge is still limited. In this study, we report outstanding alteration textures of orthopyroxene as an evidence for significant Ca metasomatism within the mantle wedge, and its relation to the hydration processes.

The Alag Khadny accretionary wedge is located in the Chandman area, western Mongolia, Central Asian Orogenic Belt. The accretionary wedge is subdivided into northern and southern belts. The northern belt is consisted of orthogneiss bodies with layers of mica schists and paragneisses, including amphibolized eclogite, marble, and serpentinite bodies. The southern belt is composed mainly of serpentinized peridotite with minor ophicarbonates and limestone layer including lenses of epidote amphibolites. The ultramafic body mainly consists of harzburgite and lherzolite with minor dunite and its origin is interpreted as mantle wedge.

We collected 17 samples from the ultramafic body in southern belt of the Alag Khadny accretionary wedge in the Chandman area. The peridotites contain primary olivine (Ol), orthopyroxene (Opx), clinopyroxene (Cpx), and spinel. The peridotites were suffered from various extents of metasomatism and hydration. P-Olivine was replaced by antigorite with various extent, whereas primary Cpx was preserved without reactions. One of the notable features that is common in the peridotite is intense replacement of orthopyroxene (>60 vol.% was replaced). The mineralogy of the orthopyroxene replacement is divided into three types: secondary Cpx (S-Cpx) + tremolite (Tr), S-Cpx + tremolite (Tr) + S-olivine, S-Cpx. S-olivine shows lower Mg# (0.85-0.91) than the primary ones (Mg#=0.90-0.91), and S-Cpx shows the lower Al content and higher Mg# than the primary Cpx. Mass-balance calculation for the Opx pseudomorph showed the gains of Ca and water, and losses of silica, Mg and Fe. Due to the lack of Ca source in the primary minerals, significant amount of Ca metasomatism occurred induced by infiltration of the external fluids. The products of Ca metasomatism (S-Cpx, Tr) are commonly cut by antigorite veins, indicating that main hydration (antigorite formation) occurred after Ca metasomatism. The stability field of mineral assemblage of the Opx replacement was consistent with the P-T conditions of eclogite bodies in the Chandman area (T= 590-630 ˚C and P=11-16 kbar), implying that the hydration and metasomatism were caused by mantle wedge due to a supply of fluids derived from dehydration of the subducting slab.

Keywords: Ca metasomatism, Mantle Wedge, Orthopyroxene, Alag Khadny accretionary wedge

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Attenuated Total Reflection Infrared (ATR-IR) Spectroscopy of Antigorite, Chrysotile and Lizardite

*Ilona Talvikki Sakaguchi[1]

1. Nagoya University

Ilona Sakaguchi[1], Yui Kouketsu[1], Katsuyoshi Michibayashi[1], Simon Wallis[2]

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Distinguishing serpentine minerals antigorite, chrysotile and lizardite from a thin section can be challenging due to the similarity of their optical properties and chemical composition. Infrared spectroscopy (IR) is a method based on the characteristic absorption of infrared radiation by different chemical bonds. Since each serpentine mineral has a distinct crystal structure, infrared spectroscopy can be applied in serpentine mineral identification. Infrared radiation is also particularly strong in polar bonds making IR spectroscopy a powerful tool in studying serpentine mineral hydroxyl groups. Transmission infrared spectroscopy is the most widely used IR method but it requires time-consuming and arduous sample preparation. Using a newer method known as attenuated total reflection infrared spectroscopy (ATR-IR) can significantly reduce the sample preparation time since the measurements can be made directly from the surface of a normal thin section.

We applied the ATR-IR method to characterize antigorite, chrysotile and lizardite from samples from Mt. Shiraga serpentinite body, located in central Shikoku, SW Japan. The ATR-IR method proved to be a reliable and simple method to measure the infrared spectrum of serpentine minerals as there were clear differences in the absorbance band positions of the three serpentine minerals. However, we observed notable differences in the absorbance band positions and absorbance intensities of serpentine minerals between the ATR-IR measurements and transmission IR measurements published in previous studies. These results reflect the fact that the ATR-IR method is susceptible to spectral distortions that are caused by the dependence of absorbance intensity to wavelength and by anomalous dispersion of infrared radiation. On the other hand, spectral mapping is much more convenient in the ATR-IR method as measurements can be done from normal thin sections. We also used the ATR-IR method to map a sample with three co-existing serpentine minerals with interesting reaction textures.

ATR-IR spectroscopy, and especially ATR-IR mapping, has a lot of potential in the field of mineral spectroscopy and it could be applied in the study of a wide variety of serpentinite microstructures, such as veining and faulting. One possible research avenue would be to combine ATR-IR mapping of serpentinite microstructures to quantitative analysis of serpentine mineral hydroxyl group absorbance intensities.

Keywords: Attenuated total reflection infrared (ATR-IR) spectroscopy , Fourier-transform infrared spectroscopy (FTIR), Sanbagawa metamorphic belt, Antigorite, Chrysotile, Lizardite

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Fabric and petrological characteristics of sheared peridotites in Marion transform fault, Southwest Indian Ridge

*Kakihata Yuki[1], Katsuyoshi Michibayashi[2], Henry Dick[3]

1. Shizuoka University Graduate School of Science, 2. Nagoya University Graduate School of Environmental Studies, 3. Woods Hole Oceanographic Institution

The ultraslow spreading (14 mm/yr) Southwest Indian Ridge (SWIR) lies between the Bouvet and Rodriguez Triple Junctions. The SWIR is volcanically inactive, possibly reflecting poor advection of heat and intensive conductive cooling. Accordingly, there are only partly thin basaltic crusts, and peridotites exposed to the sea floor. Dredge surveys have been performed along the SWIR, and basalt, gabbro and peridotite specimens have been derived since 1980s.

In this study, we studied the microstructural development of 7 peridotite samples obtained from Marion Fracture Zone of the SWIR by the PROTEA cruise Leg.5 in 1983. The peridotites consisted of olivine, orthopyroxene and clinopyroxene with amphibole, plagioclase and chlorite, as well as secondary minerals such as serpentine and magnetite. The peridotites were classified into two groups based on their microstructures: 2 ultramylonites consisting of extremely fine grains (3-5 μm) with several porphyroclasts (~15 μm) and 5 heterogeneous tectonites consisting of deformed coarse-granular textures with subsequently developed fine-grained textures. In both types of peridotites, some of olivine grains had subgrain boundaries, whereas phase mixing occurred. These textural features suggest that heterogeneous textures of tectonites had been developed as lowering temperature and decreasing grain size, and subsequently became to ultramylonites.

Major element compositions of olivine and spinel indicated that these peridotites had fertile to moderately depleted mantle composition. Amphibole grains have the chemical compositions of tremolite, magnesio-hornblende and pargasite.

The ultramylonites have intensely deformed amphibole grains, whereas the heterogeneous tectonites have amphibole ranging from undeformed to highly deformed grains, indicating that amphibole formed before and/or during intensive shearing in the mantle. Moreover, olivine crystal-fabrics within the deformed amphibole bearing peridotites have B and E types developed under hydrous conditions. Consequently, the petrophysical characteristics of peridotites indicate that the uppermost mantle below the Marion transform fault has been hydrated during shearing.

Fine olivine grains in heterogeneous tectonites showed weak crystallographic preferred orientation (CPO) patterns. In contrast, those in the ultramylonites exhibited strongly concentrated CPOs. Furthermore, olivine grains were distorted more strongly in the ultramylonites than in the tectonites. These textural characteristics imply that fine-grained textures within the tectonites were deformed by mainly grain boundary sliding/diffusion creep under relatively low differential stress, whereas the ultramylonites were mainly deformed by dislocation creep under high differential stress.

Keywords: transform fault, peridotite, deformation mechanism

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Structure and formation mechanism of lithosphere-asthenosphere boundary decoded from Ichinomegata peridotite xenoliths

*Yuto Sato[1], Kazuhito Ozawa[1]

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Lithosphere-asthenosphere boundary (LAB) is one of the largest discontinuities in mantle where heat transfer mechanisms change from conduction to convection (Sleep, 2005, 2006). Various formation mechanisms of LAB have been proposed and still controversial (Green et al., 2010; Hirschmann, 2010; Hirth & Kohlstedt, 1996; Karato, 2010, 2012; O' Reilly & Griffin, 2006). Mantle xenoliths are fragments of mantle material (Nixon, 1987) and could have derived from the LAB zone and are useful to reconstruct its internal structure and to understand the ultimate cause of LAB zone and dynamic processes operated there. We have examined spinel peridotite xenoliths from Ichinomegata maar located in the back-arc side of NE Japan to address this issue (Sato & Ozawa, submitting to Ame. Min.; Sato & Ozawa, 2017, 2018, JpGU meeting; Sato & Ozawa, 2016, 2017, AGU fall meeting). We succeeded in reconstructing the structures and clarifying the formation mechanism of the LAB zone beneath Ichinomegata.

Ichinomegata maar is a latest Pleistocene andesitic-dacitic volcano yielding spinel peridotite xenoliths (Katsui et al., 1979). Diversities of thermal, chemical, rheological, and petrological features of the xenoliths have been documented by previous studies (e.g., Kuno, 1967; Kuno & Aoki, 1970; Takahashi 1980, 1986; Koyaguchi, 1986; Tanaka & Aoki, 1981; Abe et al., 1992, 1998; Abe & Yamamoto, 1999; Satsukawa & Michibayashi, 2014; Satsukawa et al., 2017). Despite the numerous data, the derivation depths of the xenoliths have never been seriously examined. We devoted our effort to geothermobarometry of spinel peridotite xenoliths, and successfully estimated derivation pressures and temperatures ranging 0.7-1.6 GPa and 828-1081 ˚C for 8 of the 9 examined xenoliths by examining the time scale of development of every chemical zoning to identify minerals, mineral portions, and chemical species attaining equilibrium as close as possible just before the xenolith extraction.

Various depth variations were clarified. The shallow mantle, ranging from 28 to 32 km, is characterized by low temperature, granular, and plagioclase- and amphibole-bearing mantle, and the deep mantle, from 41 to 55 km, by high temperature, porphyroclastic, and plagioclase- and amphibole-free and melt-bearing mantle. It is notable that the sample-derived solidus condition coincides with the depth of change of deformation microstructures. This indicates that the wet solidus controls rheological LAB zone beneath Ichinomegata. We infer that the shallow zone corresponds to lithospheric mantle and the deep zone to LAB zone.

Intimate correlations between the depth variations of absence or presence of plagioclase and amphibole and geochemical data obtained by previous studies (e.g., Tanaka & Aoki, 1981; Abe et al., 1998) enable us to reconstruct geochemical depth variation; clinopyroxene and whole-rock of plagioclase- and amphibole-bearing shallower peridotites are characterized by light rare earth element (LREE) depleted patterns, low $^{87}Sr/^{86}Sr$ ratios (~0.7027-0.7030), and high $^{143}Nd/^{144}Nd$ ratios (~0.5133-0.5134); in contrast, those of plagioclase- and amphibole-free and melt-bearing deeper peridotites by LREE enriched patterns, high $^{87}Sr/^{86}Sr$ ratios (~0.7033-0.7047), and low $^{143}Nd/^{144}Nd$ ratios (~0.5125-0.5130).

Previous studies attributed geochemical diversity to local magma-related processes beneath MOHO (e.g., Takahashi, 1980; Abe et al., 1992). However, the systematic depth variations of geochemistry indicate a

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larger-scale stratification of the upper mantle beneath Ichinomegata. We infer that the shallower geochemically depleted mantle represents oceanic lithosphere formed during Japan Sea opening and that the deeper enriched mantle represents LAB zone which formed recently through lithosphere thinning by asthenospheric upwelling. A similar scenario was proposed by Ohki et al. (1994) on the basis of temporal variations of Nd-Sr isotopes from Middle Miocene.

Keywords: lithosphere-asthenosphere boundary zone, geothermobarometry, spinel peridotite xenolith, mantle structure

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Metasomatic banding and deformation instability in the metamorphic rocks

*mitsuhiro toriumi[1]

1. Japan agency of marine science and technology

Low grade metamorphic rocks formed in the plate boundary commonly show mineral bands composed of albite, amphiboles, chlorite and epidote in basic schists, and of chlorite, albite and quartz in pelitic schists. These bands are almost monomineralic and bimineralic and parallel to subparallel against schistosity plane. Judging from the orientation of bands nearly normal to the maximum stress direction, it seems that the banding is derived from compaction banding/porosity banding induced from the non-linearity of microcrack plasticity (Toriumi and Hara, 1995), elastic modulus (Fortin et al., 2009) and preferred orientation growth of chlorite and actinolite.
In this model, the low grade metamorphic rocks deform accompanied with progressive banding of low porosity and with migration of water vertical to the banding, and it induces stability change of solution and metamorphic minerals. Chlorite may favor the compaction bands but albite does porous bands. This type of yielding shoud lower the yield stress and then the deformation instability may occur in the metasomatic process in the plate boundary rocks.
Toriumi, M., and Hara, E., 1995, Tectonophysics, 245,249-261
Fortin, J., Stanchits,S., Dresen, G., Gueguen, Y., 2009, PAGEO, Doi 10.1007/s00024-009-0479-0

Keywords: metamorphic banding, compaction banding, deformation instability

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[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

Thu. May 30, 2019 1:45 PM - 3:15 PM JST | Thu. May 30, 2019 4:45 AM - 6:15 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-VC37] Dynamics of volcanic eruptions and their physical and chemical processes

convener:Yujiro Suzuki(Earthquake Research Institute, The University of Tokyo), Chairperson:Yujiro Suzuki(Earthquake Research Institute, The University of Tokyo), Hiroyuki Shimizu(Earthquake Research Institute, The University of Tokyo)

This session discusses the dynamics of volcanic and igneous activities such as magma accumulation, magma ascent in volcanic conduits, and dispersion of volcanic products. In order to understand such multi-scale phenomena, the researches of microscopic and macroscopic scales and the techniques that combine the different scales are required. We aim to discuss the latest approaches based on the recent observations, laboratory experiments and numerical simulations, from the viewpoint of cross-cutting research.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SVC37-01] Volcanic activities triggered or inhibited by resonance of volcanic edifices to large earthquakes

*Atsuko Namiki[1], Eleonora Rivalta[2], Heiko Woith[2], Timothy Willey[2], Stefano Parolai[3], Thomas R Walter[2] (1.Graduate School of Integrated Arts and Sciences, Hiroshima University, 2.GFZ, 3.OGS)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SVC37-02] **Groundmass crystallization experiments of an andesitic pumice under low vapor pressure.**

*Yasukawa Hiroki[1], Mayumi Mujin[1], Michihiko Nakamura[1], Shizuka Otsuki[2] (1.Division of Earth and Planetary Materials Science, Department of Earth Science, Graduate School of Science, Tohoku University., 2.National Institute of Advanced Industrial Science and Technology)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SVC37-03] Decoding pre-eruptive magma evolution and water behavior from plagioclase phenocrysts: Application to the Hoei eruption of Mt. Fuji

*Tsuyoshi Iizuka[1], Chiyo Harada[1], Kenji Shimizu[2], Takayuki Ushikubo[2], Morihisa Hamada[2], Mitsuhiro Yoshimoto[3] (1.University of Tokyo, 2.JAMSTEC, 3.Mount Fuji Research Institute)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SVC37-04] Probing magmatic processes just prior to historic eruptions at Sakurajima volcano: Toward understanding “magma pre-charge”

*Naoki Araya[1], Michihiko Nakamura[1], Satoshi Okumura[1] (1.Division of Earth and Planetary Materials Science, Department of Earth Science, Graduate School of Science, Tohoku UniversityUniversity)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SVC37-05] Magmatic processes prior to the Vulcanian eruptions of Sakurajima volcano: A combined petrologic and geophysical approach

*Sakauchi Nono[2], Michihiko Nakamura[2], ATSUSHI YASUDA[1], Satoshi Okumura[2], Naoki Araya[2], Masato Iguchi[3], Daisuke Miki[3], Nobuo Geshi[4] (1.Earthquake Research Institute, University of Tokyo, 2.Division of Earth and Planetary Materials Science, Department of Earth Science, Graduate School of Science, Tohoku University, 3.Sakurajima Volcano Research Center, Disaster Prevention Research Institute, Kyoto University, 4.Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SVC37-06] Cyclic degassing behavior accompanying dome-forming lava effusion at Shinmoedake volcano in the 2018 eruption

★Invited Papers

*Taishi Yamada[1], Hideki Ueda[1], Toshiya Mori[2], Toshikazu Tanada[1] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Geochemical Research Center, Graduate School of Science, The University of Tokyo)

Volcanic activities triggered or inhibited by resonance of volcanic edifices to large earthquakes

*Atsuko Namiki[1], Eleonora Rivalta[2], Heiko Woith[2], Timothy Willey[2], Stefano Parolai[3], Thomas R Walter[2]

1. Graduate School of Integrated Arts and Sciences, Hiroshima University, 2. GFZ, 3. OGS

The existence of a causal link between large earthquakes and volcanic unrest is widely accepted. Recent observations have also revealed counterintuitive negative responses of volcanoes to large earthquakes, including decreased gas emissions and subsidence in volcanic areas. In order to explore the mechanisms that could simultaneously explain both the positive and negative responses of volcanic activity to earthquakes, we here focus on the role played by topography. In the laboratory, we shook a volcanic edifice analogue, made of gel, previously injected with a buoyant fluid. We find that shaking triggers rapid migration of the buoyant fluid upward, downward, or laterally, depending on the fluid’ s buoyancy and storage depth; bubbly fluids stored at shallow depth ascend, while low-buoyancy fluids descend or migrate laterally. The migration of fluids induced by shaking is two orders of magnitude faster than without shaking. Downward or lateral fluid migration may decrease volcanic gas emissions and cause subsidence as a negative response, while upward migration is consistent both with an increase in volcanic activity and immediate unrest (deformation and seismicity) after large earthquakes. The fluid migration is more efficient when the oscillation frequency is close to the resonance frequency of the edifice. The resonance frequency for a 30-km-wide volcanic mountain range, such as those where subsidence was observed, is ~0.07 Hz. Only large earthquakes are able to cause oscillation at such low frequencies.

Reference:
Namiki et al., Geology (2018) 47 (1): 67-70.

Keywords: Resonance

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Groundmass crystallization experiments of an andesitic pumice under low vapor pressure.

*Yasukawa Hiroki[1], Mayumi Mujin[1], Michihiko Nakamura[1], Shizuka Otsuki[2]

1. Division of Earth and Planetary Materials Science, Department of Earth Science, Graduate School of Science, Tohoku University., 2. National Institute of Advanced Industrial Science and Technology

Recently, nanoscale crystals (ultrananolite and nanolite) have been found in groundmass glasses of volcanic rocks. These crystals are thought to crystallize at very shallow part of conduit or inside lava dome. It is suggested that nanoscale crystals recorded information about eruption style transition in shallow conduit. In addition, the eruption style is assumed to be change with viscosity increase due to crystallization of nanoscale crystals. Therefore, it is imoprtant to clarify the nucleation and growth condition of nanoscale crystals for understanding volcanic eruption dynamics . Kinetics of nanoscale crystallization is, however, poorly understood compared to that of microlites. In this study, we performed the series of crystallization experiments that simulate dehydration-induced crystallization in shallow conduit and near surface conditions and investigated the crystallization condition of ultrananolite and nanolite.

As a starting material for the experiments, we used almost microlite-free andesitic pumice clasts from the 1914 (Taisho) Plinian eruption of Sakurajima volcano. The water content in the groundmass glass is approximately 0.5 wt.%. The samples were sealed in a silica glass tube and heated instantaneously to temperatures of 800, 900, 930, and 1000˚C for 3 and 30 minutes, and 2, 8 and 32 hours. When the silica glass tube was evaluated and welded shut, vapor pressure produced via degassing of the starting material is calculated to be of 0.07 (Low Vapor Pressure runs: LVPs). The higher vapor pressures were conducted at 2, 4, and 6 MPa by dehydration of brucite powder.

The mineral assemblage of the crystallized nanolite includes magnetite and pyroxene. The crystallization mode of the groundmass crystals is mostly classified into 5 types; 1) homogeneous nucleation of pyroxene in whole the sample and following growth to the size up to nanolite and occasionally microlite, 2) homogeneous nucleation of ultrananolite in whole the sample, 3) homogeneous nucleation of pyroxene and magnetite crystallization in the vicinity of plagioclase, 4) heterogeneous nucleation of pyroxene on the surface of plagioclase phenocrysts and microlites, and 5) heterogeneous crystallization of pyroxene and magnetite on the bubble surface. Appearance of these types was dependent on the experimental conditions. Magnetite nanolite crystallized under relatively high supercooling, i.e. at low H_2O vapor pressure. Pyroxene nanolite crystallized under wide temperature and pressure conditions. Ultrananolite crystallized in all the runs at 800˚C and at LVP. This indicates that ultrananolite appears under high supercooling. These results on nanoscale crystallization can be used to constrain the pressure-temperature-time paths of volcanic pyroclasts in a shallow conduit.

Keywords: nanolite, ultrananolite

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Decoding pre-eruptive magma evolution and water behavior from plagioclase phenocrysts: Application to the Hoei eruption of Mt. Fuji

*Tsuyoshi Iizuka[1], Chiyo Harada[1], Kenji Shimizu[2], Takayuki Ushikubo[2], Morihisa Hamada[2], Mitsuhiro Yoshimoto[3]

1. University of Tokyo, 2. JAMSTEC, 3. Mount Fuji Research Institute

Explosive eruptions are often accompanied by signs of mixing of felsic and mafic magmas in their eruptive products, suggesting the potential link between explosive eruptions and magma mixing. Yet, the underlying mechanism of such eruptions remains elusive. The key to this debate is understanding pre-eruptive magma evolution including water behavior in the magma and the time lag between the magma mixing and eruption.

Water behavior in pre-eruptive magma has been widely studied using melt-inclusions in phenocrysts. More recently, it has been shown that hydrogen concentration in plagioclase phenocryst can be used as a hygrometer of pre-eruptive magma (Hamada et al., 2013). Furthermore, zoning of hydrogen content in the phenocryst can be used as a high-resolution chronometer, as hydrogen diffusion in plagioclase is sufficiently fast.

Here we report the first study that combines in-situ measurements of the contents of major and trace elements, including hydrogen, in plagioclase phenocrysts using the EPMA, LA-ICP-QMS, and SIMS, respectively. These analyses were carried out on sequential eruptive products of the 1707 Hoei eruption at Mt. Fuji. The Hoei eruption is characterized by its explosivity and wide chemical variation in the eruptive products (e.g., SiO_2=50~70 wt%), and the interaction of mafic and felsic magmas has been considered as playing a role in triggering the explosive eruption (Fujii et al., 2002).

We found that the light REE concentrations of plagioclase phenocrysts split in two clusters. These results suggest that there were at least two magma reservoirs underneath Fuji volcano in which magma differentiation had individually proceeded before the Hoei eruption, and also that plagioclase phenocrysts crystallized from these individual magmas were partly mixed before or during the eruption.

Our results further reveal that most melt inclusions have lower water contents than those estimated from hydrogen contents of the host plagioclase phenocrysts and the plagioclase-melt hydrogen partitioning. This suggests that water in melt inclusion could be more easly lost by secondary events than hydrogen in plagioclase phenocryst. Measured hydrogen contents in plagioclase phenocrysts suggest that the early-erupted felsic magma contained water up to 17wt%, whereas the late-erupted mafic magma had lower contents of ~5 wt%. Moreover, the combination of REE and hydrogen contents in the plagioclase phenocrysts (Figure) revealed that the higher water contents, Ce contents, and lower Anorthite contents in the evolved magma can be attributed to fractional crystallization. Moreover, intra-grain chemical variations suggest that rapid crystallization of plagioclase likely driven by decompression accompanied by the exsolution of water occurred in the felsic magma several hours before the explosive eruption. The decompression and water exsolution may result from the convection of the felsic magma caused by the injection of the hot and water-poor mafic magma.

Keywords: plagioclase, hygrometer, magma mixing, explosive eruption, Mt. Fuji

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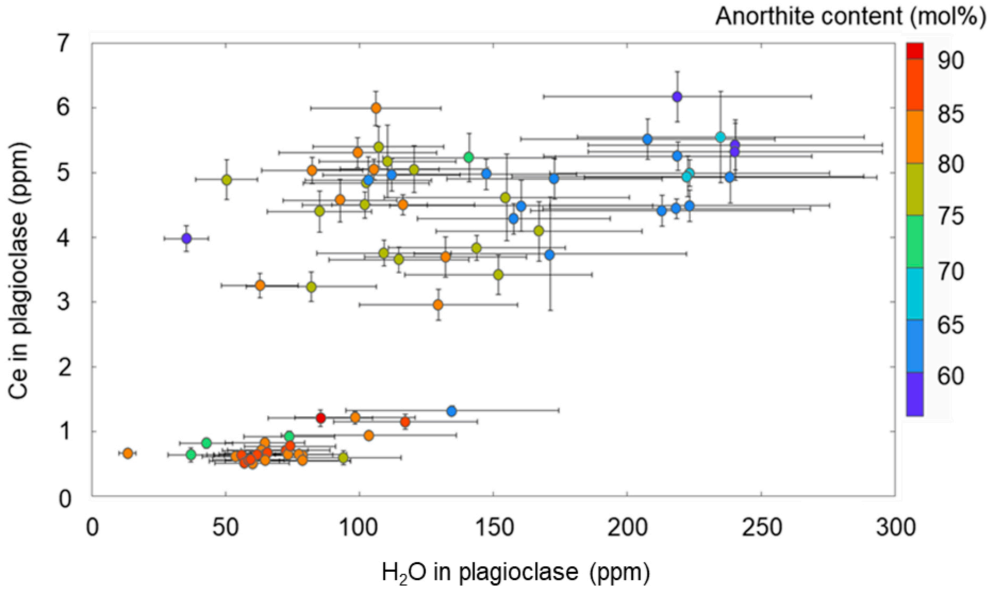


Figure: Cerium versus water contents in plagioclase phenocrysts. The plots are color-coded according to anorthite content. The water contents were calculated from the measured hydrogen concentrations in the phenocrysts.

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Probing magmatic processes just prior to historic eruptions at Sakurajima volcano: Toward understanding “magma pre-charge”

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Based on the pressure at which volatiles within phenocryst-hosted melt inclusions and plagioclase rims were finally equilibrated, Araya et al. (2019, Scientific Reports) reported that the magma storage depths immediately prior to the historic Plinian eruptions at the Sakurajima volcano (AD 1471, 1779, 1914) were much shallower (0.9–3.2 km) than those of the present magma reservoirs beneath Aira Caldera (~10 km) and Sakurajima (~4–6 km). They proposed that the Plinian eruptions were fed from a thick shallow conduit pre-charged from the magma reservoirs. How this process, “magma pre-charge”, has occurred is poorly understood because the Sakurajima case is the first report. As magma pre-charge is assumed to have occurred at least a few tens of days before each eruption, probing magmatic processes just prior to the eruptions is a key to prepare for the possible future eruption.

Magnetite is a mineral suitable for investigating short-timescale pre-eruptive processes because of its fast element diffusion (i.e., high time resolution) compared to common phenocrystic silicates. We have analysed chemical compositions of more than 300 magnetite phenocrysts in pumices and lavas from the historic eruptions. The magnetite phenocrysts showed scarce zoning in each crystal (mostly within 1 Usp mol%), while their compositional range is wide (e.g., 27–45 Usp mol% for the 1914–1915 eruption). This indicates that the eruptions had initiated from a magma reservoir heterogeneous in at least either temperature, melt composition, or oxygen fugacity, and that this heterogeneity had not been perturbed prior to the eruptions. Therefore, widely accepted models for eruption trigger, such as new magma injection and overturn of stratified magma reservoir are not likely to apply to these historic Plinian eruptions.

Keywords: Sakurajima volcano, magnetite, diffusion

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Magmatic processes prior to the Vulcanian eruptions of Sakurajima volcano: A combined petrologic and geophysical approach

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We analyzed water contents of phenocryst melt inclusions (= MIs) in the erupted materials of Vulcanian explosions from Sakurajima volcano in a period from October 30, 1975 to February 18, 2015. The 11 typical and characteristic Vulcanian explosions were selected with respect to the seismic and geodetic behaviors prior to the explosions. The water contents of 153 MIs were analyzed with FT-IR micro-reflectance spectroscopy (Yasuda, 2014). We then observed the texture of MIs and analyzed the major chemical element compositions with EMPA.

Most of the MI s have dacitic to rhyolitic compositions. The MIs in lava-type pyroclasts have lower water contents (0–1.9wt.%) than those in the scoria type (0–4.1 wt.%). This is consistent with a general view that the lava-type pyroclasts are derived from degassed and compacted magmas in a very shallow conduit. The MIs with high water contents were quenched and fragmented at deeper parts of the conduit or within short time insufficient for water re-equilibrium with surrounding melt in the shallow conduit.

The MIs in pyroclasts from the Minamidake crater have higher water contents than those from the Showa crater. The average water content of MIs in the samples from the Showa crater is 1.4 wt.%, while that from the Minamidake crater is 0.6 wt.%. This shows that the magma was ejected from the shallower part of conduit or their residence time in the shallow conduit was longer during the activity of the Showa crater, being consistent with the fact that Vulcanian explosions from the Minamidake crater were more vigorous than those from the Showa crater.

The water contents of MIs contained in the pyroclasts erupted on August 24, 1995 from the Minamidake crater were 1.9–4.3 wt.% (2.5 wt.% on average). This range of water contents is similar to those of the three historical Plinian eruptions of Sakurajima (Araya et al., 2019). This indicates that the magma ascended nearly as fast as in the Plinian eruptions, and that magma ascent rate does not solely determine the difference between Vulcanian and Plinian eruptions.

The eruption on August 24, 1995 occurred after approximately 3 months low-activity period. As a precursory phenomenon of the explosion, raid and large intrusion of magma was detected through inflation of the volcanic edifice observed with an extensometer. Five hours after the expansion started (at the time the tiltmeter scaled-out), the eruption began concurrently with the beginning of the BL swarm. In the early stage, the eruption was not accompanied by air shocks, and a fire fountain 100–200 m in height was observed, then later the activity shifted to the Vulcanian explosions with repeated air shocks. The volume of magma intruded prior to the eruption was estimated from the amount of crustal inflation to be more than 5 times as much as that of the average value for the explosions at Minamidake crater. Such a sub-Plinian-like eruption sequence on August 24, 1995 seems to be consistent with the result that the magma ascent rate was close to those of the Plinian eruptions.

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Keywords: Vulcanian explosion, Melt inclusion, Sakurajima volcano

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Cyclic degassing behavior accompanying dome-forming lava effusion at Shinmoedake volcano in the 2018 eruption

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Shinmoedake volcano, one of the most active volcanoes in the Kirishima complex in Japan, had a series of eruption in 2018. At the beginning of the eruption sequence in March 2018, Shinmoedake had a dome-forming effusive eruption. Observation networks of the National Institute for Earth Science and Disaster Resilience (NIED, V-net), the Japan Meteorological Agency (JMA), and the Geospatial Information Authority of Japan (GSJ, GEONET) around the Kirishima area detected significant ground deformation accompanying the lava effusion. The deformation can be explained by assuming a pressure source located at the same position (7 km NW from Shinmoedake, depth of 10 km) that is adopted to explain syn-eruptive ground deformation in the 2011 eruption (Ueda, 2018, VSJ). The time series of the magma chamber contraction obtained by geodetic observations provides remarkable insight to constrain the macroscopic behavior of the eruption mechanism. Here, we examine characteristics of volcanic earthquake catalogue, seismic, acoustic, tilt, SO2 gas flux measurement, and visual observation data obtained by observation networks of NIED, JMA, and University of Tokyo, to constrain detail aspects of the effusive eruption such as the magma flow regimes inside the conduit.

Hypocenters of low-frequency earthquakes accompanying the lava effusion are distributed almost vertically in the range of 0.1–3.2 km from the surface. Therefore, we assume vertical elongated conduit geometry. Syn-eruptive seismic waveforms record cyclic tremor signals with a peak frequency of about 0.8 Hz, with a duration of 5–20 minutes as well as repose time. The tremor is accompanied with explosive degassing from the crater, which is recorded by infrasound, SO2 gas flux measurement, and visual camera data. Tilt data with a bandpass filter of 250–2000 s show inflation-deflation cycles of the Shinmoedake edifice accompanying the cyclic degassing. Both inflation and deflation of the filtered tilt data correspond to the repose time and amplitude increasing of the tremor.

Some features of the cyclic degassing at Shinmoedake from our data set are summarized as follows: (1) Inflation of the volcano edifice (2) Beginning of degassing and deflation of the volcano edifice (3) End of degassing and repose time until next inflation. Such an inflation-deflation cycle is reported by Takeo et al. (2013) from observation data of lava effusion in the 2011 eruption. Dome-forming lava effusion at Santiaguito also produces such a cyclic degassing and related ground deformation (Johnson et al., 2014). The inflation prior to the degassing may have similar source physics to that related Strombolian and Vulcanian eruptions. Next our challenge is to quantify the source of those signals to estimate the amount of relating gas or magma, and relationship with the time series of the magma chamber contraction.

Acknowledgement: We appreciate the JMA to provide observation data at Kirishima area.

Keywords: Lava dome, Shinmoedake

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[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

Thu. May 30, 2019 3:30 PM - 5:00 PM JST | Thu. May 30, 2019 6:30 AM - 8:00 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-VC37] Dynamics of volcanic eruptions and their physical and chemical processes

convener:Yujiro Suzuki(Earthquake Research Institute, The University of Tokyo), Chairperson:Yujiro Suzuki(Earthquake Research Institute, The University of Tokyo), Taishi Yamada

This session discusses the dynamics of volcanic and igneous activities such as magma accumulation, magma ascent in volcanic conduits, and dispersion of volcanic products. In order to understand such multi-scale phenomena, the researches of microscopic and macroscopic scales and the techniques that combine the different scales are required. We aim to discuss the latest approaches based on the recent observations, laboratory experiments and numerical simulations, from the viewpoint of cross-cutting research.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SVC37-07] Estimation of the amplitude of infrasoundsignal based on sound diffraction

*Kyoka Ishii[1], Akihiko Yokoo[1] (1.Graduate School of Science, Kyoto University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SVC37-08] Mechanism and frequency change of pressure oscillation in the laboratory geyser system

*Noriko Teshima[1], Atsushi Toramaru[2] (1.Department of Earth and Planetary Sciences, Graduate School of Sciences, Kyushu University, 2.Department of Earth and Planetary Sciences, Faculty of Sciences, Kyushu University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SVC37-09] Effects of temperature on the run-out distance of large-scale pyroclastic density currents: Numerical simulation of a two-layer depth-averaged model

*Hiroyuki A. Shimizu[1], Takehiro Koyaguchi[1], Yujiro J. Suzuki[1] (1.Earthquake Research Institute, The University of Tokyo)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SVC37-10] **Total grain-size distribution of pumice fallout deposits (Kj-P1) from 54 ka plinian eruption at Kuju Volcano**

*Tomohiro Tsuji[1], Kishimoto Hiroshi[2], Fujita Kouji[2], Chisato Nakamura[3], Nagata Tomohiro[3], Kimura Kazunari[3], Michiharu Ikeda[1], Naoki Nishizaka[4], Kozo Onishi[4] (1.Shikoku Research Institute Inc., 2.Asia Air Survey Co. Ltd., 3.Naiba, 4.Shikoku Electric Power Co. Inc.)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SVC37-11] Estimating ashfall volumes for the 2018 Shinmoedake eruptions using the Ellipse Approximated Isopach (EAI) method - How to quantify ashfall volumes from limited ashfall observation locations

*Yasuhisa Tajima[1], Setsuya Nakada[2], Masashi NAGAI[2], Fukashi Maeno[3], Jun Oikawa[3], Teruki Oikawa[4], Yasuo Miyabuchi[5], Toshiaki Hasenaka[5], Masataka Kawaguchi[5] (1.NIPPON KOEI CO.,LTD., 2.NIED, 3.ERI, the Univ. Tokyo, 4.Geological Survey of Japan, AIST, 5.Kumamoto Univ.)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SVC37-12] Optical disdrometer measurement of tephra fall: Constraints on radar parameters for eruption cloud observations

★Invited Papers

*Tomofumi Kozono[1], Masato Iguchi[2], Takahiro Miwa[3], Masayuki Maki[4], Takeshi Maesaka[3], Daisuke Miki[2], Takeshi Nishimura[1] (1.Department of Geophysics, Graduate School of Science, Tohoku University, 2.Sakurajima Volcano Research Center, Disaster Prevention Research Institute, Kyoto University,

3.National Research Institute for Earth Science and Disaster Resilience, 4.Research and Education Center for Natural Hazards, Kagoshima University)

Estimation of the amplitude of infrasoundsignal based on sound diffraction

*Kyoka Ishii[1], Akihiko Yokoo[1]

1. Graduate School of Science, Kyoto University

Observation of infrasound signals generated from volcano eruptions provides us with important information directly reflecting explosion processes at the source. How to determine the locations of stations for acquiring clear signals has been one of the most fundamental problems for researchers. The best way to solve this problem should be a numerical simulation of infrasound wave propagation considering the propagation effect of topography (e.g., Kim & Lees, 2011; Lacanna & Ripepe, 2013). However, we have to take time and cost money to perform numerical simulations. In this study, we attempt to estimate the amplitude of infrasound signal by an easier method applying the sound diffraction theory. We replaced the cross-section of topography from the source to the station by an equivalent single screen and calculated the attenuation of the amplitude due to diffraction by the thin screen based on Macdonald's exact solution (1915). Then, our results were compared with the calculated amplitudes from 3D-FDTD simulation (Kim et al., 2015) and the observed amplitudes of 31 explosive events occurring at Showa crater, Sakurajima in September 2017. For comparison, the amplitude value was converted to the amplitude ratio with respect to the amplitude of the KUR station in the line-of-sight with the source. As a result, the amplitude ratios estimated by our method were determined at an accuracy of ±30% of the amplitude from the FDTD simulation at all stations. The amplitude ratio of our method was included in the range of the observed amplitude ratio at five stations. On the other hand, at one station, where the azimuth and distance from the source is almost similar to those of the KUR station, observation results cannot agree with the result of our method. This discrepancy suggests that the infrasound signal is affected by other effects than diffraction, such as reflection at the ground, and further study is required in the future.

Keywords: infrasound , diffraction, FDTD simulation

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Mechanism and frequency change of pressure oscillation in the laboratory geyser system

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Geysers are hydrothermal activities seen in volcanic areas, which have the similarities with volcanos in seismicity. It is known that the pressure pulses occurring inside geyser's conduit excite tremors, but the source and mechanism of the pressure pulses are still unclear. Because phenomena of natural geysers are complex due to additional factors such as the influence of atmospheric conditions, and because their interiors are hardly observed directly, simplified laboratory experiments which allow us to directly observe what are happening in the interior may be useful. In this study, we tried to reveal the mechanism of the pressure oscillation and factors controlling its dominant frequency using our fluid oscillation model and pressure and temperature data measured in our laboratory experiments.

We designed an experimental setup which reproduces cyclic eruptions of natural geysers. The setup mainly consisted of a flask and a glass tube, which correspond to natural hot water chamber and conduit, respectively. Heating the flask by the hotplate, we measured pressure and temperature in the flask, and erupted mass of each eruption. We also took video images of flask interior and water surface in the conduit with normal-speed and high-speed video cameras. From the movies of the water surface, we digitalized the vertical water column movement in the conduit using a video analysis software. We examined the effects of experimental conditions on characteristics of pressure oscillation by varying three geometric parameters of the experimental system: (i) inner flask volume, (ii) initial water level in the conduit, and (iii) cross-sectional area of the conduit.

In interpreting experimental results, we used the model proposed by Toramaru et al. (Volcanological Society of Japan 2010 Fall Meeting), in which the frequency of pressure oscillation is represented in terms of geometric parameters of the experimental system and the effective bulk modulus K* of fluid in the flask. In our experiments, it was difficult to determine correctly the effective bulk modulus K* from the movie analysis or another measurement, so we calculated the values of K* using a model to relate the pressure variation in the flask ΔP and water level in the conduit ΔL, by $AK^*/Vo = \Delta P/\Delta L$, where, A is cross-sectional area of glass tube, Vo is inner flask volume, respectively. The values other than K* were obtained from our experimental measurements. From these expressions, we calculated theoretical values of the resonance frequency and compared it with the measured values of dominant frequency of pressure oscillation.

The results showed that the measured pressure oscillation in the flask consisted of high-frequency pulses and subsequent low-frequency damped oscillation. The damped pressure oscillation had a strong inverse correlation with vertical water column movement in the conduit. From the observation of video images synchronized with pressure record, we found that the bubble formations in the flask bottom caused the pressure pulses. From an eruption to the next eruption, the dominant frequency of pressure oscillation decreased systematically. This monotonic decrease in the dominant frequency was explained by the reduction of K*, as a result of increase in the gas volume in the flask by heating. We found that the dominant frequency of pressure oscillation varied depending on experimental conditions. The variations in temporal behavior of dominant frequency could be interpreted by differences in the setting of

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geometric parameters and in the initial values of K* just after eruptions due to various erupted masses of the preceding eruptions.

In conclusion, the pressure oscillation in the experimental geyser system is caused by bubble formations in the flask and vertical water column movement in the conduit. The dominant frequency of pressure oscillation is controlled by the geometric parameters of the experimental system and the erupted mass of the preceding eruption.

Keywords: Laboratory experiment, Geyser, Pressure oscillation, Fluid oscillation, Frequency change

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Effects of temperature on the run-out distance of large-scale pyroclastic density currents: Numerical simulation of a two-layer depth-averaged model

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During large-scale explosive volcanic eruptions, a mixture of volcanic particles and gas is continuously ejected from the volcanic vent and can flow along the ground surface as a pyroclastic density current (PDC). Understanding the relationship between the run-out distance of PDC (i.e., the extent of PDC deposits) and the eruption conditions (e.g., the magma discharge rate and the temperature of erupted mixture) is desired to mitigate volcanic hazard associated with explosive eruptions. This study aims to clarify the effect of temperature on the run-out distance of large-scale PDCs on the basis of numerical simulations. The effect of temperature is a key issue, because it closely relates to the eruption style; the temperature ranges from less than 500 K for phreatomagmatic eruptions to more than 1000 K for magmatic eruptions.

Generally, the run-out distance of PDC is affected by the vertical stratification of particle concentration in PDC; it is determined by lift-off of the upper dilute part (particle concentrations < 1 vol.%) or deposition of the lower dense part (~ 10—50 vol.%). To reproduce the run-out distance of a density current with a strong density stratification, we have developed a new two-layer depth-averaged model. In order to evaluate the effects of temperature on the PDC dynamics, our model considers entrainment of ambient air into the upper dilute current, and thermal expansion of the entrained air. We assumed that a homogeneous dilute current is steadily supplied during time > 0 from the source vent on a horizontal ground surface. We performed a parametric study for various temperatures of the dilute current at the source (400—1200 K).

The numerical results show that, as a dilute current spreads radially from the source, the current density decreases through particle settling, air entrainment, and thermal expansion of the entrained air. When the frontal region of the dilute current becomes lighter than the ambient air to reverse buoyancy and lift off, the dilute current stops forward propagation and converges to a steady state (the distance between whose front position and the source position is referred to as $r_{\infty U}$). Particles settling from the base of the dilute current form a thin dense current, which also spreads radially. As the radial mass flux of the dense current at the front balances the basal deposition rate, the dense current stops forward propagation and converges to a steady state (the distance between whose front position and the source position is referred to as $r_{\infty L}$). The result of the parametric study shows that the relative magnitude between $r_{\infty U}$ and $r_{\infty L}$ depends on the temperature: $r_{\infty U}$ is shorter than $r_{\infty L}$ in high-temperature cases (> 600 K) whereas $r_{\infty U}$ is longer than $r_{\infty L}$ in low-temperature cases (< 600 K). This variation comes from the fact that the lift-off distance of the dilute current (i.e., $r_{\infty U}$) significantly increases as the temperature decreases, because thermal expansion of entrained air is suppressed with the decreasing temperature. The results of the low-temperature cases (i.e., $r_{\infty U} > r_{\infty L}$) explain the observation that stratified surge deposits originated from dilute PDCs are widely observed in the deposits of phreatomagmatic eruptions.

Keywords: Pyroclastic density current, Two-layer model, Run-out distance, Temperature of erupted material, Magmatic eruption, Phreatomagmatic eruption

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Total grain-size distribution of pumice fallout deposits (Kj-P1) from 54 ka plinian eruption at Kuju Volcano

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Constraining physical parameters (e.g. Total grain-size distribution; TGSD) of tephra dispersion and deposition from explosive volcanic eruptions have been studied using observation and analyses of deposits of recent eruptions. However, TGSD of old tephra deposit is a significant challenge and has been rarely studied, because of the difficulty of measuring grain size of altered pumice particles and lack of observation. In this study, to estimate TGSD of VEI5 dacitic plinian explosive eruption occurred at 54 ka at Kuju volcano, we conducted geological survey and grain size analyses for the Kj-P1 pumice fall deposit.

Based on grain-size distribution, maximum pumice size and components, Kj-P1 pumice fall deposit is divided into finer lower and coarser upper layer. We analyzed each grain-size distribution for the lower and upper layers.

Generally, sieving and laser-diffraction analysis have been used for measuring grain-size of tephra and we also used these methods. However, because the upper layer of Kj-P1 has been altered and lumped, it can be hardly separated. In addition, because the altered pumice particle could be broken into finer particles under water, we cannot measure accurate grain sizes. Then, we challenged a new method, image analysis, outlining pumice particles on photographs of outcrops and measure the sizes and area ratio of each pumice particles. We combined the results of the image analyses, sieving and laser-diffraction analyses at 15 and 20 localities for the lower and the upper layers. Using volonoi distribution, Md phi and sigma phi are calculated to be -1.5 and 2.5 for the upper layer and 0.5 and 2.6 for the lower layer. The result fit the observation of altered pumice particles at the outcrops better than the result without the image analyses. To verify this method, analytical methods such as numerical simulation are needed.

Keywords: grain size distribution, Kuju Volcano, plinian eruption, pumice fall deposit

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Estimating ashfall volumes for the 2018 Shinmoedake eruptions using the Ellipse Approximated Isopach (EAI) method - How to quantify ashfall volumes from limited ashfall observation locations

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A volcanic ash eruption began on March 3, 2018 at the Shinmoedake Volcano, in the Kirishima Volcanoes Group. Eruption activity increased to March 5, and lava flow was observed on March 6. Eruptions continued until June 27. We observed volcanic ashfall amounts around the Shinmoedake Volcano and analyzed volcanic ashfall volumes for each eruption using the EAI method (EAI ashfall volume) proposed by Tajima et al. (2013). The EAI method can be used in four different ways. Firstly, ashfall volume is estimated based on one ashfall deposit data point. Second, the estimation is undertaken using two ashfall deposit data points. Third, the estimation is based on three ashfall deposit data points. Fourth, the estimation is based over four ashfall deposit data points.

Tajima et al. (2013) suggest that if an accurate calculation axis and an accurate aspect ratio of a distribution are determined, we can calculate the total volume of ashfall deposit using the EAI method using only one ashfall deposit data point. The calculation axis for the ellipse must be accurate, but it is difficult to determine an accurate calculation axis from the observation. Tajima et al. (2013) determined the lower threshold of detectable ashfall as 0.1 g/m^2 for an eruption of the Sakurajima Volcano. This lower threshold of detectable ashfall value is used in this calculation. The EAI method is used based on one data point calculation, and we have taken a suitable aspect ratio of the ellipse which is fitted between the EAI isopach from 0.1 g/m^2 and a limit location of detectable ashfall. We calculated ashfall deposit volumes for the period of eruption from 11 am on March 1 to 7 am on March 2.

Next, we demonstrate a calculation using two data points. Tajima et al. (2013) suggest, if an accurate axis of the ellipse distribution is determined, we can calculate an EAI ashfall volume of the deposit using two ashfall data points. In this case, we would need a limit location of a detectable ashfall deposit, because it is difficult to determine an accurate calculation axis. In this case we select two ashfall deposit data points for the EAI calculation, then we determine a suitable axis which is fitted between the EAI isopach as 0.1 g/m^2 and a limit location of visible ashfall. In this way, we estimated the EAI ashfall volume of the eruption at 15:58 pm on March 9. For comparison, we observed a limit location of visible ashfall on a car.

We show a calculation procedure for three ashfall deposit data points. This is a normal calculation case shown by Tajima et al (2013). We select two ashfall deposit data values for the EAI calculation, and determine a suitable axis to fit the observation points and the calculated distribution. However, sometimes it is take the over or under estimated volume from the calculation, because estimation of EAI ashfall volume can be influenced by environmental variables, such as wind direction changes, depositional conditions of ash-fall, and other research conditions. Lastly, we demonstrate the estimation of ashfall deposit volumes using four ashfall deposit data points. In this case, we select two ash-fall values for the EAI calculation. We determined a suitable axis which best fits the observation points and the calculated distribution. Using four ashfall deposit data points improves accuracy.

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It is determined the EAI ashfall volumes of over 10 eruptions of the 2018 Shinmoedake eruptions. We assume that the eruption rate of each volumes per an hour increased before the lava flow producing. We will discuss the accuracy of the EAI method and the practical applications of this method.

Keywords: Shinmoedake, ash fall, EAI

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Optical disdrometer measurement of tephra fall: Constraints on radar parameters for eruption cloud observations

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A tephra fallout process during a volcanic eruption has mainly been investigated by geological method such as based on measurement of mass and grain size distribution on tephra deposits. Recently, a combination of the tephra fallout deposit data with numerical simulations of tephra dispersal and fallout contributes to understanding the detail of the eruption dynamics. In order to further promote the combination between the simulations and the observations, we need multi-parameter observations of the eruptive phenomena with high-time resolution which is comparable with the timescale of the eruption. One of the methods for the high-resolution observations is to apply techniques already used in other fields, such as precipitation measurements by weather radar and disdrometer in meteorology. In this study, we investigated the main characteristics of tephra fall from the eruptions at Sakurajima volcano in southern Kyushu, Japan by using a laser based optical disdrometer, Parsivel.

The disdrometer measurements were carried out for two years at one station located 2.5 km south of Showa crater of Sakurajima volcano, and made it possible to detect 76 tephra fall events, in which particle size and fall velocity were simultaneously measured with one-minute sampling interval. We found that the tephra fall can be easily distinguished from precipitation because of a notable feature of the tephra fall that both the particle size and the fall velocity gradually decrease with time during each event. The detected events were compared with the information about the direction of eruption cloud which is reported in eruption list by JMA, and it was found that the detection rate of the tephra fall during the eruptions with south-directed eruption cloud is about 7 times higher than that with other directions. Furthermore, the feature of the temporal changes in the size and the velocity was also most obvious in the case of south-directed eruption cloud. These indicate that the disdrometer can successfully measure the tephra fall directly reaching from the crater location to the station, and that the disdrometer measurements at multiple stations covering all directions may provide valuable information about the tephra dispersion and eruption cloud dynamics.

By using the tephra fall events, we obtained a quantitative relationship between the particle size and fall velocity. The cumulative weight of the tephra fall during one event was also measured by digital electric scale set close to the disdrometer, which enabled us to calculate the density of the particles. On the basis of the size-velocity relationship and the particle density data, we can estimate morphological parameters of volcanic particles in models of terminal fall velocity in previous studies. Furthermore, the tephra size and fall velocity data enabled us to calculate a particle size distribution per unit volume and size class, and we found that this distribution is well explained by exponential distribution. In the case of precipitation, the value of exponent is modeled as a function of the amount of rain fall. When we estimate the exponent as a function of the amount of the tephra fall using the same manner as precipitation, it was found that the exponent is smaller than that for precipitation. Because the size-velocity relationship and the particle size distribution are important parameters for radar analysis, the formulation and parametrization for its relationship and distribution in this study can be utilized for eruption cloud observations by weather radar.

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Keywords: Tephra size , Tephra fall velocity, Parsivel, Particle size distribution, Vulcanian eruption

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[J] Oral | S (Solid Earth Sciences)：S-TT Technology & Techniques

Thu. May 30, 2019 10:45 AM - 12:15 PM JST | Thu. May 30, 2019 1:45 AM - 3:15 AM UTC | A11 TOKYO BAY MAKUHARI HALL

[S-TT43] seismic monitoring and processing system

convener:Takahiro Maeda(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Masanao Shinohara(Earthquake Research Institute, The University of Tokyo)

This session covers scientific and technical issues in seismic monitoring or data processing systems for earthquakes or explosions observation. This includes development or improvement of seismic observation networks, innovative techniques in observation and monitoring, cutting-edge data acquisition and processing techniques in geophysical explorations. Other topics related to geophysical observation are also welcome.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[STT43-01] Summary and Considerations about Characteristics of Borehole Stress Meter for Continuous Observation

*Hiroshi Ishii[1], Yasuhiro Asai[1] (1.Tono Research Institute of Earthquake Science, Association for the Development of Earthquake Prediction)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[STT43-02] Seismic monitoring by an autonomous robotic float equipped with a hydrophone: MERMAID

*Masayuki Obayashi[1], Hiroko Sugioka[2] (1.Japan Agency for Marine-Earth Science and Technology, 2.Department of Planetology, Kobe University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[STT43-03] Earthquake observation in a borehole over 250 °C using high temperature optical fiber and DAS technology

*Tsunehisa KIMURA[1] (1.Schlumberger)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[STT43-04] Distributed Acoustic Sensing measurement by using seafloor optical fiber cable system off Sanriku for dense seismic observation

*Masanao Shinohara[1], Tomoaki Yamada[1], Takeshi Akuhara[1], Kimihiro Mochizuki[1], Takeo Kasajima[2], Takahiro Arioka[2], Masayuki Hamakawa[3], Shunsuke Kubota[4] (1.Earthquake Research Institute, University of Tokyo, 2.Fujitsu Laboratories Ltd., 3.Fujitsu Limited, 4.YK Giken Co., Ltd.)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

Discussion

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

Discussion

Summary and Considerations about Characteristics of Borehole Stress Meter for Continuous Observation

*Hiroshi Ishii[1], Yasuhiro Asai[1]

1. Tono Research Institute of Earthquake Science, Association for the Development of Earthquake Prediction

Summary and Considerations about Borehole Stress Meter for Continuous Observation

We will explain the following items
1. Stress Meter can Observe both Stress and Strain
2. Stress unlike Strain can be Derived without Knowing an Elastic Constant
3. Why is Observed Elastic Invariants Similar with Vertical Component ?
4. How High Resolution Does a Stress Meter Have ?
5.How Wide Observation Range Does a Stress Meter Have ?

Keywords: Borehole Stress Meter for Continuous Observation, Observation of both Stress and Strain, Wide Observation Range, Similarity of Elastic Invariants and Vertical Component , High Resolution

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Seismic monitoring by an autonomous robotic float equipped with a hydrophone: MERMAID

*Masayuki Obayashi[1], Hiroko Sugioka[2]

1. Japan Agency for Marine-Earth Science and Technology, 2. Department of Planetology, Kobe University

Seismic monitoring in the oceans has been limited to rather localized experiments such as ocean bottom seismometers (OBSs) and moored hydrophones. Because about 70% of the Earth is covered by water, advances in seismic monitoring depend on the development of radically new instruments, capable of providing seismic data all over the ocean. Recently a new instrument, named MERMAID (Mobile Earthquake Recording in Marine Areas by Independent Divers), was developed to measure acoustic signals converted from seismic waves at the seafloor. The MERMAID is an autonomous robotic float equipped with a hydrophone and drifts passively at 1,500 −2,000 m depth until an earthquake signal is detected. If this is identified as a strong P wave, the MERMAID ascends at speed of 10 cm/s for transmission of the recorded waveform within time window of a hundred seconds before and after the P wave arrival as well as its global positioning system coordinates at the surface. After transmitting the data via satellite links, the MERMAID descends at speed of 5 cm/s to monitor earthquake signals at 1,500 −2,000 m depth again. Therefore we are able to obtain seismograms from the ocean in quasi-real time. Under an international project collaborated among Japan, France, United States and China, we planed to deploy more than 40 drifting buoys with hydrophone to image the detail of the South Pacific mantle plume that is one of two huge mantle plumes from the base of the mantle. As part of this project, we deployed drifting floats in the South Pacific during the 1st leg of MR18-06 cruise. We will show the obtained seismograms and discuss their quality.

Keywords: seismic monitoring in the ocean, underwater acoustic wave, float, hydrophone

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Earthquake observation in a borehole over 250 ˚C using high temperature optical fiber and DAS technology

*Tsunehisa KIMURA[1]

1. Schlumberger

DAS (Distributed Acoustic Sensing) technology has been used to meet the demands of pipeline monitoring and intrusion detection in Oil & Gas business since 2011. The latest optical fiber sensing technology using differential phase data called “hDVS” (heterodyne Distributed Vibration Sensing), now enables DAS to record seismic signal including VSP (Vertical Seismic Profiling)[1)]. Three-dimensional imaging can also be performed by a 3DVSP method[2)]. We have introduced the observation of natural earthquakes and waves, targeting the tsunami detection, using the hDVS device at recent meetings of JpGU and the seismological society of Japan (SSJ)[3)].

Late 2018, we conducted an experiment of natural earthquake observation using the hDVS system at the geothermal well in Japan. A high temperature optical fiber logging cable with 300 ˚C rating was run in a deviated well having a maximum depth of about 1,600 m and connected the third generation hDVS acquisition system to the optical fiber (single mode fiber) and recorded natural earthquake events for 5 days. The maximum temperature recorded at a depth of about 900 m was more than 250 ˚C. Under such a high temperature environment, almost all electronic, electric and magnetic sensors including seismometers cannot operate for a long time. Even with the use of DAS equipment, there is no precedent as far as I know, at least it is the first attempt in Japan.

A weight of 2 m length and 25 kg weight was attached to the high temperature optical fiber logging cable, and the observation was started by lowering the weight to the depth of 977 m inside the casing in order to avoid the weight becoming stuck in the open hole section of the well. With continuous recording with 60 seconds as one file, data of 975 m section from the surface was recorded for 5 days. In this paper, we report on the result of verifying how much observation of natural earthquake waves can be performed by using continuous measurement data.

During the observation period, we succeeded in capturing six natural earthquake events. Two of them were medium-scale earthquakes published in the earthquake information of the Japan Meteorological Agency (JMA). An example of this was recorded as follows.

(21st of November, 2018 04:09:49.9 Latitude 30˚24.0'N Longitude 130˚9.0'E 123km depth M5.2)

Earthquake data recorded by hDVS is shown in Fig. 1.

The arrival time of the P-wave analyzed from the waveform is 4:10:12.2 JST on 21st of November at the deepest part of the borehole and 4:10:12.5 JST near surface. Measurement parameters were gauge length 4 m, spatial sampling 1 m, and sampling period 1 msec. We also conducted reprocessing to change the gauge length and confirmed that data with higher S/N can be obtained. Reprocessing the raw data for an optimized gauge length is a capability that is unique to hDVS amongst the available DAS techniques.

We also compared it with continuous seismometer records by NIED (Hi-net). The nearest Hi-net station

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from the wellsite (just about 4km away), is compared with the recorded hDVS data, and it was found that they match well. For small earthquake events, S/N was higher in the measurement data of hDVS in some cases, which will be shown during the presentation.

It was confirmed that hDVS/DAS system can be used to monitor natural earthquake events while monitoring the reservoir or other purpose under very high-temperature condition such as geothermal well or very deep well that reaches a mantle, if the condition of the optical fiber is good.

Acknowledgements: JMA and NIRD data are used as a reference earthquake data for comparison. We thank these organizations.

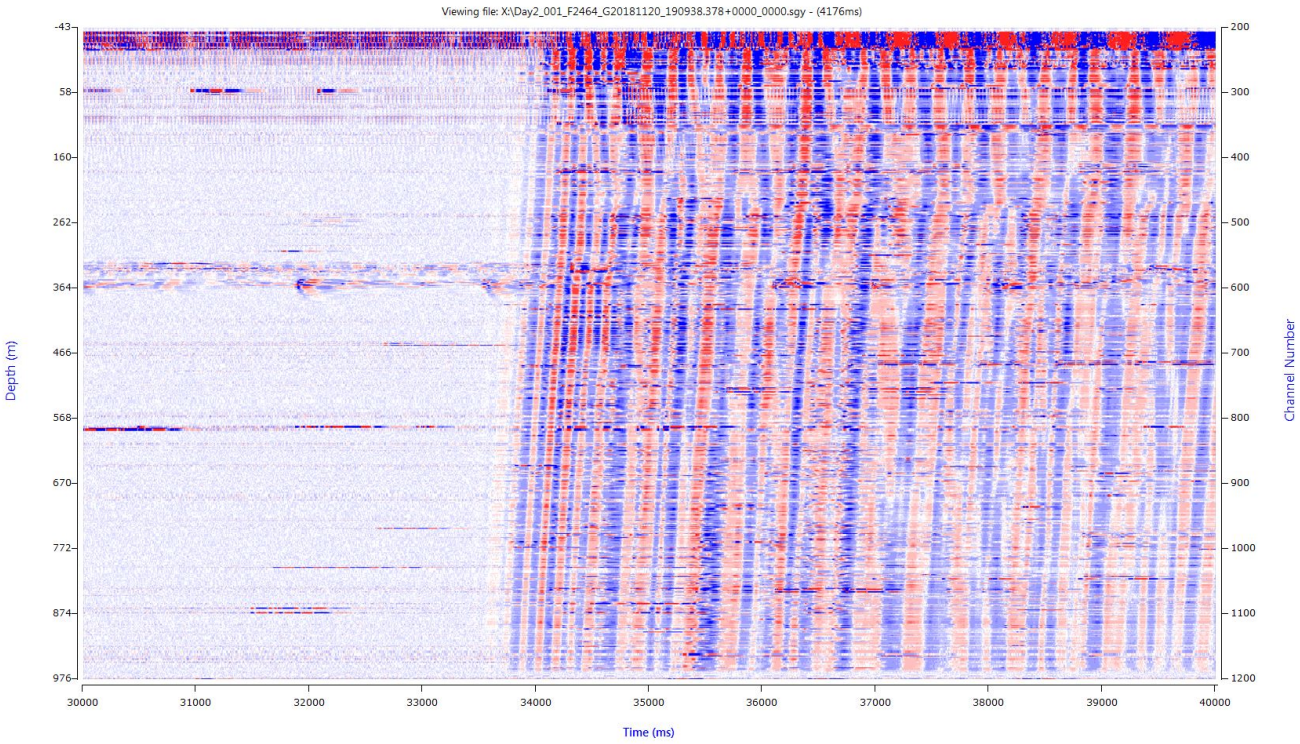
References:

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2) Kimura, T. et al, Hybrid 3D VSP Using Fiber-Optic Technology and a Conventional Borehole Seismic Array Tool, EAGE Copenhagen 2018 (Th H 10) Extended Abstract.

3) Kimura, T., Kobayashi, Y., Naruse, R., and Xue, Z., Earthquake events monitoring in a well using Optical Fiber and DAS Technology, JpGU 2018 (STT50-04), Kimura, T., Summary of Earthquake Events Recorded in Japan using DAS Technology, and Future Vision, SSJ 2018 (S02-P12).

Keywords: DAS, hDVS, optical fiber, high temperature, seismic monitoring, earthquake



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Distributed Acoustic Sensing measurement by using seafloor optical fiber cable system off Sanriku for dense seismic observation

*Masanao Shinohara[1], Tomoaki Yamada[1], Takeshi Akuhara[1], Kimihiro Mochizuki[1], Takeo Kasajima[2], Takahiro Arioka[2], Masayuki Hamakawa[3], Shunsuke Kubota[4]

1. Earthquake Research Institute, University of Tokyo, 2. Fujitsu Laboratories Ltd., 3. Fujitsu Limited, 4. YK Giken Co., Ltd.

Recently Distributed Acoustic Sensing (DAS) measurement which utilizes an optical fiber itself as a sensor becomes popular for security surveillance, monitoring of oil pipe line system. etc. In addition, DAS measurement begins to be applied to seismic prospecting such as vertical seismic profiling for an exploration of energy resources. As DAS measurement is thought to be useful for earthquake observation, there is a trial to observe an earthquake using a seafloor optical fiber. DAS measurement is one of optical fiber sensing technologies. A coherent laser pulse with short duration is transmitted continuously to a single mode optical fiber, and backscattered light is observed. When a small deformation of a fiber occurs by a vibration near fiber, a pattern change of the backscattered light is observed. Travel time of light and pulse length correspond to distance of measurement point and spatially resolution, respectively. Spatially resolution is 1 - 20 m in the highest case. From these characteristics, DAS measurement enables a linear array seismic observation. A length of the array with short sensor interval corresponds to that of a deployed optical fiber. Using the present technology, the maximum length of a DAS measurement reaches more than 70 km. On the other hand, development of data processing is needed because the principle of measurement by the DAS differs from that of conventional seismic measurement using a pendulum. In 1996, a seafloor seismic tsunami observation system using an optical fiber cable was deployed off Sanriku by Earthquake Research Institute, the University of Tokyo. The system still continues the observations experiencing an interruption by a damage of the 2011 Tohoku-oki earthquake. The system has six spare (dark) optical fibers for future extension. The length of dark fibers is about 120 km without a repeater. The dark fibers are suitable for DAS measurement due to dispersion shifted single mode fiber. Therefore we start development of a seafloor seismic observation system by the DAS technology with Sanriku cable observation system as a next generation of marine seismic observation system. The observation system using the DAS measurement can increase spatial resolution on seafloor seismic observation. In February 2019, we made a pilot observation of DAS measurement using a dark fiber of Sanriku seafloor observation system. An interrogator was installed in the landing station temporarily, data were recorded continuously for 100 km length with spatial resolution of 10 m or 40 m and sampling frequency of about 500 Hz. As a result, earthquakes including small local earthquakes occurring near the cable system, deep earthquakes were recorded. We will develop data processing using the obtained data.

Keywords: Seafloor optical cabled observation system off Sanriku, Distributed Acoustic Sensing (DAS) measurement, High dense seafloor seismic observation

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Thu. May 30, 2019 10:45 AM - 12:15 PM JST | Thu. May 30, 2019 1:45 AM - 3:15 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[S-CG52] Petrology, Mineralogy & Resource Geology

convener:Tatsuo Nozaki(Research and Development Center for Submarine Resources, Japan Agency for Marine-Earth Science and Technology), Satoshi SAITO(Graduate School of Science and Engineering, Ehime University), Koichi Momma(National Museum of Nature and Science), Nobutaka Tsuchiya(Department of Geology, Faculty of Education, Iwate University), Chairperson:Tatsuo Nozaki(JAMSTEC), Satoshi Saito

We widely invite presentations in the fields of petrology, mineralogy and resource geology. Especially description of minerals and rocks, investigation of their origin and evolution by field investigation and/or laboratory experiments, and development of new methods are accepted.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SCG52-01] Coordinated sample preparation with cryo-FIB-SEM and X-ray CT: Applications to chemical analysis for fluid inclusions in minerals

*Yu Kodama[1], Naotaka Tomioka[2], Tatsuhiko Kawamoto[3], Junichiro Kuroda[4], Masafumi MURAYAMA[5], Motoo Ito[2] (1.Marine Works Japan Ltd., 2.Kochi Institute for Core Sample Research, JAMSTEC, 3.Department of Geoscience, Faculty of Science, Shizuoka University, 4.Atmosphere and Ocean Research Institute, the University of Tokyo, 5.Faculty of Agriculture and Marine Science, Kochi University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SCG52-02] Feasibility Study for Precise Particle Characterization of Fine Clay Particle Using An Automated Particle Image Analysis and Nanotrakcking Analysis.

*Daisuke Sasakura[1], Aiko Hayauchi[1], Sho Kimura[2] (1.MalvernPanalytical Japan ,Div of Spectris Co.Ltd,., 2.Faculty of Agriculture, University of the Ryukyu)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SCG52-03] Crystal structure and local structures of natural perovskite-type (Na,REE,Ca)(Ti, Nb)O_3 loparite by single crystal diffraction and XAFS analyses

*Ginga Kitahara[1], Akira Yoshiasa[1], Makoto Tokuda[1], Kazumasa Sugiyama[2] (1.Kumamoto University, 2.Tohoku University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SCG52-04] Crystal Size Distributions based on crystal habit of groundmass pyroxene crystals in the ejecta of the Shinmoedake 2011 eruption

*Shota Okumura[1], Mayumi Mujin[2], Akira Tsuchiyama[1], Norimasa Shimobayashi[1], Akira Miyake[1] (1.Department of Geology and Mineralogy, Graduate School of Science, Kyoto University, 2.Division of Earth and Planetary Materials Science, Department of Earth Science, Tohoku University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SCG52-05] Petrochemistry and zircon U-Pb age of ``lateritic'' metamorphic rocks from the Kitakami Mountains

*Nobutaka Tsuchiya[1], Yamato Kumagai[1], Tatsuro Adachi[2], Nobuhiko Nakano[2], Yasuhito Osanai[2] (1.Department of Geology, Faculty of Education, Iwate University, 2.Department of Earth Sciences, Faculty of Social and Cultural Studies, Kyushu University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SCG52-06] How to make 'syn-plutonic dike' - - - Another story from the Ryoke granitic province, Southwest Japan

*Takashi Nakajima[1], Hiroyuki Kamiyama[2], Ian S. Williams[3] (1.Geological Survey of Japan, 2.Ueyama-Shisui, Co. Ltd., 3.Australian National University)

Coordinated sample preparation with cryo-FIB-SEM and X-ray CT: Applications to chemical analysis for fluid inclusions in minerals

*Yu Kodama[1], Naotaka Tomioka[2], Tatsuhiko Kawamoto[3], Junichiro Kuroda[4], Masafumi MURAYAMA[5], Motoo Ito[2]

1. Marine Works Japan Ltd., 2. Kochi Institute for Core Sample Research, JAMSTEC, 3. Department of Geoscience, Faculty of Science, Shizuoka University, 4. Atmosphere and Ocean Research Institute, the University of Tokyo, 5. Faculty of Agriculture and Marine Science, Kochi University

Hydrothermal fluids and seawater are often entrapped in minerals as fluid inclusions in crustal/mantle materials, marine halites and even in rare meteorites [1, 2, 3, 4]. The chemical compositions of fluid inclusions and mineral inclusion therein are keys to decipher their origins and evolution of the geofulids. A laser-ablation inductively-coupled-plasma mass-spectrometry (LA-ICP-MS), a Raman spectrometry and an environmental SEM (cryo-SEM with EDS) are methods for chemical analysis of fluid inclusions, entrapped tiny minerals and gasses. For example, Kawamoto and coworkers recently determined Na/K ratio of fluid inclusions in olivine crystals from mantle xenoliths from the Pinatubo volcano by LA-ICP-MS in 20-μm spatial resolution [1]. The attempt successfully provided new insight on the fate of seawater subducting into the mantle in a plate convergent region. Lowenstein et al. investigated major chemistry of fluid inclusions from marine halites by a cryo-SEM with EDS system, and found systematic and oscillating changes in Phanerozoic seawater chemistry (Na^+ vs. Cl^- and Mg^{2+} vs. Cl^-) [3].

As unique sample preparation and analytical approach to a fluid inclusion, combined instrument of focused ion beam system and scanning electron microscope with a cryo sample stage (cryo-FIB-SEM) is recently utilized (e.g., Yoshida et al., 2018 [2]). Fluid inclusions can be exposed as ices in the vacuum sample chamber of cryo-FIB-SEM, and then the frozen fluids can be directly analyzed by EDS attached to SEM. Advantages of this approach are a direct access to fluid inclusions by precise sample milling with FIB, and simultaneous analysis for major elements with a relatively high spatial resolution (~5 μm). The method has been first applied to fluid inclusions in quartz [2].

A cryo-FIB-SEM approach is, however, time-consuming: entire processing and analysis with cryo-FIB-SEM requires several to few tens of hours for a several tens micrometer-sized sample. Descriptions of exact locations and spatial distribution of each fluid inclusion in host minerals will help to minimize a processing time with FIB. We, therefore, used a laboratory-based micro-focus XCT apparatus (μXCT) at the Center for Advanced Marine Core Research, Kochi University for acquiring an accurate three-dimensional characterization of fluid inclusions in minerals with a spatial resolution of 0.5 to 2.5 μm depending on sample size. In the present study, we aim to improve the throughput of the fluid inclusion analysis using cryo-FIB-SEM and establish a reasonable analytical flow. We have obtained spatial distributions of fluids in olivine from the Pinatubo xenoliths and those in halite in Sicilian rock by μXCT. Pretreatments for the samples have been carried out by micro-sampling system, and then microfabrication and chemical analysis of frozen fluids in the samples have been carried

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out by cryo-FIB-SEM.

In this talk, we will present the effectiveness of coordinated sample preparation utilizing cryo-FIB-SEM and μXCT, and a comprehensive microanalysis of fluid inclusions in addition to cryo-FIB-SEM. For instance, residues of fluid inclusions and associated minute minerals in FIB-processed samples can be further characterized in a higher spatial resolution by an analytical transmission electron microscope (TEM) and a secondary ion mass spectrometer (SIMS).

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[2] Yoshida, K., Orozbaev, R., Hirajima, T., Miyake, A., Tsuchiyama, A., Bakirov, A., Takasu, A., Sakiev, K. (2018). Micro-excavation and direct chemical analysis of individual fluid inclusion by cryo-FIB-SEM-EDS: Application to the UHP talc-garnet-chloritoid schist from the Makbal Metamorphic Complex, Kyrgyz Tian-Shan. Geochemical Journal, 52(1), 59-67.
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[4] Zolensky, M. E., Bodnar, R. J., Gibson, E. K., Nyquist, L. E., Reese, Y., Shih, C. Y., & Wiesmann, H. (1999). Asteroidal water within fluid inclusion-bearing halite in an H5 chondrite, Monahans (1998). Science, 285(5432), 1377-1379.

Keywords: cryo-FIB-SEM-EDS, fluid inclusion, micro-focus X-ray CT

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Feasibility Study for Precise Particle Characterization of Fine Clay Particle Using An Automated Particle Image Analysis and Nanotrakcking Analysis.

*Daisuke Sasakura[1], Aiko Hayauchi[1], Sho Kimura[2]

1. MalvernPanalytical Japan ,Div of Spectris Co.Ltd,., 2. Faculty of Agriculture, University of the Ryukyu

Introduction

Clay minerals are very common in soils, in fine-grained sedimentary rocks such as shale, mudstone, and siltstone and in fine-grained metamorphic slate and phyllite. Typical mechanism to generation of clay is alteration of the surface on mineral rock due to affected by transfer of water on the earth surface. Behavior of generation of clay is controlled by surface of minerals be forced to transform to other mineral component due to the moment contact with water. Particle size of clay minerals are usually ultrafine-grained, such as normally considered to be less than 2 micrometers in size on standard particle size distributions. Notable properties of clay are high-affinities with water, minerals due to unique properties of possible to make intercalation in crystal structure, and possibly disperse to anywhere with moving of water on earth surface due to fine particle size range. Therefore, to understand characteristics of clay is possible to consider as a maker index parameter of material transportation on the surface of earth. Especially particle characterization of clay is promising as fundamental parameter. Existing approaches to characterize of particle are such as an electron microscope (Scanning type: SEM, Transmission type :TEM) , an optical microscope (OM) , a laser diffraction (LD), an electro zone methods (coulter counter) and a dynamic light scattering (DLS) . However, drawbacks of these methods were such as indirect method, limited work on concentration determination, time consuming to measure over than several thousand particles and requirement to highly concentration (over than 3wt%) of ionized water. Complementally analytical approach using an automated particle image analysis (APIA) and Nanotracking analysis (NTA) are promising tools to as new flamework. In this report will be discuss for feasibility and technical discussion to applicable for fine clay using this flamework.

Material and Methods.

As model samples for clay mineral, purchased Kaolin was used. To investigate purity and chemical components using crystal structure , XRD (Aereris , MalvernPanalytical , Almero, Netherlands) was used. Profile of XRD chart suggested diffraction peaks on 9.6, 19.3, 19.9, and 29.1 degrees. These peaks were significantly suggested as Pyrophyllite using library search.To characterize micrometer particles range, APIA analyses were conducted on a Morphologi G3SE as automated image analysis system (MalvernPanalytical Instruments, Worcestershire, UK). To characterize nanometer range, NTA analyses were conducted on a NS300 as nanotracking analyzing systems (MalvernPanalytical Instruments, Worcestershire, UK) with particle concentration.

Keywords: Clay Minerals, Particle Morphology, Particle Charactarization

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Crystal structure and local structures of natural perovskite-type (Na,REE,Ca)(Ti, Nb)O_3 loparite by single crystal diffraction and XAFS analyses

*Ginga Kitahara[1], Akira Yoshiasa[1], Makoto Tokuda[1], Kazumasa Sugiyama[2]

1. Kumamoto University, 2. Tohoku University

The perovskite type compound ABX_3 expresses various physical properties such as ferroelectricity and piezoelectricity, symmetry changes according to composition, pressure and temperature, and various deformations of framework constituted by BX_6 octahedral occur. Even in a solid solution, ferroelectricity, para electricity, superionic conductivity and the like are developed. Recently, it has attracted attention as a material for solar cells.

The perovskite-type minerals, which exist in the Earth’ s mantle, are one of the major host mineral of trace elements such as Th and REE. However, there are few detailed studies on rare earth elements and various heavy metals contained in naturally occurring perovskite-type minerals. In this study, we report on structural properties of solid solution, local structural characteristics of contained elements and irregularities due to radioactive elements, etc.

Analysis of chemical composition using SEM JSM-7001F manufactured by JEOL and EDS INCA SYSTEM manufactured by Oxford, and BL-9C and NW10A of KEK were used analysis of local structures and oxidation states by XAFS analysis and refinement of single crystal structure using Rigaku XtaLAB Super Nova.

The mineral produced from, Mt. Khibiny, Kola, Russia, which we treat as samples, is the solid solution with Lueshite $Na^{+}Nb^{5+}O_3$, Loparite $Na^{+}REE^{3+}Ti^{4+}{}_2O_6$, Perovskite $Ca^{2+}Ti^{4+}O_3$, Tausonite $Sr^{2+}Ti^{4+}O_3$ as end members. (Mitchell and Chakhmouradian 2000) SEM-EDS analysis reveal that there are albites mainly composed of $NaAlSi_3O_8$ at the rim. Therefore, we performed single crystal X-ray diffraction experiment with untwinned crystals picked up from the center.

Many discussions have been made on the crystal structure of Loparite. (Haggerty and Mariano 1983, Vlasov 1966, Mitchell 1996, Zubkova et al. 1998, Chakhmouradian et al. 1999, Mitchell et al. 2000) We attempted to analyze rhombohedral, tetragonal and tetragonal crystals which have been mentioned in previous research using this sample. Rhombohedral crystal: space group *R-3c*, a = 5.5077(2), c = 13.4906(5), Tetragonal crystal: space group *I4/mcm*, a = 5.5166(6), c = 7.7814(10), Ortho crystal Space group *Pbnm*, a = 5.5142(5), b = 5.5085(7), c = 7.7961(8) From more precise structural analysis, we will discuss the phase transition of Loparite structure etc.

From the shape of the XANES spectrum of Fe by spectral analysis, it turned out that the oxidation state of Fe contained is divalent, similar to the Ce-perovskite we investigated last time. In the Ti K-edge spectrum, it can be seen that the local distortion around Ti is considerably large from the peak intensity of pre-edge. With the substitution of Nb, the local strain of Ti at the octahedral site in the solid solution is larger than the $CaTiO_3$ end component, and the electron transition probability from 1s to 3d orbital is increasing. In the Th L3-edge spectrum, XANES is remarkable, and it can be interpreted that the actinoid element Th changes to U by causing radioactive decay, and irregularization corresponding to local metamictization

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occurs.

Keywords: perovskite, XAFS, structure refinement, Loparite

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Crystal Size Distributions based on crystal habit of groundmass pyroxene crystals in the ejecta of the Shinmoedake 2011 eruption

*Shota Okumura[1], Mayumi Mujin[2], Akira Tsuchiyama[1], Norimasa Shimobayashi[1], Akira Miyake[1]

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The 2011 eruption of Shinmoedake, Kirishima volcano, Japan, is characterized by the transition of eruption styles and was preceded by magma mixing (e.g., Suzuki et al., 2013). However, the condition in the volcano has not fully clarified yet, thus clarification of the transition processes needs more information about the magma ascent process from the chamber to the shallow conduit. Meanwhile, Marsh (1988) has proposed that Crystal Size Distributions (CSDs) reflect the kinetic and physical processes affecting crystallization. Mujin and Nakamura (2014) and Mujin et al. (2017) have studied the CSDs of the groundmass crystals in the products of the eruption, and found that the CSD plots exhibit kinks which divide the groundmass crystals into two groups; the coarser ones with the gentler slope and the finer ones with the steeper slope. They proposed that the CSDs reflect the difference of the physicochemical conditions of magma depending on eruption styles. In this study, we focused on pyroxene crystals in groundmass to obtain the information about the physicochemical conditions during ascent in the conduit.

The samples used were the gray pumice of sub-Plinian eruptions and Vulcanian explosions of Shinmoedake 2011 eruption. We determined the miller indices of the pyroxene groundmass crystals by X-ray CT at SPring-8 (BL47XU) and an electron backscatter diffraction (EBSD), analyzed the size and shape of them with a field emission scanning electron microscope (FE-SEM), observed their microtextures with a transmission electron microscope (TEM), and performed composition analysis by a scanning TEM with an energy dispersive X-ray spectrometer (STEM-EDS).

We found that many of the crystals were in a hexagonal or octagonal prism. The former consisted of {010} and {110} prismatic faces and the latter had {100} faces. There were more hexagonal crystals than octagonal ones in the sub-Plinian pumice. In the Vulcanian pumice, by contrast, octagonal ones were dominant and there were only a few of hexagonal ones. In both eruption styles, the hexagonal ones were distributed in finer part than the octagonal ones. The slopes of the CSD also differed according to the habits; that is, the slopes of the hexagonal ones were steeper than that of the octagonal ones. The TEM observation showed that these pyroxene crystals in groundmass were composite crystals composed of orthopyroxene (Opx) and clinopyroxene (Cpx) which was attached to both {100} faces of the Opx, and that the Cpx parts on the both sides were occasionally in twin orientation relationship each other. Their microtextures were symmetric with respect to *c*-axis, which indicated the concentric spreads of the textures.

We found that the size distributions and slopes of the hexagonal and octagonal ones were similar to those of the finer group and the coarser group in Mujin and Nakamura (2014), respectively. Marsh (1988) proposed that CSD slope is a measure of the product of growth rate and residence time. Assuming that the growth rates were almost the same regardless of habits, residence times could be estimated from the CSD slopes as similar durations to the magma ascent durations in the conduit estimated from geophysical data (Kozono et al., 2013, Sato et al., 2013). In particular, the estimated residence time of the hexagonal ones in sub-Plinian pumice was similar to the ascend duration in sub-Plinian eruption. Hence, the hexagonal habit is assumed to reflect the relatively rapid magma ascent rate, which indicates that the

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habits of pyroxene groundmass crystals may reflect the ascent rates in the conduits. Moreover, the TEM observation suggests that microtextures of the crystals may record the temporal change of conditions during the ascent, which indicates the possibility that pyroxene groundmass crystals contribute to reveal the behavior of magma.

Keywords: CSD, crystal habit, pyroxene, volcano

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Petrochemistry and zircon U-Pb age of ``lateritic'' metamorphic rocks from the Kitakami Mountains

*Nobutaka Tsuchiya[1], Yamato Kumagai[1], Tatsuro Adachi[2], Nobuhiko Nakano[2], Yasuhito Osanai[2]

1. Department of Geology, Faculty of Education, Iwate University, 2. Department of Earth Sciences, Faculty of Social and Cultural Studies, Kyushu University

Fe- and Al-rich metamorphic rocks were discovered from the Shinkama, Ofunato City, Kitakami Mountains, Japan. These metamorphic rocks underwent contact metamorphism during the intrusion of the lower Cretaceous Goyosan granitic rocks. The rocks from Shinkama are mainly composed of Pl, Bt, Ms, Grt, Crd(+/-), Kfs, Spl(+/-), Ilm, Ap. On the other hand, the rocks from Shinkama east are Pl, Bt, Ms, Grt(+/-), Crd, Kfs, Spl, And(+/-), Sil(+/-), Crn(+/-), Ilm, Ap. These rocks are characterized by low SiO2 contents (20--47%), high FeO* contents (12--33%) and high Al2O3 contents (18--38%). Bulk rock chemistry of the metamorphic rocks are resemble those from ``lateritic'' rocks from the Abukuma Metamorphic Belt. ``Lateritic'' rocks from the Abukuma Metamorphic Belt characteristically contains staurolite, however, metamorphic rocks from Shinkama does not include staurolite. This indicates the possibility that the metamorphic rocks in the Shinkama were probalbly metamorphosed under low pressure conditions than those from the Abukuma Metamorphic Belt.

U-Pb dating of zircons were carried out using Agilent 7500cx quadrupole inductively coupled plasma mass spectrometer (ICP-MS) with a New Wave Research UP-213 Nd-YAG UV (213 nm) laser ablation system (LA) installed at the Kyushu University. The operating parameters of analyses with LA-ICP-MS system are after Adachi et al. (2012). Zircon grains from the Shinkama metamorphic rocks are euhedral crystal (ca. 0.05mm) with remarkable oscillatory zoning, and define a concordant age of 126+/- 3Ma. On the other hand, zircon grains of subhedral crystal (larger than 0.1mm) with no oscillatory zoning, and define a concordant age of 326+/- 3Ma. The former age correspond to the contact metamorphism of Early Cretaceous, on the other hand, the latter corresopond to the hydrothermal alteration event of Carboniferous.

Keywords: laterite, metamorphic rocks, zircon U-Pb age, petrochemistry

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How to make 'syn-plutonic dike' --- Another story from the Ryoke granitic province, Southwest Japan

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1. Geological Survey of Japan, 2. Ueyama-Shisui, Co. Ltd., 3. Australian National University

Syn-plutonic dike is interpreted to express a magma chamber process with intermingling silicic and mafic magmas in fluidal state.

In the Ryoke granitoids in Southwest Japan, mafic rocks often occur in so-called syn-plutonic dikes. They are pillow-like balls in the silicic matrix (pillow-type), and dikes intruding silicic matrix with silicic back-veins into them (dike-type). We found the 14-20Ma time discrepancies between mafic and silicic rocks in above both two types of syn-plutonic dikes in the Ryoke granitoids, 90-94Ma of silicic rocks and 70-75Ma of mafic rocks in zircon U-Pb ages. The time duration of 14-20Ma seems too long to imagine that these two components of the syn-plutonic dike was generated during a lifetime of a single magma chamber.

In a silicic rock of those syn-plutonic dike, we found a partly dissolved and re-grown intrastructure of a zircon grain in the CL image, with the ages of cc.70Ma in the re-grown part and cc.90Ma in the undissolved core. The mafic rocks of the syn-plutonic dike nearby gives cc.70Ma and the host Ryoke granitoids around them give 90-96Ma. So it could be interpreted that the syn-plutonic dike was formed with injection of the mafic magma at cc.70Ma into the already solidified 90-96Ma granitoids and partially melted them, which led the physical interaction of local silicic mushy melt and mafic magma. The partly dissolved and re-grown zircon described above could tell that story of forming syn-plutonic dike.

As this type of the “syn-plutonic dikes” occur widespread in a km-sized area in the Ryoke granitoids, that process may be regarded as local and partial revival of granitic magma chamber.

Keywords: syn-plutonic dike, U-Pb ages, Ryoke granitic rocks, magma chamber process, Southwest Japan, Cretaceous

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Thu. May 30, 2019 10:45 AM - 12:15 PM JST | Thu. May 30, 2019 1:45 AM - 3:15 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-CG53] Environment formed and maintained by active faults

convener:Naoji Koizumi(School of Environmental Science,the University of Shiga Prefecture), Makoto Yamano(Earthquake Research Institute, the University of Tokyo), Takafumi Kasaya(Japan Agency for Marine-Earth Science and Technology), Hideki Hamamoto(Center for Environmental Science in Saitama), Chairperson:NAOJI KOIZUMI, TADANORI GOTO(Graduate School of Engineering, Kyoto University)

An active fault causes a large earthquake at a very low frequency such as once every several thousand to tens of thousands years and destroys the surrounding environment. On the other hand, during the period when the large earthquake or the fault movement does not occur, the unique environments such as mountains, basins, structural lakes, hot springs and mineral deposits are formed and maintained by the topography and hydrogeological structure made by the accumulation of the fault movement. In general, the presence of active faults is recognized as a factor of environmental destruction, but it is also necessary to understand the active faults as a factor of environmental formation and maintenance. In this session, we welcome wide-ranging topics on the role of active faults as a factor for the formation and maintenance of the environment and how to investigate it.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SCG53-01] Effect of the Hanaore fault and Biwako-seigan fault on the water quality of the Ado river in Shiga Prefecture

*Naoji Koizumi[1], Masahiro Ueda[1], Shinsuke Minote[1], Tatsuya Tanaka[1], Masahiro Maruo[1], Kanto Mitani[2] (1.School of Environmental Science,the University of Shiga Prefecture, 2.Daikokuten Bussan Co., Ltd.)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SCG53-02] Hydrothermal vents in the deep basin of Lake Biwa

★Invited Papers

*Michio Kumagai[1] (1.Ritsumeikan University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SCG53-03] Heat flow anomalies observed on the seafloor in the vicinity of faults: indication of fluid flow

*Makoto Yamano[1], Shusaku Goto[2], Yoshifumi Kawada[3], Hideki Hamamoto[4] (1.Earthq. Res. Inst., Univ. Tokyo, 2.Geol. Surv. Japan, AIST, 3.IRIDeS, Tohoku Univ., 4.Center Environ. Sci. Saitama)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SCG53-04] How can we quantify the hydraulic permeability of fault based on geophysical survey?

*Tada-nori Goto[1], Sota Kawaguchi[1] (1.Graduate School of Engineering, Kyoto University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SCG53-05] Healing process of the Nojima Fault zone after 1995 Hyogo-ken Nanbu earthquake

*Hideki Murakami[1], Naoto Oshiman[2], Ryokei Yoshimura[2], Tsutomu Miura[2], Masato Kamo[2] (1.Research and Education Faculty,Kochi University, 2.Disaster Prevention Research Institute,Kyoto University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SCG53-06] Discussion on the environment formed and maintained by active faults

*Naoji Koizumi[1] (1.School of Environmental Science,the University of Shiga Prefecture)

Effect of the Hanaore fault and Biwako-seigan fault on the water quality of the Ado river in Shiga Prefecture

*Naoji Koizumi[1], Masahiro Ueda[1], Shinsuke Minote[1], Tatsuya Tanaka[1], Masahiro Maruo[1], Kanto Mitani[2]

1. School of Environmental Science,the University of Shiga Prefecture, 2. Daikokuten Bussan Co., Ltd.

1.Introduction
Along a fault plain, there is a fractured damage zone, which has high permeability. This zone is often become groundwater path from deep to shallow (Faulkner et al., 2010). As a result, the fault-related groundwater stably supplies heat and chemical materials including water itself, which make some effect on the environment in and around the fault zone. For example, hot and mineral springs tends to distribute in and around fault zones. This fault-related groundwater should also have some effect on the river in the case that the river runs along or across the fault.

The Ado river, which is located in the western part of Shiga Prefecture, is the second longest in the rivers which flow into Lake Biwa, which is the largest lake in Japan. The catchment area of the Ado river is also the largest in the rivers which flow into Lake Biwa. In the part of the upstream and most of the midstream, the Ado river runs along the Hanaore fault. In the downstream the Ado river cross the Biwako-seigan fault (Fig.1). Both of the faults are the main active faults in the western part of the Shiga Prefecture. Therefore the Ado river is suitable for investigating the effect of active faults on the river water quality.

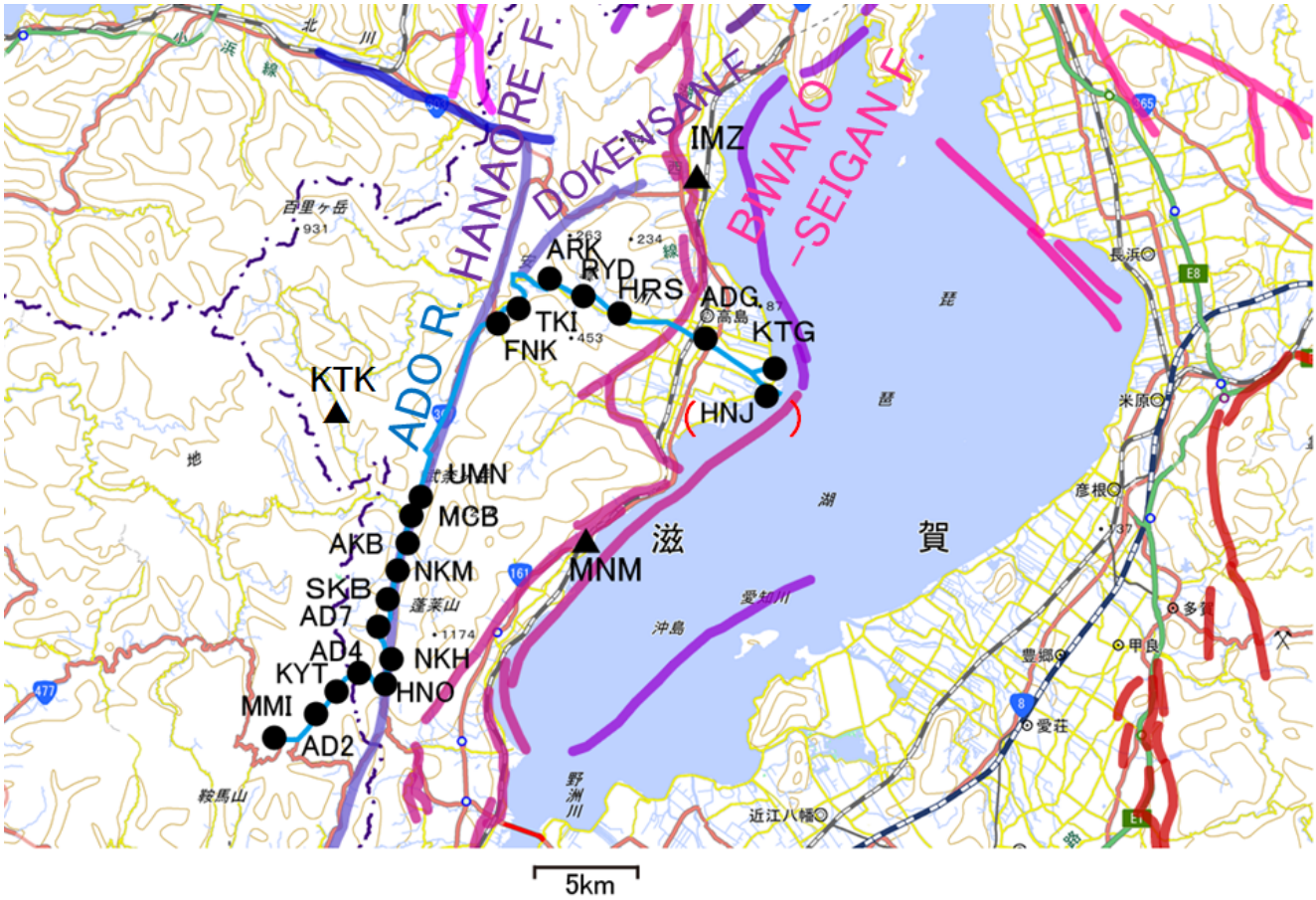
2.Observation
We surveyed the Ado river during the period from August 12 to August 14 in 2018 (Fig.1) , which is named the spatial survey. Before this period there had been no precipitation for thirteen days at IMZ and MNM. Therefore it is considered that the river water was mainly composed of the base flow, which supplies from groundwater to river. We also surveyed the Ado river at RYD, HRS, ADG and KTG about once a month from April, 2018, which is named the temporal survey.

3.Result
In the spatial survey the water quality type was Ca-HCO3 at all the sampling points. The ion concentrations were gradually increased from AD7 to TKI although there were no systematic change in the ion concentrations at the other sampling points. Between HRS and ADG, where the Ado river crosses the Biwako-seigan fault, there was no change in the ion concentrations. In the temporal survey, there was also no no change in the ion concentrations between HRS and ADG. This shows that the Hanaore fault has some effect on the water quality of the Ado river although the Biwako-seigan fault has little effect on it.

Fig.1 The solid circles show the sampling points of the Ado river during the period from August 12 to August 14 in 2018. The solid triangles denote meteorological observation points of Japan Meteorologidal Agency. This is modified from the figure of the active fault database of Japan (Geological Survey of Japan, AIST, 2019). The background map is from Geographycal Information Authority of Japan (2019).

Keywords: Ado river, Active fault, Water quality, Permeability

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Hydrothermal vents in the deep basin of Lake Biwa

*Michio Kumagai[1]

1. Ritsumeikan University

The autonomous underwater vehicle (AUV) “Tantan” was constructed and first deployed in the year 2000, as the world’s first AUV conceived for lake ecosystem exploration and monitoring. Tantan (meaning “freshwater surveillance” in Japanese) was designed to move along bottom slopes keeping a constant distance above the sediments, with a payload that includes two high-definition video cameras, a digital camera, a submersible microscope and various sensors. In December 2009, Tantan identified turbid water ebullition on the deep area in the North Basin of Lake Biwa, which is a larger basin with maximum depth 104 m and 99% water volume, and follow-up investigations were conducted in April, December 2010 and January 2012. This study confirmed the existence of hydrothermal vents, and provided the evidence that their vent numbers per unit area on the lake bottom have increased from 1.0 km^{-2} vent in 2009 to 54.0 vents km^{-2} in 2012. We also found that those discovered vents located along the ridge of sunken mountains which form the basement of Lake Biwa with covered sediments. Some back-up investigations have been performed with a remotely operated vehicle (ROV) and several kinds of sonar devices, and all of the outputs support the existence of vents found by Tantan.

Keywords: vent, Lake Biwa, AUV



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Heat flow anomalies observed on the seafloor in the vicinity of faults: indication of fluid flow

*Makoto Yamano[1], Shusaku Goto[2], Yoshifumi Kawada[3], Hideki Hamamoto[4]

1. Earthq. Res. Inst., Univ. Tokyo, 2. Geol. Surv. Japan, AIST, 3. IRIDeS, Tohoku Univ., 4. Center Environ. Sci. Saitama

Active fluid flow along faults may yield temperature or surface heat flow anomalies because advective heat transport by fluid flow is much more efficient than conductive transport. On land, it is rather difficult to observe such anomalies as temperature profile measurement in deep boreholes is required. On the other hand, we can conduct dense heat flow measurements on seafloor if surface sediment is soft enough to allow penetration of temperature probes. Heat flow and/or temperature anomalies in the vicinity of faults have been reported in some accretionary prisms, e.g., Cascadia and Barbados subduction zones. In this presentation, we show examples of heat flow anomalies associated with faults on the seafloor in the Nankai Trough area.

Accretionary prism developed landward of the Nankai Trough is extensively faulted in a compressional stress field due to subduction of the Philippine Sea plate. At the toe of the prism off Muroto, eastern Shikoku, closely-spaced heat flow measurements were made with a ROV and conspicuous high anomalies were found around the second frontal thrust, indicating that pore fluid flows upward along the fault (Kawada et al., 2014). Off the Kii peninsula, a large thrust fault system termed the megasplay cuts through the entire prism and its branches reach the seafloor. Yamano et al. (2014) conducted heat flow measurements with a surface ship across a branch of the megasplay and observed high heat flow values on the lower part of a fault scarp. Goto et al. (2008) made measurements with a submersible around biological communities along another branch of the megasplay and showed a sharp heat flow variation in a scale of several meters. These observations demonstrate that fluid flow along faults in various spatial scales can be detected by surface heat flow measurements.

The velocity or flux of vertical fluid flow may be estimated through long-term monitoring of temperature distribution in surface sediment. Temporal variation of the bottom water temperature propagates downward through sediment by thermal diffusion. Since this propagation process is affected by vertical fluid flow, analysis of long-term record of temperatures at multiple depths allows us to estimate fluid flow velocity (Goto et al., 2005). This method was applied to temperature records obtained in and around a biological community located a tip of the megasplay branch fault and the result indicates the existence of upward fluid flow (Kawada et al., 2013).

Keywords: heat flow anomaly, fluid flow, fault, heat transport, long-term monitoring

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How can we quantify the hydraulic permeability of fault based on geophysical survey?

*Tada-nori Goto[1], Sota Kawaguchi[1]

1. Graduate School of Engineering, Kyoto University

For understanding impacts of faults/fractures to the Earth's environment, evaluation of hydraulic permeability along fault and fractures are required because they hydrogeologically play a role of pathway of deep groundwater and gas. Previous studies have obtained the hydraulic characteristics using boreholes and rock samples. However, such information is only valid in a local scale, and it is basically considered to be difficult to estimate the hydraulic permeability at several-hundred meter scales or more. In this study, we try to estimate the permeability in and around fractures in typical bedrocks (e.g., granitic rocks) based on the geophysical explorations: resistivity, seismic velocity and so on. The geophysical logging experiment (e.g., cross-hole tomography) can indicate both local and larger scale geophysical information. More large-scaled information can be obtained by land-surface geophysical surveys. For evaluation of permeability of large-scale fault, a rock physical modeling will be helpful since it can connect geophysical property to the hydraulic property theoretically or numerically.
Prior to the challenge of large-scale permeability estimation, we applied the rock physical modeling to the small-scale geophysical measurements. We measured DC resistivity and elastic properties (Young modulus) on the exposed fresh granite at the Mizunami Underground Research Laboratory, Japan Atomic Energy Agency. Based on the simple rock physical model, we estimated the permeability of granite with less fracturing. The in-situ permeability measurements confirmed that the estimated values are enough close to the measured ones (within the difference of half of order). The technique is also valid to the permeability measurements by pumping test at wells. We succeeded that the observed permeability obtained at Mizunami can be reproduced by only using geophysical logging data such as resistivity and seismic P-wave velocity.
Then, we applied this rock physical model to the large-scale geophysical images based on the magnetotellurics and seismic tomography. Although it is a preliminary result, the estimated permeability structure by our method is not realistic one unfortunately. In this study, we discuss on the additional information and technique how the accuracy of estimated permeability is improved.

Keywords: Permeability, Rock Physics, Resistivity

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Healing process of the Nojima Fault zone after 1995 Hyogo-ken Nanbu earthquake

*Hideki Murakami[1], Naoto Oshiman[2], Ryokei Yoshimura[2], Tsutomu Miura[2], Masato Kamo[2]

1. Research and Education Faculty,Kochi University, 2. Disaster Prevention Research Institute,Kyoto University

Two faults of the Nojima Fault and the Higashiura Fault exist in the northeastern part of Awaji Island. Repeated activities of these faults have formed the topography of Awaji Island. In this study, we report the result of the Nojima water injection experiment of 2018 and the healing process of the Nojima Fault zone estimated from self-potential variations associated with water injection experiments. The water injection experiments were conducted 8 times between 1997 and 2018 in an 1800 m long borehole near the Nojima Fault, which is the surface earthquake fault of 1995 Hyogo-ken Nanbu earthquake, to investigate the recovery process of the fault zone after the large earthquake. We have estimated the time evolution of hydraulic parameters from self-potential variations associated with water injection. It is expected that hydraulic parameters will decrease as the healing process of the fault zone progresses. Though the Nojima Fault has repeatedly moved at a recurrence interval of ca. 2,000 years during the Late Quaternary, it is estimated from the experiment results that the healing process of the fault zone is progressing in several years after the earthquake shorter than the recurrence interval.

Keywords: Nojima Fault, healing process of a fault, water injection experiment, self-potential

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Discussion on the environment formed and maintained by active faults

*Naoji Koizumi[1]

1. School of Environmental Science,the University of Shiga Prefecture

In this presentation we will comprehensively discuss on the environment formed and maintained by active faults.

Keywords: Active fault, Environment

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Thu. May 30, 2019 9:00 AM - 10:30 AM JST | Thu. May 30, 2019 12:00 AM - 1:30 AM UTC | A11 TOKYO BAY MAKUHARI HALL

[S-CG55] Crustal fluids and deformation

convener:Yuichi Kitagawa(Tectono-Hydrology Research Group, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Naoji Koizumi(School of Environmental Science,the University of Shiga Prefecture), Koji Umeda(Hirosaki University), Fumiaki Tsunomori(Geochemical Research Center, Graduate School of Science, University of Tokyo), Chairperson:Yuichi Kitagawa(産業技術総合研究所地質調査総合センター地震地下水研究グループ), Fumiaki Tsunomori(東京大学大学院理学系研究科地殻化学実験施設)

We will provide an opportunity to discuss about observation and modeling of crustal fluids. Topics of interests include, but not limited to (1) a field of physics and chemistry of fault fluids, which is related to earthquake occurrences and researches physical and chemical changes of the fluids caused by crustal deformation including earthquakes, (2) a field of earthquake hydrology, which estimates crustal deformation from level, pressure and chemistry of groundwater using poroelastic theory, and (3) a field of chemistry of crustal fluids, which concerns chemical and isotopic features of the crustal fluids and try to estimate the flux of them.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SCG55-01] Estimation of fault models of the short-term SSE using groundwater pressures at the Hokusei observation site

*Yuichi Kitagawa[1], Norio Matsumoto[1] (1.Tectono-Hydrology Research Group, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology)

9:15 AM - 9:35 AM JST | 12:15 AM - 12:35 AM UTC

[SCG55-02] Groundwater level changes during the 2018 Hokkaido Eastern Iburi earthquake

★Invited Papers

*Tomo Shibata[1], Ryo Takahashi[2], Hiroaki Takahashi[3], Takanori Kagoshima[4], Yuji Sano[4], Daniele Pinti[5] (1.Graduate School of Science, Kyoto University, 2.Geological Survey of Hokkaido, Hokkaido Research Organization, 3.Graduate School of Science, Hokkaido University, 4.Atmosphere and Ocean Research Institute, The University of Tokyo, 5.GEOTOP, Université du Québec)

9:35 AM - 9:50 AM JST | 12:35 AM - 12:50 AM UTC

[SCG55-03] Postseismic streamflow changes after the 2016 Kumamoto earthquake

*Naoji Koizumi[1], Shinsuke Minote[1], Tatusya Tanaka[1] (1.School of Environmental Science,the University of Shiga Prefecture)

9:50 AM - 10:05 AM JST | 12:50 AM - 1:05 AM UTC

[SCG55-04] Development of Radium Concentration Monitoring System based on Gamma-Ray Spectroscopy

*Fumiaki Tsunomori[1], Shigekazu Nagai[2], Junji Yoshii[3], Yoshihide Kimura[4], Yoriyuki Kamakura[5], Yuki Inoue[5], Norihito Sato[6], Shiro Sakuragi[7], Ryuichi Shimizu[8], V N Gluchschenko[9] (1.Geochemical Research Center, Graduate School of Science, University of Tokyo, 2.Graduate School of Engineering, Mie University, 3.Advanced Clinical Research Center, Fukushima Medical University, 4.Graduate School of Engineering, Osaka University, 5.Faculty of Information Science and Technology, Osaka Institute of Technology, 6.Chiyoda Technol corp., 7.Union Material Inc., 8.Office for University-Industry Collaboration, Osaka University, 9.Institute of Nuclear Physics, Almaty, Republic of Kazakhstan)

10:05 AM - 10:25 AM JST | 1:05 AM - 1:25 AM UTC

[SCG55-05] ^{222}Rn concentration distribution in Yatsushiro Sea

★Invited Papers

*Kuniyo Kawabata[1], Fumiaki Tsunomori[2], Yujin Kitamura[1], Hakuho-Maru K18-3 scientists (1.Graduate School of Science and Engineering, KAGOSHIMA UNIVERSITY, 2.Geochemical Research Center, Graduate

School of Science, University of Tokyo)

10:25 AM - 10:30 AM JST | 1:25 AM - 1:30 AM UTC
Discussion

Estimation of fault models of the short-term SSE using groundwater pressures at the Hokusei observation site

*Yuichi Kitagawa[1], Norio Matsumoto[1]

1. Tectono-Hydrology Research Group, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology

One of the problems is the lack of high quality crustal deformation/groundwater observation sites in the western part of Aichi prefecture and the northern part of Mie prefecture around Ise Bay, in terms of the estimation of short-term slow slip events (SSEs) occurring at the plate boundary of the Nankai Trough. One of the causes is that unconsolidated sedimentary layers such as the Tokai Group are thickly deposited in this area. In May 2016, the inner pipe of the observation well at the Hokusei observation site located in the northern part of Mie prefecture was sealed with a packer in order to improve the response of groundwater level to crustal deformation. Because the permeability of the target aquifer at this site is low, the groundwater level before the sealing was poor in response to crustal strain changes before the sealing. The groundwater pressure is observed after sealing, then tidal fluctuation clearly appeared in the groundwater pressure, therefore we found the response of the groundwater pressure to crustal deformation to be clearly improved. The response of the groundwater pressure to crustal strain after sealing improved about 10 times than that of the groundwater level before the sealing. By eliminating the tidal component, barometric pressure response, and rain response from the groundwater pressure data, short-term SSEs were detected by the changes in groundwater pressure in July 2016, November 2017 and April 2018. And then slips of the short-term SSEs were estimated to be spread to Northern Ise Bay by the data of strain, tilt and groundwater pressure. In the area around Northern Ise Bay where deep low frequency tremors are not active, it is shown that short-term SSEs repeatedly occurred. In soft sedimentary layer which is unsuitable for observation of crustal deformation by strain meter and tilt meter, it is showed that the measurement of groundwater level (pressure) is a powerful means of crustal deformation observation.

Keywords: groundwater, strain sensitivity, closed well, slow slip event

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Groundwater level changes during the 2018 Hokkaido Eastern Iburi earthquake

*Tomo Shibata[1], Ryo Takahashi[2], Hiroaki Takahashi[3], Takanori Kagoshima[4], Yuji Sano[4], Daniele Pinti[5]

1. Graduate School of Science, Kyoto University, 2. Geological Survey of Hokkaido, Hokkaido Research Organization, 3. Graduate School of Science, Hokkaido University, 4. Atmosphere and Ocean Research Institute, The University of Tokyo, 5. GEOTOP, Université du Québec

Groundwater table level in wells can fluctuate under stress provoked by earthquakes located even thousands of kilometers away. The mechanisms of changes in groundwater level can be explained by hydrological changes such as pore-pressure response to coseismic static elastic strain, permeability changes caused by seismic waves and fluid migration along seismogenic dilatant cracks or crustal ruptures. The Geological Survey of Hokkaido, Hokkaido Research Organization (HRO), has been monitoring groundwater tables in several wells after the 2018 Hokkaido Eastern Iburi earthquake. The wells were drilled for exploiting hot spring water but have not been used in the last 20 years. The groundwater level was measured by pressure gauges with resolution about 5-10 mm in 10-minute intervals in each monitored well. After the Hokkaido Eastern Iburi earthquake, we were able to find a step-like decrease in groundwater levels in three wells. These wells are located within the region where tensile changes of the quake-induced volumetric strain can be calculated by using the fault model, suggesting that the changes in groundwater levels are qualitatively consistent with those in volumetric strain. The observed groundwater level changes are also affected by tidal and barometric effects, and we can estimate the response of groundwater level for tidal components. The tidal responses in all the wells have not changed before and after the earthquake.

Keywords: Groundwater level, Poroelastic behavior, Earthquake, Hokkaido

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Postseismic streamflow changes after the 2016 Kumamoto earthquake

*Naoji Koizumi[1], Shinsuke Minote[1], Tatusya Tanaka[1]

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It has been well known that large earthquakes sometimes cause hydrological changes widely in and around the region of strong ground motion. In several cases of those changes, stream flow and spring flow increases in lowland and water table drops in highland. It has often been explained by permeability enhancement in the region of strong ground motion (Rojstaczer et al. ,1995; Wang and Manga, 2004). Since Japan is relatively rich in water resources, people may have not paid much attention to these earthquake-related hydrological changes. But those hydrological changes are clearly one of the seismic risks and should also be examined in Japan because those changes sometimes continue for a period of several months to years (Rojstaczer et al. ,1995) .

The 2016 Kumamoto Earthquake, which occurred mainly in Kumamoto Prefecture, Japan in April 2016, caused severe damages in and around Kumamoto Prefecture. It also caused many changes in stream water and groundwater (Ichiyanagi and Ando, 2017; Sato et al., 2017). The region of strong ground motion of the main shock spreads from the coastal plain to the Aso caldera.

We analyzed the data of streamflow at fourteen flow rate observation stations of three major rivers in Kumamoto prefecture during the period from 1990s to 2017. After the 2016 Kumamoto earthquake, streamflow was increased at four of the fourteen observation stations, where the rivers flow from the Aso caldera or the foot of Mt.Aso. However the streamflow was not increased just after the 2016 Kumamoto earthquake. It was increased 2 months after the Kumamoto earthquake, when a heavy rainfall occurred. In addition it is found that (flood frow rate/precipitation amount) ratio tends to be increased when the precipitation amount is large after the 2016 Kumamoto earthquake. This can be explained not by permeability enhancement but by decrease of the soil moisture retention capacity. In and around the region of the strong ground motion of the 2016 Kumamoto earthquake there were many mudslides and landslides, which could reduce the soil moisture retention capacity. The earthquake-related decrease of the soil moisture retention capacity could have caused the streamflow increase in and around the region of the strong ground motion of the 2016 Kumamoto earthquake.

Keywords: Kumamoto earthquake, Streamflow, Permeability, Strong ground motion

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Development of Radium Concentration Monitoring System based on Gamma-Ray Spectroscopy

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1. Geochemical Research Center, Graduate School of Science, University of Tokyo, 2. Graduate School of Engineering, Mie University, 3. Advanced Clinical Research Center, Fukushima Medical University, 4. Graduate School of Engineering, Osaka University, 5. Faculty of Information Science and Technology, Osaka Institute of Technology, 6. Chiyoda Technol corp., 7. Union Material Inc., 8. Office for University-Industry Collaboration, Osaka University, 9. Institute of Nuclear Physics, Almaty, Republic of Kazakhstan

We have developed a radium concentration monitoring system in order to analyze a radium concentration in soil samples based on a gamma-ray spectrum. A gamma-ray spectrum of a soil sample was measured by a SrI_2 solid scintillator equipped by a multi-pixel photon counter (hereinafter a detector). The detector was shielded by 5cm-thick lead brocks, because 214-bismuth, which is a daughter elements of radium contained in cement materials, emits strong gamma-ray. We have achieved 80% background reduction. We prepared a calibration curve in order to determine a soil radium concentration by a peak area of 214-bismuth in a gamma-ray spectrum of JG-1 geochemical reference sample (AIST, GSJ). We are going to have a discussion to improve problems of this system.

Keywords: Soil Radium Concentration, Gamma-Ray Spectroscopy

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^{222}Rn concentration distribution in Yatsushiro Sea

*Kuniyo Kawabata[1], Fumiaki Tsunomori[2], Yujin Kitamura[1], Hakuho-Maru K18-3 scientists

1. Graduate School of Science and Engineering, KAGOSHIMA UNIVERSITY, 2. Geochemical Research Center, Graduate School of Science, University of Tokyo

Radon concentrations in Yatsushiro sea were surveyed to examine relationship with the submarine sediments and geological structure such as submarine active faults.

^{222}Rn is a radioactive noble gas and occurs naturally in earth’ s crust as an intermediate step in the normal radioactive decay chain of uranium series. Radon shows high solubility for water and thus high mobility through groundwater and fluids in earth’ s crust. Concentration of radon in crustal fluid and groundwater can provide a clue to understand geology of the aquifer and state of crustal deformation as crack formation and change in strain state, because its release rate depends mainly on rock surface area. Recently location of active faults and its activity have been examined by using the method (e.g. Malgrange and Gleeson, 2014, Tsunomori et al., 2017).

A bunch of submarine active faults underlies in Yatsushiro area sea. These faults compose the Futagawa-Hinagu Fault zone which was activated at the 2016 Kumamoto earthquake. To evaluate records of submarine landslides and changes in submarine circumstances due to historical earthquakes, R/V Hakuho-Maru sailed for research expedition (KH-1803) in Yatsushiro sea from 27th to 30th July, 2018. We collected bottom water from obtained multiple cores and piston cores, and pore waters from piston cores for the measurement of the radon concentration in the sample water on board.
The results of radon concentration distribution from multiple cores, (MC 1-12), show that higher concentration along the Line Y18a. The radon concentrations from bottom water of piston cores (PC 1-11) also show similar results while the values are larger than the results from multiple cores. A higher radon concentration is attributed to difference in (1) Radium concentration in sediments, and/or (2) properties of sediments such as porosity and/or surface area of grains which are caused by difference in types of sediment or fault activity in sediments. The Line Y18a extends across a major submarine active fault (FA1, Tanoura-Tsunagi-oki-faults) (Kagohara et al., 2011). Such a geological setting suggests that the radon concentration distribution in Yatsushiro sea might reflect the current fault activity. We discuss the contributing factor of the higher radon concentration by comparison with Ra concentration in sediment, sediment properties in each site and geological structure in Yatsushiro sea.

Keywords: Radon concentration in water, Submarine active fault, Yatsushiro sea, γ ray analysis, The 2016 Kumamoto earthquake

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Thu. May 30, 2019 1:45 PM - 3:15 PM JST | Thu. May 30, 2019 4:45 AM - 6:15 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-CG58] Brittle-Ductile Transition and Supercritical Geofluids for Crustal Energy in Island Arc

convener:Noriyoshi Tsuchiya(Graduate School of Environmental Studies, Tohoku University), Hiroshi Asanuma(AIST), Yasuo Ogawa(Volcanic Fluid Research Center, School of Science, Tokyo Institute of Technology), Shigemi Naganawa(Akita University), Chairperson:Noriyoshi Tsuchiya, Atsushi Okamoto

Nature of rock mass below the brittle-ductile transition (BDT) is of great scientific interest to understand various phenomenon in the Earth's crust. We will review and discuss current understanding of characteristics the rock mass below the BDT, including composites, stress, failure mechanism induced by liquid injection and associates earthquake generation mechanism, and water rock interaction, considering engineered geothermal development in the BDT. Discussions on the possible phenomena in the geothermal development in the BDT will be followed in this session.
New drilling technology is key of issues. This session will cover advanced drilling technology under high temperature conditions for energy extraction.

1:45 PM - 1:55 PM JST | 4:45 AM - 4:55 AM UTC

[SCG58-01] Supercritical Geothermal Resources as a Function of Mass and Energy Transport in Subduction Zone

*Noriyoshi Tsuchiya[1] (1.Graduate School of Environmental Studies, Tohoku University)

1:55 PM - 2:05 PM JST | 4:55 AM - 5:05 AM UTC

[SCG58-02] Outline of NEDO Supercritical Geothermal Project

*Hiroshi Asanuma[1] (1.AIST)

2:05 PM - 2:30 PM JST | 5:05 AM - 5:30 AM UTC

[SCG58-03] Mineral precipitation/dissolution from water and brine with decreasing temperatures along hydrostatic pressures

★Invited Papers

*Kenichi Hoshino[1] (1.Department of Earth and Planetary Systems Science, Hiroshima University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SCG58-04] Thermodynamic data of aqueous species for supercritical water–rock interaction: dissolution experiments and density-based extrapolation

*Atsushi Okamoto[1], Hajime Ishii[1], Ryosuke Oyanagi[2], Noriyoshi Tsuchiya[1] (1.Graduate School of Environmental Studies, 2.JAMSTEC)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SCG58-05] Nitrogen isotope ratios of ammonium in hypersaline hot spring waters distributed along Arima-Takatsuki fault zone.

*Kazuhiro Amita[1], Takashi Nakamura[2], Shinji Ohsawa[3] (1.Faculty of Engineering Science, Akita University, 2.International Research Center for River Basin Environment, University of YAMANASHI, 3.Institute for Geothermal Sciences, Graduate School of Science, Kyoto University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SCG58-06] **Crustal fluid pressure gradients and permeability estimated from fluid-rock reaction zones**

*Masaoki Uno[1], Diana Mindaleva[1], Noriyoshi Tsuchiya[1] (1.Graduate School of Environmental Studies, Tohoku University)

Supercritical Geothermal Resources as a Function of Mass and Energy Transport in Subduction Zone

*Noriyoshi Tsuchiya[1]

1. Graduate School of Environmental Studies, Tohoku University

Our research group is conducting fundamental and engineering studies of “Supercritical Geothermal Development”. Fracture networks and their formation mechanisms would be studied by using petrological and fluid inclusion studies in order to understand the geological model of a supercritical geothermal reservoir. The granite-porphyry system provides useful information for understanding supercritical geothermal reservoirs and EGS technology as novel energy system in subduction zone. Hydrothermal experiments under supercritical conditions were performed by using tri-axial machine. Fracture cloud could be formed and permeability was enhanced in supercritical conditions.
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Keywords: geothermal, subduction zone, energy transport, supercritical

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Outline of NEDO Supercritical Geothermal Project

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1. AIST

Nationalwide potential of “Supercritical Geothermal Power Generation” has been roughly estimated to reach hundreds GW, although there are a lot of scientific unknowns and necessary technological breakthroughs. NEDO has funded to survey the most promising location of the proof-of-concept drilling and to investigate detailed feasibility of the Supercritical Geothermal Power Generation from FY2018, and 6 projects are on-going. Outline of the studies in the NEDO Supercritical Geothermal Project will be presented in the session.

Keywords: Supercritical Geothermal

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Mineral precipitation/dissolution from water and brine with decreasing temperatures along hydrostatic pressures

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Mineral-fluid interactions with decreasing temperatures along hydrostatic pressures, from 15.84 MPa - 500°C to 6.64 MPa - 200°C, have been simulated for 0.01 molal and 1 molal NaCl solutions. The dielectric constants of the former were taken from SUPCRT92 (Johnson et al., 1992), while those of the latter has been proposed from quartz solubility data in brine as:

$$\varepsilon_b / \varepsilon_w = a / (2\pi b)^{0.5} \exp(-(T - c)^2 / (2b)) + d,$$

where, ε_b is the constant of the 1 molal NaCl solution, ε_w is that of water derived by SUPCRT92, π represents the ratio of the circumference of a circle to its diameter, T is a temperature in Celsius, the parameter a depends on a pressure (P in MPa) as a = -0.9 * P + 420, and b, c and d are the constants as 13000, 300 and 0.8, respectively.

On the other hand, a difference in chemical potentials of a jth solute ($\Delta\mu^\circ_j$) in the solution and water may be expressed as:

$$\Delta\mu^\circ_j = \omega_j(1/\varepsilon_b - 1/\varepsilon_w),$$

where, ω_j is the Born coefficient of the solute. Since the coefficients of the most charged species as well as $SiO_{2(aq)}$ are positive and ε_b is larger than ε_w in the simulated conditions, the chemical potentials of the above solutes in brine are smaller than those in water. This causes great differences between mineral solubilities in water (0.01M NaCl) and in brine (1M NaCl) as below.

Quartz

Since quartz solubility decreases with decreasing temperatures in water and brine, quartz precipitates from the both solvents with decreasing temperatures. However, because a decreasing rate of solubility in brine is smaller at higher temperatures and larger at lower temperatures, the precipitation amount shows a maximum at around 350 - 400°C. On the other hand, the amount decreases monotonically with decreasing temperatures in water.

Feldspar

Aluminum is dissolved mostly as AlO_2^- (= $Al(OH)_4^-$) in the both solvents. Equilibrium constants of dissolution reactions of K-feldspar, albite and anorthite with the above Al species decrease with decreasing temperatures. Therefore, the precipitation amounts of those feldspar from water solvent decrease monotonically with decreasing temperatures. On the other hand, it is quite interesting that they dissolve in brine at higher temperatures, while precipitate at lower.

Pyroxene and Al-free amphibole

Most pyroxene and amphibole show similar tendencies as feldspar. They gradually precipitate or dissolve small amounts with decreasing temperatures in water, while they dissolve in brine at higher temperatures and precipitate at lower.

One of the conceivable causes of the above temperature dependencies of the silicate precipitation/dissolution in brine is a great difference in activity coefficients of charged species. For

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example, the activity coefficients (Debye-Hückel terms) for a divalent element in 0.01M NaCl solutions at 450°C and 300°C are 0.34 and 0.47, respectively, while they differ largely in 1M solutions as 0.023 and 0.20, respectively.
Carbonate
$CO_{2(aq)}$ is the major dissolved species above 250°C in the both solvents. Since the equilibrium constants of dissolution reactions of calcite, dolomite and magnesite with $CO_{2(aq)}$ decrease with decreasing temperatures, they precipitate from water gradually with decreasing temperatures, while they dissolve in brine at higher temperatures and precipitate at lower as feldspar, pyroxene and amphibole.

It should be emphasized that the temperatures of brine at which the above all silicate and carbonate minerals change their modes from dissolution to precipitation are around 400°C - 300°C.

Precipitation/dissolution of solid solutions of the above minerals and alteration (hydration) of some of the above minerals will also be discussed in the presentation.

Keywords: dielectric constant, brine, mineral, precipitation, dissolution

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Thermodynamic data of aqueous species for supercritical water–rock interaction: dissolution experiments and density-based extrapolation

*Atsushi Okamoto[1], Hajime Ishii[1], Ryosuke Oyanagi[2], Noriyoshi Tsuchiya[1]

1. Graduate School of Environmental Studies, 2. JAMSTEC

Geothermal reservoirs under the supercritical conditions (supercritical geothermal reservoirs) have been taken grater attentions as the potential renewable energy in volcanic areas in the world. The chemical and physical processes of such supercritical regions are of special importance for various geological processes including understanding the formation of hydrothermal ore deposits, hydrological properties around brittle-ductile transitions of the crusts, and metamorphic and metasomatic processes. The thermodynamic data of the aqueous species at elevated temperatures and pressures has been constructed based on the Helgeson-Kirham-Flowers (HKF) model, where molar Gibbs energy is defined as a function of dielectric constant of water and species-specific Born parameter (e.g., Tanger and Helgeson, 1988), and the most common data is available through a software SUPCRT92. However, a large issue for understanding the supercritical water-rock interaction is a lack of thermodynamic data of charged aqueous species (ions and complexes) for the region near critical point of water and low water-density region (<0.35 g/cm3). In contrast to the electrostatic model like HKF model, the empirical density model has been proposed based on the fact that the log of molar Gibbs free energy of aqueous species shows a linear relationship with log of water density. Based on this model, Caciagli and Manning (2003) proposed the extrapolation of SUPCRT log K data to the high pressure regions; however, the effectiveness of this method to the low density region is not clear. In addition, the experiments for dissolution experiments are lacking for the low-density region.

In the present study, we tried the expansion of log K data set of the speciation and mineral dissolution into the vapor-like supercritical region (400, 420 degreeC, 20-35 MPa). We also conducted the new experiments for the mineral solubility measurements. The apparatus consist of 60 ml vessel with Ti inner wall, and pressure was controlled by syringe pump. We conducted the dissolution experiments with albite power and mix powders of albite-K-feldspar-quartz. Then, for evaluating the validity of the extrapolated data, we compared the extrapolated logK of mineral dissolution equilibrium and the ion products (log Q) obtained from the solution chemistry of the experiments and extrapolated log K data set of aqueous species. The deviation of log K from log Q is systematic and less than 2 in log unit, indicating the effectiveness of this method as the first approximation.

Reference

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Keywords: thermodynamic data, supercritical fluids, water-rock interaction, hydrothermal experiments

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Nitrogen isotope ratios of ammonium in hypersaline hot spring waters distributed along Arima-Takatsuki fault zone.

*Kazuhiro Amita[1], Takashi Nakamura[2], Shinji Ohsawa[3]

1. Faculty of Engineering Science, Akita University, 2. International Research Center for River Basin Environment, University of YAMANASHI, 3. Institute for Geothermal Sciences, Graduate School of Science, Kyoto University

Recently, there has been a lot of research on the relationship between hot springs and deep thermal fluids (Slab dehydrated fluids) which are thought to be released from subducting oceanic plate (eg, Kazahaya et al., 2014; Kusuda et al., 2014). These researches shown that the water of slab dehydrated fluid is a high salinity of Na-Cl type and rich in the CO2, and that the isotope ratios of helium and carbon had the similar values as that of the mantle. On the other hand, although nitrogen (ammonium ion) is a component contained in most deep fluids, it is not clear properties and behaviors. Studies on nitrogen in rocks have been conducted since the 1960's that have been obtained many knowledge on their concentrations and isotope ratios. Haendel (1986) pointed out that the concentration and isotope ratios of ammonia nitrogen in rock, change systematically with the progression of a series of metamorphism from sediment to rock. In this relation, the nitrogen concentration decreased as the degree of metamorphism progressed, and conversely the nitrogen isotopic ratio increased. Similar trends have also been confirmed in subsequent studies (eg, Gray and Marilyn, 1991, Yiefei, 2006). On the other hand, Amita et al. (2014) pointed out the possibility that metamorphism is involved in the made of deep thermal fluids. Therefore, it is expected that we can obtain knowledge about the behavior of nitrogen in deep under the earth's surface by clarifying the relationship between the nitrogen isotope ratios of rocks and deep fluids. Therefore, as a preliminary approach to the measurement of the nitrogen isotope ratios of ammonium ion contained in the hypersaline hot spring, two hot springs distributed along the Arima-Takatsuki fault zone are selected and performed sampling survey and nitrogen isotope ratios of ammonium ion were measured. Two sampling points are part of the hot springs that the authors have performed research in the past (Osawa et al., 2015) and are well-understood hot springs whose chemical and isotopic properties. Therefore, as a preliminary approach to the measurement of the nitrogen isotope ratios of ammonium ion contained in the hypersaline hot spring, two hot springs distributed along the Arima-Takatsuki fault zone are selected and performed sampling survey and nitrogen isotope ratios of ammonium ion were measured. The hot spring water samples collected at the sampling site were immediately cooled and frozen immediately to suppress biological activity and kept until just before the isotope analysis. Pretreatment for measurement of nitrogen stable isotope ratio of ammonium ion was carried out by ammonia gas diffusion method which can suppress measurement inhibition due to decomposition of dissolved organic nitrogen. The water samples were made alkaline in a sealing vial, ammonium ion was scattered as ammonia gas, and catched to a filter paper acidified with diluted sulfuric acid, and the object was analyzed using an isotope ratio mass spectrometer (ANCA-GSL with Hydra 20-20, Sercon Ltd.). As a result of the analysis, we obtained results of +13.3 (‰) and +12.8 (‰) as nitrogen isotope ratios of two hot spring water samples. Since these results are values before data correction, careful consideration is required at the evaluation. Although, it was confirmed that the measurement of nitrogen isotopic ratios can be performed even for hyper saline hot springs where the total dissolved solids exceeds tens of thousands ppm.

Keywords: Nitrogen isotope ratios, Ammonium ion, Hypersaline hot spring

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Crustal fluid pressure gradients and permeability estimated from fluid-rock reaction zones

*Masaoki Uno[1], Diana Mindaleva[1], Noriyoshi Tsuchiya[1]

1. Graduate School of Environmental Studies, Tohoku University

High pore fluid pressure has been recognized by geophysical observations and is generally considered as triggers of earthquakes and slow–earthquakes (e.g., Audet and Bürgmann, 2014). Although such high pore fluid pressure is recognized as mineral filled fractures in geologic observations, the actual fluid pressure gradients in the crustal rock have not been evaluated quantitatively and remain largely unknown. Here we propose a new methodology estimating the fluid pressure gradients recorded in fluid-rock reaction zones, by utilizing thermodynamic analyses in conjunction with trace element profiles along the reaction zones. With numerical analysis of reactive advection-diffusion transport profiles of Cl and F in the fluid-rock reaction zones, we constrain the duration, fluid velocity and permeability of the fluid-rock reaction zones. We have analyzed amphibolite and granulite hosted fluid–rock reaction zones at Sør Rodane mountains, East Antarctica. The analyses of decimeter scale granitic dyke–crust reaction zone at 0.5 GPa, 700˚C (Uno et al., 2017) show fluid pressure gradients of ~100 MPa/10 cm or ~1 MPa/mm. mm-sized hydration reaction zones around single fracture at ~0.5 GPa, 450˚C (Mindaleva et al., in prep.) also suggest fluid pressure gradients of ~1 MPa/mm. These extremely high fluid pressure gradients represent the low permeability of the intact amphibolite and granulite host rocks without fractures. The estimated permeabilities are ~10^{-20} m^2 for the granulite–granitic dyke reaction zones and amphibolite–fluid reaction zones, and are several orders smaller than the widely accepted crustal permeability model (~10^{-18} m^2; e.g., Ingebritsen and Manning, 2010). On the other hand, permeability along the fractures are estimated as high as $10^{-14–15}$ m^2 for the granulite and amphibolite-hosted fractures, which is analogous to the permeability estimated for the hypocenter migration for the inland earthquake swarms (~10^{-15} m^2; e.g., Okada et al., 2014). These results show the importance of low permeability of intact amphibolite/granulite-facies metamorphic rocks in conjunction with episodic high permeability of brittle fractures even at high temperature conditions of 450–700˚C, both of which affect the regional scale permeability in the deep crust.

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Keywords: fluid pressure gradient, permeability, time-scales of fluid infiltration, fluid-rock reaction zone

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Thu. May 30, 2019 3:30 PM - 5:00 PM JST | Thu. May 30, 2019 6:30 AM - 8:00 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-CG58] Brittle-Ductile Transition and Supercritical Geofluids for Crustal Energy in Island Arc

convener:Noriyoshi Tsuchiya(Graduate School of Environmental Studies, Tohoku University), Hiroshi Asanuma(AIST), Yasuo Ogawa(Volcanic Fluid Research Center, School of Science, Tokyo Institute of Technology), Shigemi Naganawa(Akita University), Chairperson:Noriyoshi Tsuchiya

Nature of rock mass below the brittle-ductile transition (BDT) is of great scientific interest to understand various phenomenon in the Earth's crust. We will review and discuss current understanding of characteristics the rock mass below the BDT, including composites, stress, failure mechanism induced by liquid injection and associates earthquake generation mechanism, and water rock interaction, considering engineered geothermal development in the BDT. Discussions on the possible phenomena in the geothermal development in the BDT will be followed in this session.
 New drilling technology is key of issues. This session will cover advanced drilling technology under high temperature conditions for energy extraction.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SCG58-07] 3D S-wave velocity structure in volcanic region using surface-wave tomography

*Hiro Nimiya[1], Tatsunori Ikeda[1], Takeshi Tsuji[1] (1.Kyushu University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SCG58-08] Resistivity-Based Temperature and Permeability Estimation of the Kakkonda Geothermal Field, Japan, Using a Neural Network

*Ugou Tsubasa[1], Kazuya Ishitsuka[2], Toru Mogi[3] (1.Department of Socio-Environmental Engineering Scool of Engineering Hokkaido University, 2.Division of Urban Management, Grduate School of Engineering, Kyoto University, 3.Division of Sustinable Resources Enginieering, Faculty of Engineering, Hokkaido University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SCG58-09] Preliminary report on geothermal structure revealed by geological and MT surveys around Akayumatasawa river in Sanzugawa caldera, NE Japan

*Keishi Nunohara[1], Kuo Hsuan Tseng[2], Hiroki Okano[1], Yasuo Ogawa[2], Noriyoshi Tsuchiya[1] (1.Graduate school of Environmental Studies Tohoku University , 2.Graduate school of Science , Tokyo Institute of Technology)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SCG58-10] Characterization of hydraulic fracturing phenomena in supercritical geothermal environments revealed by elastic wave measurements

*Miura Takahiro[1], Noriaki Watanabe[1], Kiyotoshi Sakaguchi[1], Ryota Goto, Kota Yamane, Takeshi Komai[1], Youqing CHEN[2], Takuya ISHIBASHI[3], Noriyoshi Tsuchiya[1] (1. Graduate School of Environmental Studies, Tohoku University, 2.Graduate School of Energy Science, Kyoto University, 3.AIST, FREA)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SCG58-11] Experimental measurements of transport pore radius of thermally cracked granite and the relationship of pore structure to permeability

*Sueyoshi Kazumasa[1], Tadashi Yokoyama[2], Ikuo Katayama[1] (1.Department of Earth and Planetary Systems Science, Hiroshima University, 2.Graduate School of Integrated Arts and Sciences, Hiroshima University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SCG58-12] Geothermal reservoir evaluation by using TL of Quartz and Fluid Flow Simulation Model of the Kakkonda system in Japan

*Alvaro Josue Amaya[1], Nobuo Hirano[1], Noriyoshi Tsuchiya[1] (1.Tohoku University. Graduate School of Environmental Studies)

3D S-wave velocity structure in volcanic region using surface-wave tomography

*Hiro Nimiya[1], Tatsunori Ikeda[1], Takeshi Tsuji[1]

1. Kyushu University

EGS (Engineered / Enhanced Geothermal System) is expected to generate significant energy and reduce CO2 emission. Although EGS could be effective in Japan where many volcanoes exist, there are still many problems to solve to run the power plant using EGS. The supercritical fluid which can exist below the brittle-ductile transition (BDT) is essential to develop the EGS. However, structures and physical properties around and below BDT are still unclear. Since the development of EGS needs long time before operation and requires high cost, it is important to evaluate the suitable area for EGS. Therefore, estimating the structure in high spatial resolution from surface to around BDT is important to develop EGS and reduce risks.

In recent years, surface-wave analysis has been widely applied to estimate underground structure from ambient noise. In this analysis, surface-wave phase velocity can be estimated from ambient noise, and S-wave velocity structures can be estimated from surface-wave phase velocity because phase velocity strongly depends on S-wave velocity. Surface-wave analysis using ambient noise does not require active sources. Therefore, this is effective to survey steep area where it is difficult to enter such as geothermal area. In addition, this method is also effective to monitor change in subsurface for a long period because we can obtain seismic ambient noise continuously only using seismometers.

We used continuous seismic data recorded by a high-sensitivity seismograph network (Hi-net) for a year. We computed cross spectra of ambient noise data between the station pairs, and extracted phase velocity dispersion curves using the frequency domain method. Since the frequency domain method can overcome the limitation of interstation distance (far-field approximation) occurred in the time domain method, we can extract phase velocity at short-interstation pairs which reflect local structures. We then estimated the 3D S-wave velocity structure by applying a direct surface-wave inversion method. Our results show the low velocity structures beneath active volcanoes such as Mt. Asama, and Mt. Nasu, that could reflect volcanic fluid. If we apply this method to dense seismometers around the geothermal fields or volcanic area, we could obtain S-wave velocity in higher spatial resolution and use the information to identify suitable reservoir for EGS.

Keywords: Surface-wave tomography, S-wave velocity structure, seismic ambient noise, volcano, geothermal

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Resistivity-Based Temperature and Permeability Estimation of the Kakkonda Geothermal Field, Japan, Using a Neural Network

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Estimation of temperature distribution around a geothermal field is important to understand a geothermal system. Previously, temperature distributions were successfully estimated by a neural network based on temperature logs and magnetotelluric (MT) data (Ishitsuka et al., 2018). This method firstly learns the relationship between three-dimensional locations, resistivities and temperatures by a neural network or neural kriging. Then, the optimized neural network is used to estimate temperature distribution based on a resistivity structure obtained by the MT method. On the other hand, not only temperature but also permeability are important physical parameters to evaluate a geothermal system. In this study, we developed a method to estimate permeability distribution as well as temperature distribution by a neural network and neural kriging. The methodology was applied to the Kakkonda geothermal field, Japan.
Permeability along a well is not generally measured. Therefore, to create a training data of permeability, we estimated permeability along a well based on porosity deduced from resistivity log using Archie’s law. Temperature-dependence of the resistivity of water was corrected at the processing. In addition, we assumed that the salt concentration at each depth was equal to the salt concentration of the collected fluid inclusion. Subsequently, the porosity was converted into the permeability by the Kozeny-Carman equation.
We then estimated temperature and permeability distribution around the Kakkonda geothermal field. For training data, we used temperature logs and the estimated permeability logs using resistivity profiles at the 7 wells (Hanano and Kajiwara, 1999). To estimate temperature distribution, we used the resistivity structure by Yamaya et al. (2017) using the MT method.
As for the result, the temperature rising was estimated in the deep part, and the point where the high-temperature fluid is considered to be rising from the geothermal reservoir was estimated. The permeability showed a high value, especially in the low resistivity part. The accuracy of the estimated temperature and permeability distribution was evaluated by comparing temperature data measured beneath a depth of 3100 m of WD-1 well. As a result of accuracy verification, neural networks showed the smallest temperature error when the number of the intermediate layers was 2, and the permeability error was the smallest when the number of the intermediate layers was 9. Both the temperature and the permeability of neural kriging were smaller than those of neural networks. Although further development of the methodology to increase the accuracy of the estimation is required, our results demonstrated the effectiveness of our neural network approach to estimate permeability as well as temperature distribution around a geothermal field.
This study is supported by a NEDO project.

Keywords: Neural network, Teperature, Permeability

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Preliminary report on geothermal structure revealed by geological and MT surveys around Akayumatasawa river in Sanzugawa caldera, NE Japan

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Inner part of Sanzugawa caldera, NE Japan, is one of the promising geothermal areas that had been found by many geological and geophysical surveys after 1970’ s. In this area, one geothermal power plant (Uenotai geothermal power plant) is currently in operation, and additional one (Wasabizawa geothermal power plant) is being constructed now.

There are a number of high-temperature hot springs along Akayumatasawa river that flows through the center of Sanzugawa caldera. This study reports the resistivity and geological structures based on MT surveys and field surveys around Akayumatasawa. In addition to these structures, the gravity structure, distribution of hot springs, and hypocenter clusters under Akayumatasawa indicate existence of geothermal fluid that is ascending from deep subsurface.

Keywords: geothermal structure, MT, geothermal fluid

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Characterization of hydraulic fracturing phenomena in supercritical geothermal environments revealed by elastic wave measurements

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Supercritical geothermal resources above the critical temperature of water (374℃) are expected as potential novel geothermal resources [Watanabe et al., 2017, Nat. Geosci.]. Although granitic rocks under temperature and depth conditions where supercritical geothermal resources are present are considered ductile against compression, they may be brittle against tensile, so that it is suggested that the reservoir layer may be formed. In fact, we carried out hydraulic fracturing experiments on cylindrical granite with a borehole in σ_1 direction placed under 450℃ and confining pressure triaxial stress (greatest principal stress σ_1:90MPa, intermediate principal stress σ_2 / least principal stress σ_3:40 MPa), and then three-dimensional isotropic reticulated fractures are formed with a smaller water pressure than hydraulic fracturing at low temperature, and it is found that the permeability increases by about 1000 times [Watanabe et al., 2017, Geophys. Res. Lett.]. Based on this previous study, we are currently working on clarifying the phenomenon of hydraulic fracturing under supercritical geothermal environments using a hydraulic fracturing experiment system under high stress and true triaxial stress conditions.

We have carried out hydraulic fracturing experiments on cubic granite with vertically downward borehole at 400℃ or 450℃ and true triaxial stress (σ_1:40 MPa, σ_2:15 MPa, σ_3:5 MPa), and AE (Acoustic Emission) measurement during the experiment and P-wave velocity measurement before and after the experiment have been conducted. As a result, irrespective of temperature and stress field, the P wave velocity of the rock after the experiment decreased isotropically, and it was suggested that the formation of reticulated fractures found in the previous study is mainly due to pressurization of existing microcracks which are isotropically distributed in rocks by low viscosity water. Furthermore, as a result of AE measurement during the experiment, the peak of AE occurrence was present not only at the time when the borehole pressure reached the maximum value (breakdown pressure) but also after the breakdown. Considering the deformation behavior of the rock during the experiment and the observation result of the thin sections after the experiment, it is suggested that the first peak is due to the occurrence of hydraulic fracturing but the second peak is due to the occurrence of small scale shear deformation and fracture depending on the stress field of the rock where strength has decreased by hydraulic fracturing. As a result, the possibility that the rock behavior after the breakdown also affects the ultimate fracture pattern and the change of permeability was newly found.

・Watanabe, N. et al. Potentially exploitable supercritical geothermal resources in the ductile crust. Nat. Geosci. 10(2), 140–144 (2017).

・Watanabe, N., Egawa, M., Sakaguchi, K., Ishibashi, T. & Tsuchiya, N. Hydrofracturing and permeability enhancement in granite from subcritical/brittle to supercritical/ductile conditions. Geophys. Res. Lett. 44,

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5468–5475 (2017).

Keywords: geothermal, supercritical, true-triaxial

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Experimental measurements of transport pore radius of thermally cracked granite and the relationship of pore structure to permeability

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Fluid flow in rocks plays a key role in many geological processes such as geothermal reservoirs. Permeability is known to be dependent on porosity and pore radius (Walsh and Brace, 1984), while direct determination of pore radius is usually more difficult than determination of permeability. Water expulsion method (Yokoyama and Takeuchi, 2009) is a way to determine the radius of transport pore from gas pressure at which gas breaks through a water-saturated sample (ΔP_{break}). Although several previous studies investigated the relationship between permeability and ΔP_{break} of impermeable rock such as mudstone, those of granite have not been reported. In this study, we develop the water expulsion method under confining pressure and aim to evaluate the relationship between permeability and pore characteristics such as porosity and transport pore radius under high pressure up to 30 MPa.

Thermally-cracked Aji granites were prepared to cylindrical shape (20 mm long and 20 mm in diameter). Thermal cracking was introduced by heating up to 600 ℃ and porosity of a heat-treated sample was about 2.4 % . The transport pore radius was determined by a manner similar to those reported in Yokoyama and Takeuchi (2009), which is an experimental method measuring gas pressure ΔP_{break} (Pa) at which gas breaks through a water-saturated sample. From ΔP_{break} and interfacial tension γ (N m^{-1}), transport pore radius r (m) can be estimated as follows: $r = 2\gamma / \Delta P_{break}$. Permeability was determined from the flow rate at a constant pore pressure (P_p = 0.5 - 3 MPa). The flow rate was measured by a flow method using water as a pore fluid and permeability was calculated following Darcy’ s law. Porosity was estimated using the gas porosimeter, where the grain volume and pore volume of a sample were determined by using Boyle’ s law. Experiments were performed under confining pressure ranging 5 to 30 MPa at room temperature.

Transport pore radius and permeability of thermally-cracked Aji granite were 0.74 μm and 5.5×10^{-17} m^2 under confining pressure of 5 MPa. These values decreased with increase in confining pressure and were 0.14 μm and 2.0×10^{-18} m^2 under confining pressure of 30 MPa. Permeability k (m^2) of granite can be approximated by pore radius r and porosity ϕ according to the relation: $k = 5.32\times10^{-3}\,\phi\, r^2$. This indicates that permeability is primarily dependent on transport pore radius. These results are consistent with the conventional permeability model (Simpson et al., 2003) and estimation of transport pore radius is important for understanding permeability of granite.

Keywords: permeability, transport pore radius, water expulsion method

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Geothermal reservoir evaluation by using TL of Quartz and Fluid Flow Simulation Model of the Kakkonda system in Japan

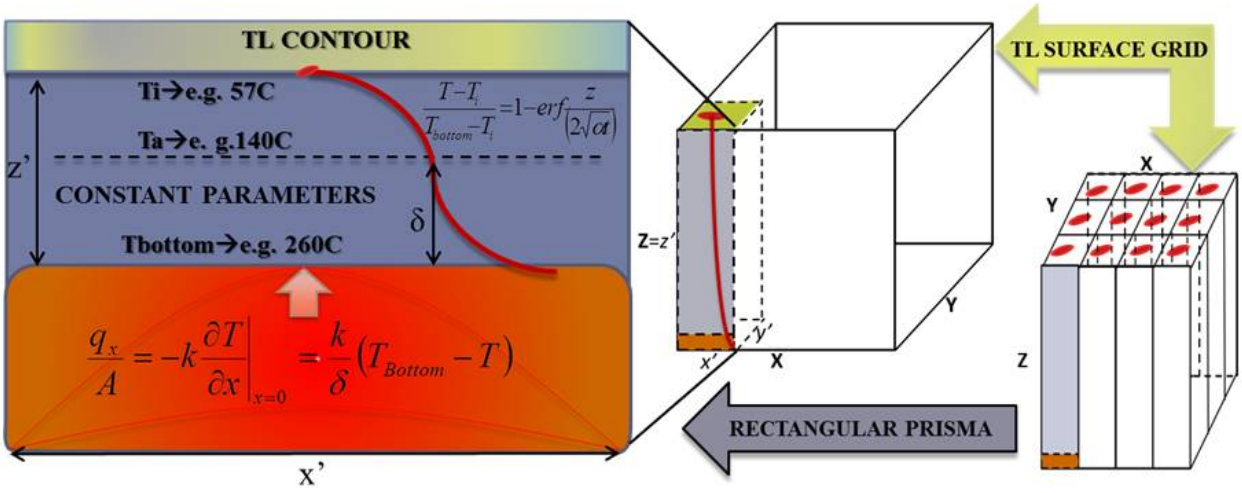
*Alvaro Josue Amaya[1], Nobuo Hirano[1], Noriyoshi Tsuchiya[1]

1. Tohoku University. Graduate School of Environmental Studies

Thermoluminescence (TL) of quartz is used in many geoscientist applications: Radiation measurements, geological dating and recently in geothermal activity prospection. After kinetic understanding, a new geothermal reservoir model has been developed based on the analysis of geological thermoluminescence surface samples and cuttings of borehole quartz samples combined with the system behavior equations. This novel methodology has been designed especially for an early stage of geothermal exploration condition and has been validated in the Kakkonda geothermal field in its initial exploration state. The system was simulated from surface to 5 Km on depth. In order to obtain the geothermal model that uses TL as a heat sensor, the sensitivity of the mineral property to natural heat has been monitored and evaluated through kinetic TL quartz decay experiments using aliquots of a standard sample rooted from same geothermal origin and subjected to different controlled conditions of temperatures taken at different time and deconvoluted by keeping constant 4 peak positions for all database; this has allowed the development of novel TL equations that have been coupled in this proposed reservoir model, which, is based on the description of the system through 3 governing equations for a specific control volume: the geothermal potential system balance, the Fourier equation, and the non-steady state heat conduction equation. Coupled with reservoir model and thermoluminescence model, we can obtain a numerical model of three-dimensional geothermal prospecting temperatures at any position (X, Y, Z) got through geoprocessing GIS tools. Finally, the 3D thermal model was used to parameterize a fluid flow simulation that considers the supercritical condition of the system at 5 Km as a heat source model and by using Hydrotherm software many scenarios of natural system evolution were gotten and a novel sustainable application for operation of the geothermal production operation in the Kakkonda Geothermal Power Plant was proposed.

Keywords: Thermoluminescence, Geothermal Reservoir Evaluation, Thermal Modeling

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Thu. May 30, 2019 1:45 PM - 3:15 PM JST | Thu. May 30, 2019 4:45 AM - 6:15 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[S-CG59] Reducing risks from earthquakes, tsunamis & volcanoes: new applications of realtime geophysical data

convener:Masashi Ogiso(Meteorological Research Institute, Japan Meteorological Agency), Naotaka YAMAMOTO CHIKASADA(National Research Institute for Earth Science and Disaster Resilience), Satoshi Kawamoto(Geospatial Information Authority of Japan), Mitsuyuki Hoshiba(Meteorological Research Institute), Chairperson:Mitsuyuki Hoshiba(Meteorological Res. Inst., JMA, Japan), Satoshi Kawamoto(Geospatial Information Authority of Japan)

As the number of population centers grows in regions with earthquake, tsunami and volcano hazards, the importance of improving methods for rapid, realtime estimates of activity increases. Realtime monitoring, analysis, and prediction of seismic ground motion, crustal movement and tsunami will be powerful tools to contribute to earthquake and tsunami disaster preparedness/mitigation. Tsunami and Earthquake Early Warning systems exist today in many locations around the world. Now JMA has started to promptly provide Eruption Notices to inform people of impending and beginning volcanic eruptions. Large events like the 2011 Tohoku Earthquake (Mw9.0) have demonstrated some of the shortcomings of existing techniques. In this session, we invite presentations on new ideas, methods and applications of (near) realtime analysis of seismic, geodetic and tsunami data, to the problem of realtime prediction aimed at improving disaster preparedness/mitigation in the fields of earthquake, tsunami and volcano observation. Presentation is encouraged to bring together scientists, engineers, and practitioners from a broad range of backgrounds from around the world, and to promote collaborative communication at the leading edge of the science and technologies.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SCG59-01] Earthquake early warning in the United States and beyond

★Invited Papers

*Richard M Allen[1] (1.University of California Berkeley)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SCG59-02] Study on the relationship between seismometer site environment and earthquake early warning seismic parameter estimation accuracy

*Katsutomo Niwa[1], Naoyasu Iwata[1], Shunroku Yamamoto[1] (1.Railway Technical Research Institute)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SCG59-03] **Prediction of surface ground motion using underground seismic records based on data assimilation (2)**

*Masaya Ishihara[1], Hisashi Nakahara[1] (1.Solid Earth Physics Laboratory, Department of Geophysics, Graduate School of Science, Tohoku University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SCG59-04] Development of Realtlime Long-Period Ground-Motion Prediction System and Demonstration Experiment

★Invited Papers

*Shin Aoi[1], Takeshi Kimura[1], Takashi Kunugi[1], Wataru Suzuki[1], Yadab Prasad Dhakal[1], Naoto Kojya[2] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Japan Meteorological Agency)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SCG59-05] Real-time forecasting of long-period ground motions for the Nankai Trough earthquake: The effectivity of the Green function-based data assimilation method

*Atsuki Oba[1], Takashi Furumura[1], Takuto Maeda[2] (1.Earthquake Research Institute, University of Tokyo, 2.Graduate School of Science and Technology, Hirosaki University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SCG59-06] Development of EEW system exchanging real-time seismic intensity and seismic waveform

*Shigeki Horiuchi[1], Yuko Sato[1], Taku Urabe[2], Yamaimaiti Nizhamudong[3], Kazuo Sasaki[3] (1.Home Seismometer Corporation, 2.telemetra , 3.Challenge)

Earthquake early warning in the United States and beyond

*Richard M Allen[1]

1. University of California Berkeley

The ShakeAlert earthquake early warning (EEW) system is now delivering alerts up and down the west-coast of the United States (California, Oregon and Washington). The warnings are being used by targeted groups including transportation, schools, hospitals and other infrastructure operators. Alert are also available to the public in some regions through smartphone apps, and there is an expectation that they will be more widely available in the coming months. The system is operated by the US Geological Survey in cooperation with UC Berkeley, Caltech, the University of Oregon and the University of Washington.

The ShakeAlerts are currently generated by seismic-only algorithms, specifically the EPIC point-source algorithm and the FINDER finite-source algorithm. A great deal of research effort is underway to determine the accuracy and reliability of the current system, and to determine what additional information could be provided by new algorithms. In particular, the use of geodetic observations to improve magnitude estimates and estimate fault finiteness for the largest events is being explored, as is the addition of the PLUM ground motion model approach.

Looking beyond traditional seismic and geodetic networks, the use of smartphones to detect earthquakes and characterize their likely impact for EEW is also being explored. The MyShake global smartphone seismic network is currently recording ground shaking using the 40,000 Android phones that have the app installed. More than 800 earthquakes around the globe have been detected, and research is underway to use these detections to generate alerts and also to improve the quality of alerts from traditional networks.

Keywords: Earthquake , Warnings

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Study on the relationship between seismometer site environment and earthquake early warning seismic parameter estimation accuracy

*Katsutomo Niwa[1], Naoyasu Iwata[1], Shunroku Yamamoto[1]

1. Railway Technical Research Institute

When earthquakes that threaten the safety of railway facilities and running trains occur, earthquake early warning systems aim to stop the trains as soon as possible. The seismometers installed for these systems automatically detect the P-wave arrival, then using information from the initial few seconds of the P-wave estimate seismic parameters such as epicentral distance, epicentral back-azimuth and magnitude, in order to quickly issue an alarm if necessary.

In this research, in order to improve the accuracy of the seismic parameters estimation, we examined the influence of the seismometers installation environment on the accuracy. We defined as characteristics representing the site environment: the ambient noise level of the observation site, determined from 2 seconds of the waveform recorded before P-wave arrival; and the hardness of the subsurface ground, indicated by the average S-wave velocity from the depth of 30m to the surface, henceforth referred to as AVS30.

Firstly, we calculated the RMS pf the 2 seconds of data before the P-wave arrival as the noise level, and checked the relationship between the noise level and the estimation error of the seismic parameters. When the noise level is small, the error of the P-wave detection time tends to become small. When the noise level is large, the automatic P-wave detection time tends to be earlier than would be chosen manually. The epicentral distance tends to be underestimated as the noise level is larger. The estimation error of the epicentral back-azimuth tends to decrease the estimation error as the noise level decreases. However, the magnitude based on the calculated displacement is hardly affected by the noise level, because the magnitude is determined by the maximum value of the observed amplitude.

Following this, we checked the relationship between AVS30 and the estimation error of the seismic parameters. The AVS30 is calculated from the K-NET PS logging result according to a method proposed by Shi and Midorikawa (1999). Since the variation of AVS30 showed little correlation with the estimation error, it can be thought that P-wave detection is hardly affected by the hardness of the subsurface ground. Though the epicentral distance tends to be underestimated as AVS30 gets smaller, this is only to a small extent. The epicentral back-azimuth tends to be smaller as the AVS30 is larger. The magnitude estimation is not correlated with the AVS30.

According to the results outlined above, the accuracy of the seismic parameters estimation will be improved in a quiet environment where the ambient vibration is small, and the subsurface ground is relatively hard. When we select the installation site of seismometers for earthquake early warning, we should therefore give priority to site environments with these characteristics.

Keywords: Earthquake early warning, Seismic parameters estimation, Seismometers installation environment, Noise level, Averaged S-wave velocity

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Prediction of surface ground motion using underground seismic records based on data assimilation (2)

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Introduction

To improve Earthquake early warning (EEW), methods using data assimilation have been proposed for seismic wave field prediction (e.g. Hoshiba et al., 2015) and tsunami prediction (Maeda et al., 2015). Hoshiba et al. (2015) used radiative transfer theory to predict the spatial distribution of seismic intensity. Maeda et al. (2015) used wave equation for tsunami prediction. Recently, Furumura et al. (2018 SSJ) used wave equation for the prediction of long-period seismic ground motion. However, data assimilation based on wave equation has probably not yet used for short-period seismic waves due to restrictions on the density of observation stations, computational costs, and so on. In order to predict short period seismic waves, therefore, we started to apply data assimilation based on wave equation to one-dimensional problems for vertical boreholes such as KiK-net (Ishihara and Nakahara, 2018 SSJ). If we can reproduce surface seismic records quickly and precisely from subsurface seismic records, we will be able to speed up the issuing of alarms more quickly than with surface earthquake records alone. This research is regarded as a basic research towards the advancement of the onsite type EEW for local earthquakes.

Data, Method

In this study, we used NIED KiK-net CHBH10 (Chiba) station. At this observation site, strong motion seismometers are installed on the surface and at a depth of 2000m. We analyzed 60 earthquakes of over M5 occurring around Chiba prefecture. In the simulation, we used the method of Tanaka & Takenaka (2004) which can solve the oblique incidence of plane waves in horizontally stratified structure efficiently by the finite difference method. We calculated the direction of arrival and the incident angle of seismic waves from the particle trajectory of the 1-second-long initial P waves on subsurface records. We simulated the wavefield based on the finite difference method using seismic velocity structure estimated from the logging information. Using the calculated incident angles and subsurface records, we simulated waveforms on the ground surface and compared them with observed waveforms.

Results and discussion

Ishihara and Nakahara (2018 SSJ) found out two problems in this analysis. First, the degree of the fit between observed and calculated waveforms becomes worse with the lapse time. This is caused by artificial upgoing waves which occur when observed waveforms (upgoing wave + downgoing wave) and calculated waveforms (falling wave) do not match at a subsurface station. Another big problem is that the degree of the fit is deteriorated as the angle of incidence becomes larger. This is because artificial SV waves are generated due to the absence of information about stress when inputting observation values (particle velocity) of P waves at the subsurface observation station.

In this study, we calculated the ratio of artificial SV to P waves assuming only P wave input (stress input is zero) to evaluate this effect. The incident angle was varied from 0 ˚to 45 ˚with a step of 1 ˚. As a result, artificial SV waves are generated with an amplitude of about 4% of the P-wave maximum amplitude for an incident angle of 10 ˚, about 10% for 20 ˚, about 25% for 30 ˚and 50% for 45 ˚. In addition, in order to

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reduce this effect, we are repeating simulations by adding virtual stress conditions and subsurface observation stations.
In the future, we will compare our result with the wavefield calculation of Haskell (1962). In order to solve these problems and to improve the prediction accuracy, we will consider optimum arrangements of subsurface observation stations and suitable settings of appropriate stress conditions.

Keywords: earthquake early warning, data assimilation

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Development of Realtlime Long-Period Ground-Motion Prediction System and Demonstration Experiment

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1. National Research Institute for Earth Science and Disaster Resilience, 2. Japan Meteorological Agency

Current technology seems to be hard to predict an occurrence of earthquakes, but is capable to deliver realtime earthquake information just after the occurrence. For railway systems, the earthquake early warning (EEW) system for Shinkansen was utilized in 1990s. For nationwide warning and alerts, Japan Meteorological Agency (JMA) has operated the EEW system since 2007, and realtime information of ground motion plays an important role in society.

On the other hand, the JMA EEW provides only seismic intensities, and not yet to alert broader ground motion information such as long-period ground motions. Long-period ground motions generated during large earthquakes shake skyscrapers in urban area and cause furniture overturning and damage of elevators in them. Recently, JMA issues the long-period ground motion levels based on 5%-damped absolute velocity response spectra in the period range of 1.6 to 7.8 s to respond beyond the seismic intensity measures. Dhakal et al. [2015] constructed a ground motion prediction equation (GMPE) for absolute velocity response spectra in the period range of 1 to 10 s using 36 earthquakes and 12,401 strong motion recordings observed at K-NET and KiK-net stations. The GMPE can provide accurate predictions with correction factors that use depths of the Vs 1.4 km/s layer beneath the sites from the subsurface velocity model provided by the Japan Seismic Hazard Information Station (J-SHIS). The GMPE has an advantage to use the JMA magnitude Mj that is available immediately after the earthquake, not moment magnitude Mw. We developed realtlime long-period ground-motion prediction system using the GMPE of Dhakal et al. [2015] and hypocenter locations and earthquake magnitudes provided by the JMA EEW.

JMA plans to deliver alerts of EEW for long-period ground motions that are similar to the current EEW for seismic intensities. A working group to investigate prediction information for various needs has been established at JMA to activate the plan. Realtime prediction information for ground motions is not allowed to open to the public based on the weather service law. Therefore, NIED collaborates with JMA, and performs demonstration experiments to deliver prediction information of long-period ground motions where NIED acts as a virtual business predictor. The demonstration experiments consist of two types. One is an experiment to use automatic processed prediction information. The other is an experiment to use spatial distribution of prediction information.

In this presentation, we introduce demonstration experiments, results, and future perspectives to deliver observation and realtime prediction information to users using long-period ground-motion prediction system and API and long-period ground-motion monitor.

Keywords: long-period ground-motion, realtlime prediction, earthquake early warning, demonstration experiment

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Real-time forecasting of long-period ground motions for the Nankai Trough earthquake: The effectivity of the Green function-based data assimilation method

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In this study, we considered the possibility of more efficient data assimilation method in order to realize real-time forecasting of Long-Period (LP) ground motions based on the assimilation of strong-motion records and simulation of seismic wave propagation.

Furumura et al. (2019) conducted the real-time forecasting experiment of LP ground motions in the metropolitan area for the 2007 Off Niigata and the 2011 Off Tohoku earthquakes based on the data assimilation of the K-NET and KiK-net records and seismic wave propagation simulation using 3-D FDM. They used optimum interpolation technique, which was also used for real-time forecasting of seismic intensity (Hoshiba and Aoki, 2015) and tsunami (Maeda et al., 2015; Gusman et al., 2016). Since the performance of the supercomputers has improved a lot for recent years, simulation for the Japanese islands scale can be done several times faster than the propagation speed of the seismic wave. However, more effort is necessary to reduce the computational time in order to attain longer lead time before the shaking.

In this study, we considered the applicability of Green's function-based data assimilation. This method is proposed by Wang et al. (2017) as Green'sFunction Tsunami Data Assimilation (GFTDA). GFTDA is the method developed for efficient data assimilation and forecast of tsunami using offshore tsunami network. The Green's functions between the target point and each station are calculated beforehand. The tsunami waveform at the target point is calculated instantaneously by convoluting these Green's functions and the residuals between observation and forecast calculated for each station. This method is proved to be mathematically equivalent to the previous data assimilation method in Wang et al. (2017).

To validate the use of this Green's function-based method for the forecast of LP ground motions, we first conducted the numerical experiment for the 2004 off the Kii Peninsula earthquake (M7.4) and forecasted the LP ground motions at Shinjuku (K-NET TKY007) using the strong-motion records observed in this event. Green's functions are calculated efficiently using reciprocity. The results showed that instant forecast can be available with its accuracy equivalent to that of the previous method. LP ground motions in the distant target point can be forecasted immediately after the assimilation of the observed data near the source, which leads to much longer lead time. Moreover, more accurate forecast and longer lead time were obtained by using offshore stations in DONET, a dense oceanfloor network system for earthquake and tsunamis.

Next, we conducted the forecast experiment for the Nankai Trough earthquake using this method. The target points were Konohana (KiK-net OSKH02), Tsushima (K-NET AIC003) and Shinjuku (K-NET TKY007) stations. For the source model, we used the 1944 Tonankai earthquake, the 1946 Nankai earthquake and the largest event expected (M9) suggested by the Cabinet Office, Japan (2016). For each event, LP ground motions were calculated by 3-D FDM and were used as the observation data. In addition to

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aforementioned networks, stations in the JMA submarine cable network and hypothetical stations of N-net, a newly-planned ocean bottom seismograph/tsunameter network off Hyuganada, were also used. The intensity of strong ground motions was evaluated by GMRotD50 (the median value of the geometric means of the response spectra for two horizontal components when rotating from 0 to 90 degree; Boore et al., 2006). For the evaluation of the duration of LP ground motions, cumulative displacement was calculated. The accuracy of the forecast improved with the assimilation time. In the experiment for the 1946 Nankai earthquake, for example, when the rupture started form the east side, the forecast at Shinjuku with velocity response spectrum and cumulative displacement 70% of the actual observation was obtained about 80 s before the large amplitude LP ground motions started. It required 70 s assimilation after the rupture started. In the case that the rupture started from the west side, the longer lead time (~120 s) was secured when the accuracy reached the same level due to the farther distance between the target point and the rupture initiation point. However, because LP ground motions developed as the fault rupture approached the metropolitan area, longer assimilation time (~100 s) was necessary. From these results, it will be suggested that assimilation should be done while the fault rupture extends and the forecasts should be updated constantly as well as the importance of the strong-motion records near the source region in order to the realize both accurate forecast and longer lead time.

Keywords: long-period ground motions, data assimilation, Green's function

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Development of EEW system exchanging real-time seismic intensity and seismic waveform

*Shigeki Horiuchi[1], Yuko Sato[1], Taku Urabe[2], Yamaimaiti Nizhamudong[3], Kazuo Sasaki[3]

1. Home Seismometer Corporation, 2. telemetra , 3. Challenge

1. Introduction JMA started to issue PLUM telegram in EEW system, which delivers values of real-time intensity measured at all JMA seismic stations in addition to the values of hypocenter parameters. Since the magnitude saturates when a catastrophic earthquake occurs, JMA recommends to use the PLUM method, which uses the maximum value of intensity within 30 km from user location for the intensity estimation. Horiuchi et al. (2011) proposed a method to estimate the fault area of a catastrophic event in real time by using the spatial distribution of real-time seismic intensities. In this report, we developed a system that estimates the location of fault area, displays it on the screen of user’ s PC, and outputs the sound alarm. This system collects continuous waveform from seismic stations using MEMS sensor and delivers waveform data at a time of earthquake occurrence to users PC.

2. Method of real-time estimation of the fault area of a catastrophic event In the case JMA issues EEW with magnitude 7.7 or more, the present system starts to determine fault area by using the method of Horiuchi et al. (2011) with data of real-time shaking intensities. When values of observed seismic intensity is larger than the estimated values from the empirical attenuation equation by Shi and Midorikawa (1999), their method determines distances from these stations to the edge of the fault and determine the location of fault area from the distribution of the edge locations.

3. System overview The present system consists of center server and seismic observation stations equipped with MEMS sensor and Raspberry pi. The roles of center server are (1) receives the plum telegrams from JMA, (2) accepts user registration, (3) acquires continuous waveforms for observation stations, (4) transmits followings to the windows PC of users, 1) hypocenter parameters from JMA, 2) Real-time seismic intensities from JMA and from observation stations of Raspberry Pi, 3) Waveform data at a time of earthquake occurrence. It is required for the user to register user information such as the coordinates of the user location from the Web screen. When the EEW is delivered, the predicted seismic intensity is outputted on the screen. There is a function to issue EEW for the training. In a case a user generates an earthquake in the web site of center server, the center server sends hypocenter parameters and values of shaking intensity to him. If the testing earthquake is a catastrophic event, his PC computes and displays the spread of the fault area for the testing event.

4. result

(1) Since the present PC software provides shaking intensity data and the real-time waveform from the neighboring observation station, these data may be effectively used for the accurate damage prediction by a strong earthquake.

(2) We checked with using observed shaking intensity data whether the spread of the fault area are correctly obtained by the present system. We use shaking intensity data obtained by K-NET from the 17 major earthquakes for the checking. As a result, it was shown that a nearly correct fault area was estimated.

Keywords: EEW, Real-time estimation of the spread of the fault area of a Catastrophic earthquake, exchange of seismic waveform, Rasberry pi seismic station

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Thu. May 30, 2019 3:30 PM - 5:00 PM JST | Thu. May 30, 2019 6:30 AM - 8:00 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[S-CG59] Reducing risks from earthquakes, tsunamis & volcanoes: new applications of realtime geophysical data

convener:Masashi Ogiso(Meteorological Research Institute, Japan Meteorological Agency), Naotaka YAMAMOTO CHIKASADA(National Research Institute for Earth Science and Disaster Resilience), Satoshi Kawamoto(Geospatial Information Authority of Japan), Mitsuyuki Hoshiba(Meteorological Research Institute), Chairperson:Naotaka Chikasada(National Res. Inst. for Earth Science and Disaster Resilience), Masashi Ogiso(Meteorological Research Institute, JMA)

As the number of population centers grows in regions with earthquake, tsunami and volcano hazards, the importance of improving methods for rapid, realtime estimates of activity increases. Realtime monitoring, analysis, and prediction of seismic ground motion, crustal movement and tsunami will be powerful tools to contribute to earthquake and tsunami disaster preparedness/mitigation. Tsunami and Earthquake Early Warning systems exist today in many locations around the world. Now JMA has started to promptly provide Eruption Notices to inform people of impending and beginning volcanic eruptions. Large events like the 2011 Tohoku Earthquake (Mw9.0) have demonstrated some of the shortcomings of existing techniques. In this session, we invite presentations on new ideas, methods and applications of (near) realtime analysis of seismic, geodetic and tsunami data, to the problem of realtime prediction aimed at improving disaster preparedness/mitigation in the fields of earthquake, tsunami and volcano observation. Presentation is encouraged to bring together scientists, engineers, and practitioners from a broad range of backgrounds from around the world, and to promote collaborative communication at the leading edge of the science and technologies.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SCG59-07] Enhancements of real time seismic intensity estimation using seismic intensity meters maintained by a local government – Case study on Tottori prefecture -

*Takao Kagawa[1] (1.Tottori University Graduate School of Engineering)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SCG59-08] **Drawig of the realtime seismic intesity on live screen and maximum distribution map for the Earthquak disaster prevension.**
-Planar indication of seismic intensity using surface ground amplification factor-

*Kenji Kanjo[1], Isao Takahashi[1], Yoshinori Shinohara[1], Rami Ibrahim[2] (1.Takamisawa cybernetics Co. Ltd, 2.Earthquake Research Institute, University of Tokyo)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SCG59-09] Improvements of the GEONET real-time analysis system (REGARD) for more reliable operation

*Kazuyuki Ohashi[1], Satoshi Abe[1], Yasuaki Kakiage[1], Satoshi Kawamoto[1], Hiroshi Munekane[1] (1.GSI of Japan)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SCG59-10] Development of “real-time” uncertainty evaluation algorithm for the estimated coseismic fault model using MCMC approach

*Keitaro Ohno[1], Yusaku Ohta[1] (1.Recerch Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SCG59-11] Drifting float measurement of pressure change by tsunami

*Masayuki Obayashi[1], Shingo Watada[2], Hiroko Sugioka[3] (1.Japan Agency for Marine-Earth Science and Technology, 2.Earthquake Research Institute, University of Tokyo, 3.Department of Planetology, Kobe University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SCG59-12] Development of the Real-time Forecasting for Meteorite Impact Tsunami

*Naotaka YAMAMOTO CHIKASADA[1], Toshitaka Baba[2], Tetsuharu Fuse[3] (1.NIED, 2.Tokushima University, 3.NICT)

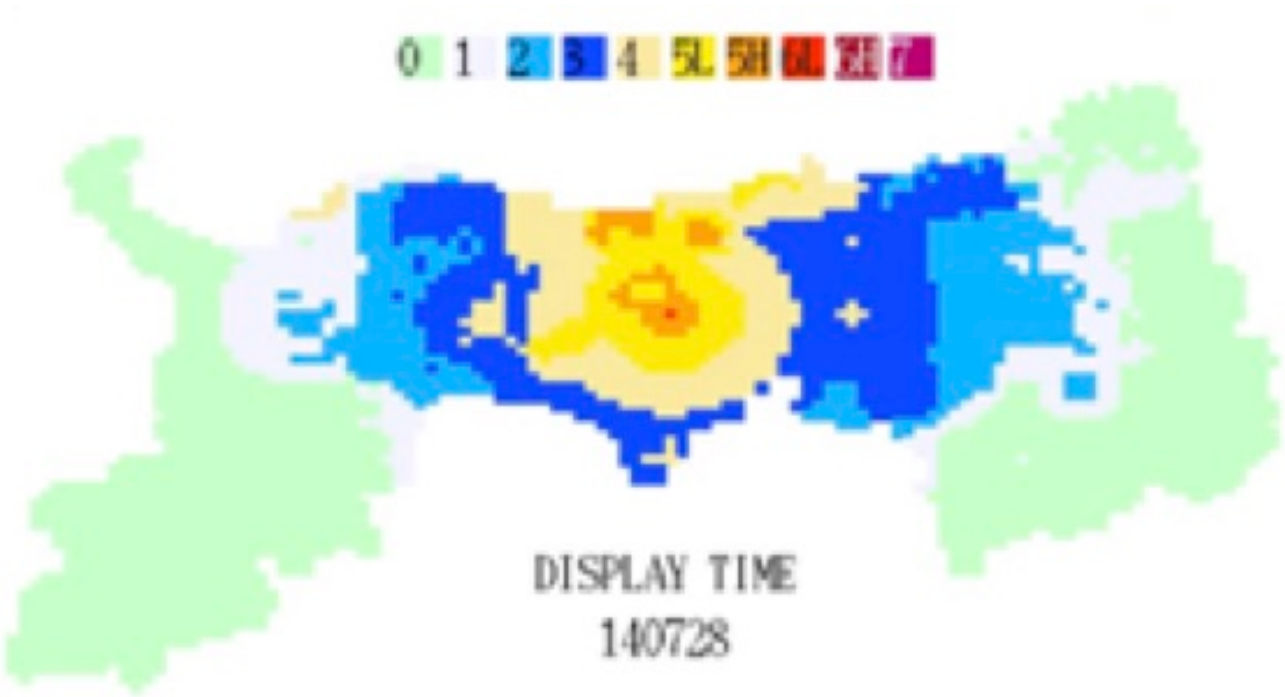
Enhancements of real time seismic intensity estimation using seismic intensity meters maintained by a local government –Case study on Tottori prefecture -

*Takao Kagawa[1]

1. Tottori University Graduate School of Engineering

Enhancements of real time seismic intensity estimation using seismic intensity meters maintained by a local government is demonstrated. Dense observation network is desirable for upgrading accuracy and quality of Earthquake Early Warning System. Seismic intensity meters installed in all municipalities are the most suitable equipment for the purpose. The seismic intensity meters in Tottori prefecture are improved to broadcast packets with peak ground acceleration and JMA seismic intensity at every one second. The data are received at Tottori University and PLUM method is applied to the data for estimating JMA seismic intensity distribution at 1km grid points. In this study, two additional methodologies are introduced on the system. One is attenuation of seismic intensities from observed sites and propagation from every grids for estimation. Another is introduction of P wave amplitudes for seismic intensity estimation. Using the methodologies, we can obtain rapid and detailed seismic intensity distribution than before.

Keywords: Local Government, Seismic Intensity Meter, Real Time, PLUM method, P wave



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Drawig of the realtime seismic intesity on live screen and maximum distribution map for the Earthquak disaster prevension. -Planar indication of seismic intensity using surface ground amplification factor-

*Kenji Kanjo[1], Isao Takahashi[1], Yoshinori Shinohara[1], Rami Ibrahim[2]

1. Takamisawa cybernetics Co. Ltd, 2. Earthquake Research Institute, University of Tokyo

Earthquake damage can be caused from a small-sized earthquake (magnitude class 4.5) occurs in inland areas to a large-sized earthquake such as the 2011 Tohoku earthquake (Mw 9.1). In recent years, it is possible to estimate the amount of detailed displacement of the destruction zone from the inversion analysis of observed data. Moreover, ground motion prediction equations (GMPEs) and earthquake prediction recipes have been proposed. Those developments contributed to the earthquake disaster mitigation measures. Earthquake early warning system (EEW) of Japan has been in operation since 2007, it is very useful to issue information that have a great impact on disaster mitigation, however, some problems still exist with the information issued by EEW. For instance, the warnings are sometimes issued after S-wave arrivals, which leaves an area without alarm known as a blind zone area.

In this study, we used a dense seismic network dataset recorded during the 2016 Kumamoto (Mw 7.0), and the 2019 January 3rd (Mw 5.1) earthquakes, maximum JMA intensity of 7 and 6 upper, respectively. In spite of the difference of magnitudes and source size area the two earthquakes had close maximum intensity values. It noted that the average spacing distribution of seismic instrument in that regions is ~ 4-5 km. We here obtain the maximum peak ground acceleration (PGA) on free surface on each observed point, we then corrected PGA to engineering basement, using site effect information from J-SHIS (NIED), spaced by 1×1 km^2. Using PGA on engineering bedrock, we estimate the PGA on free surface by multiplying with surface amplification factor at each grid point of 1×1 km^2, we then evaluate the seismic intensity at each grid. We repeat this process for each observed point considering the inter-station distance and finally produce the intensity map.

Our method gives a quick information about earthquake location (close or far), hypocentral depth (shallow or deep) inferred from apparent velocity distribution maps. It also recognizes the earthquake source size (small or large) inferred from the spatial distribution of PGA. We also attempted scaling by so-called P wave detection and maximum seismic intensity distribution prediction using theoretical amplitude ratio (5 times) of S wave / P wave at the seismic source.

It is a very important issue to observe the strong-ground motion in real-time to improve the performance of EEW. We strongly recommend local government to have their own high density network, which gives a quick earthquake disaster information. The Japan Meteorological Agency will aim for speeding up and improving the precision of emergency earthquakes (eliminating the blind zone) by integrating server information of each local government (with small budget without directly telemetering observation point data covering several thousands of points).

Acknowledgments
We express our appreciations to the officials in Tokyo, Kyoto, Nara, Sapporo,
Kumamoto, Miyagi, Fukushima and Ibaraki prefectures uploaded the seismic intensity data used for the

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analysis to the Japan Meteorological Agency Web page.

Keywords: Local government measurement intensity meter, Engineer basement seismic intensity , Evaluate by surface amplification factor , Real time seismic intensity, Live view, Maximum seismic intensity distribution map

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Improvements of the GEONET real-time analysis system (REGARD) for more reliable operation

*Kazuyuki Ohashi[1], Satoshi Abe[1], Yasuaki Kakiage[1], Satoshi Kawamoto[1], Hiroshi Munekane[1]

1. GSI of Japan

The displacement data produced by GNSS observations never saturate for large earthquakes in contrast to seismometer data that has a limitation of instrument saturation. Geospatial Information Authority of Japan has launched a real-time GNSS analysis system named “REGARD” which estimates finite fault models based on the Japanese nationwide GNSS network GEONET. The REGARD system has been in operation since April, 2016. The system experienced 2016 Kumamoto earthquake, and provided a single rectangular fault model with very high variance reduction (VR) of 96%. The REGARD system has been become increasingly important for rapid response to major earthquakes for providing coseismic displacements, finite model estimate, and moment magnitude rapidly. Therefore, the system must be more stable. So we try to implement other positioning procedure to REGARD system.

The REGARD system conduct relative positioning by using reference station data and rover station data. If reference station data lacked, we can’t obtain the coordinates of all other station. So we focus on Precise Point Positioning(PPP). Real-time PPP analysis needs correction data of Ionospheric delay, Tropospheric delay, satellite clock and so on. We implement as follow system. (1) Collect real time observation data from about 100 worldwide GNSS station. (2) Estimate ephemeris and collection data by using MADOCA(Multi-GNSS Advanced Demonstration tool for Orbit and Clock Analysis) developed by JAXA. (3) Conduct real time PPP analysis.

As a results of accuracy evaluation of real time PPP analysis, the accuracy is less than REGARD system. If we subtract one station results from other station(PPP-differential), the accuracy is improvement as well as REGRAD system. Therefore, real time PPP analysis system is expected to be useful for improving redundancy and robustness of REGARD system.

Keywords: REGARD, GNSS, PPP

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Development of “real-time” uncertainty evaluation algorithm for the estimated coseismic fault model using MCMC approach

*Keitaro Ohno[1], Yusaku Ohta[1]

1. Recerch Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University

Rapid understanding of the magnitude of large earthquakes and their associated fault dimensions are extremely important. Since September 2012, Geospatial Information Authority of Japan (GSI) and Tohoku University are jointly developing the GEONET real-time analysis system (REGARD). REGARD system rapidly estimates two types of coseismic fault models, which are slip distribution along the plate interface and single rectangular fault model, using permanent displacement field based on the real-time GNSS tine series. Currently, REGARD adopted the maximum likelihood approach to estimate the optimum model. The system has two points to be improved. As first point, it is difficult to estimate the quantitative uncertainty estimation of the obtained result because of the estimated result should contain both of the observation error of the real time GNSS and modeling error caused by the model settings. Understanding of such uncertainties quantitatively based on the data is important for evaluation of the result for disaster response. Second point, the problem is non-linear to estimate the single rectangular fault model in REGARD. Thus, the result strongly may depend on the initial values of the fault parameters. It is necessary to find the global minimum quickly for real-time use.

Based on these backgrounds, we are developing coseismic fault model estimation system using MCMC (Markov Chain Monte Carlo methods), which is probabilistic approach based on Bayesian statistics. MCMC does not specify one maximum likelihood value, but estimates the posterior probability density function (PDF). In addition, dependency on the initial value is relatively small by searching unknown parameters over a wide range randomly. In this study, we focus on the development the algorithm to estimate the single rectangular fault model deduced from permanent coseismic displacement field in real-time. We adopted basic Metropolis Hasting method as sampler and utilized parallel tempering approach to improve the sampling efficiency. One of the challenges for using MCMC in real time is how to make search settings, such as initial value, walk distance, variance of likelihood function, and Burn-in, which are generally decided by the try and error. We suggest a method of deciding these values automatically using scaling law and original sampling flow. Other challenging issue is calculation time. In generally, the calculation cost of MCMC is problem for the real-time purpose. To improve the performance of the MCMC we adopted OpenMP for the parallelization of the computing.

We applied this approach to the 2011 Tohoku-Oki earthquake, 2016 Kumamoto earthquake, and 2016 Fukushima-Oki earthquake using the actual permanent displacement time series from REGARD. In each estimations, we got 1×10^6 samples and obtained posterior PDF within 30 seconds. To emphasize, this algorithm could estimate the magnitude as distributions based on the data. Especially in Tohoku-Oki earthquake, obtained results clearly shows the tradeoff between the fault area and the slip amount. This result suggests that the onshore GNSS data cannot constrain them, which are extremely important factors for precise near-field tsunami forecasting.
In our presentation, we will show the more detail characteristic of the algorithm. We are working on development of it for single rectangular fault model aiming at actual operation. Furthermore, we will expand this approach to not only the single rectangular fault but also the slip distribution along the plate interface.

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Keywords: MCMC, GNSS, real-rime, rapid prediction, bayesian, uncertainty

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Drifting float measurement of pressure change by tsunami

*Masayuki Obayashi[1], Shingo Watada[2], Hiroko Sugioka[3]

1. Japan Agency for Marine-Earth Science and Technology, 2. Earthquake Research Institute, University of Tokyo, 3. Department of Planetology, Kobe University

Recently a new instrument, named MERMAID (Mobile Earthquake Recording in Marine Areas by Independent Divers), was developed to measure acoustic signals converted from seismic waves at the seafloor. The MERMAID is a Lagrangian drifter equipped with a hydrophone and drifts passively at 1,500 –2,000 m depth until an earthquake signal is detected. If this is identified as a strong P wave, the MERMAID ascends at speed of 10 cm/s for transmission of the recorded waveform within time window of a hundred seconds before and after the P wave arrival as well as its global positioning system (GPS) coordinates at the surface. After transmitting the data via satellite links, the MERMAID descends at speed of 5 cm/s to monitor earthquake signals at 1,500 –2,000 m depth again.
It was reported that tsunamis were recorded by hydrophones (e.g. Okal et al., 2007), notably in frequency bands extending outside the range of the Shallow Water Approximation. If MERMAID floats can cover the oceans as dense as the Argo project of which almost 4000 floats are now drifting to measure temperature and salinity in the oceans, we acquire valuable tsunami data. Here we estimate what signals are observed by a MERMAID, by comparing to the pressure change of the 2010 Chile Tsunami measured by a differential pressure gauge (DPG) at about 4800 m deep seafloor.
We assume linearized water wave with period T, amplitude H, and phase velocity c as shown in Figure 1. Phase velocity c is given by $c = (g \tanh(kD) / k)^{1/2}$, where k is horizontal wavenumber $k = \omega / c$, $\omega = 2\pi / T$ is angular frequency and g is gravity. The wavenumber $k(\omega, D)$ of the water waves in a constant depth ocean as a function of a wave period is obtained by the recursion equation. The water wave height $W(x, t)$ as the function of time t and horizontal position x is expressed as
$W(x,t) = H e^{i(kx-\omega t)}$
The MERMAID is Lagrangian float drifting at a depth of z ($0 > z > -D$) and measures Lagrangian pressure of water, where D is water depth.
Lagrangian pressure $\delta p(x, z, t)$ is given by
$\delta p(x, z, t) = -\{H \rho_o g \sinh(kz) / (\sinh(kD) \cosh(kD))\} e^{i(kx-\omega t)}$
Eulerian pressure is given by
$p'(x, z, t) = \{H \rho_o g \cosh(k(D+z)) / \cosh(kD)\} e^{i(kx-\omega t)}$
Therefore, pressure measured by a DPG at seafloor is expressed as
$p'(x,-D, t) = \{H \rho_o g / \cosh(kD)\} e^{i(kx-\omega t)}$
and the pressure $\delta p(z)$ measured by a MERMAID at z depth can be related
with the DPG pressure $p'(D)$ by
$\delta p(z) = R\, p'(-D)$, $R = -\sinh(kz) / \sinh(kD)$
If T is large enough that k is close to 0, R becomes close to z/D. Figure 2 shows the R as the function of T for floats at 1000 (blue) and 2000 (red) m depth, suggesting the R acts as a low-pass filter. Figure 3 shows the predicted pressure changes observed floats drifting at 1000 (blue) and 2000 (red) m depth. In the presentation, we will discuss availability of tsunami measurement by a float.

Keywords: tsunami, float, hydrophone, differential pressure gauge

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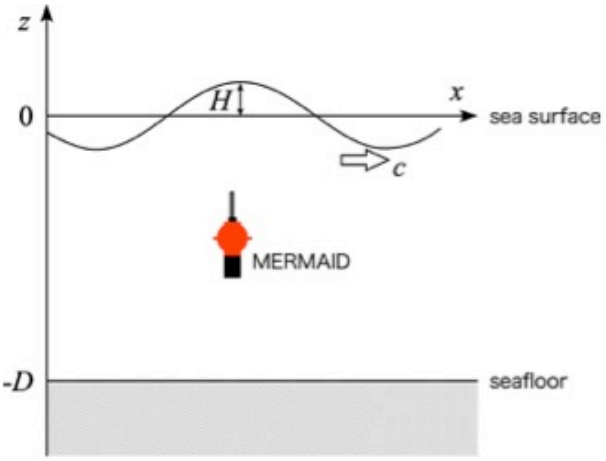


Figure 1. Problem setting

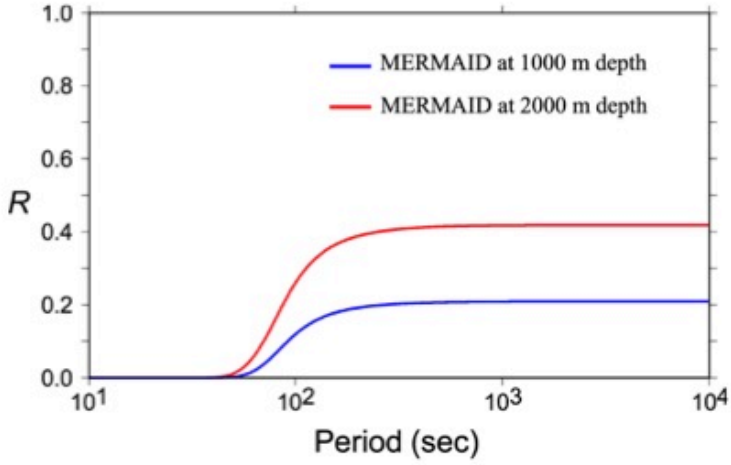


Figure 2. R as the function of period T

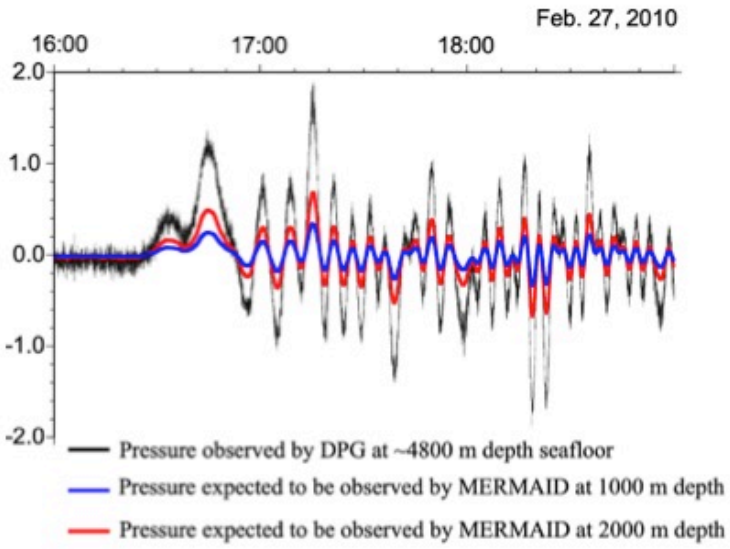


Figure 3. Predicted pressure changes observed by MERMAIDs at 1000 and 2000 m depth.

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Development of the Real-time Forecasting for Meteorite Impact Tsunami

*Naotaka YAMAMOTO CHIKASADA[1], Toshitaka Baba[2], Tetsuharu Fuse[3]

1. NIED, 2. Tokushima University, 3. NICT

Tsunami induced by earthquakes, submarine landslides, volcanic eruption in submarine and coastal area and meteorological phenomena is one of the most devastating natural disasters. A meteorite impact into the oceans spawn large tsunami depending on the size and velocity of the meteorite and the sea depth at the location of the impact as well. However, we do not have a numerical model to reproduce both of meteorite impacts and tsunami propagations. We have started to develop a new numerical model to simulate tsunamis generated by the meteorite impact combining iSALE (Wünnemann et al., 2006) for simulating impact phenomena and JAGURS (Baba et al., 2017) for simulating tsunami. The iSALE is a multi-material and multi-rheology shock physics code for simulating impact phenomena. JAGURS is a parallelized tsunami simulation code to solve two-dimensional non-linear long-wave equation with Boussinesq terms for representing observed tsunami waveforms, tsunami height and inundation. We set sea-floor deformation, sea-surface disturbance and velocity of gravity wave which is the output from iSALE to the input of JAGURS. We then calculate tsunami height along the coastlines in any place using ASTER GDEM version 2 (Fujisada et al., 2012) and GEBCO_2014 Grid. ASTER GDEM has one arcsecond (about 30 m) spatial resolution and covers land between 56S and 60N latitude as a topographic data. GEBCO’s gridded bathymetric data has thirty arcseconds (about 1 km) spatial resolution for the worldwide.
We first investigate the tsunami generation using iSALE code for creating tsunami source model depending on the meteor size, the velocity of impact, the size of cavity, the width and depth of crater and tsunami propagation speed. We also investigate probabilistic hazard of meteorite impact tsunami using simplified cavity curves with developed JAGURS built-in. Finally, we construct a new numerical model of meteorite impact tsunami combining iSALE and JAGURS. Additionally, we consider the way of automatic detection of meteorite impact using the recode of the highly sensitive seismograph network in real-time.
We gratefully acknowledge the developers of iSALE, including Gareth Collins, Kai Wünnemann, Boris Ivanov, H. Jay Melosh and Dirk Elbeshausen. Data analysis and visualizations of iSALE were carried out on PC cluster and computers at Center for Computational Astrophysics, National Astronomical Observatory of Japan. This work was partially supported by JSPS KAKENHI Grant Number JP18K04674.

Keywords: Real-time forecast, Tsunami, Meteorite impact

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[J] Oral | B (Biogeosciences)：B-PT Paleontology

Thu. May 30, 2019 1:45 PM - 3:15 PM JST | Thu. May 30, 2019 4:45 AM - 6:15 AM UTC | 201A 2F

[B-PT05] Biotic History

convener:Isao Motoyama(Department of Earth and Environmental Sciences, Yamagata University), Takao Ubukata(Division of Geology & Mineralogy, Department of Earth & Planetary Sciences, Kyoto University), Kazuyoshi Moriya(Department of Earth Sciences, Faculty of Education and Integrated Arts and Sciences, Waseda University), Chairperson:Isao Motoyama, Takao Ubukata, Kazuyoshi Moriya

The Biotic History session covers all aspects of ancient life and the history of biosphere through the geologic time. The study of ancient life is essential for unveiling mysteries of our planet earth. It also provides evidence for evolution of oceans, continents and island arcs. Modern progress in this field has been enhanced by interdisciplinary collaboration with allied sciences, such as paleoceanography and evolutionary biology. Our session intends to be a hub of communication amongst all earth scientists studying the biosphere; we welcome biological and biogeochemical approaches toward the understanding of the history of life.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[BPT05-01] Cause of accelerated evolution of Earth's life; four-layered underground robust bio-communities played a critical role for the accelerated genome evolution as a response of mass extinction

*Shigenori Maruyama[1], Akio Kanai[2], Issay Narumi[3] (1.Earth-Life Science Institute, Tokyo Institute of Technology, 2.keio University, 3.Toyo University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[BPT05-02] Amino acid composition in molluscan shells and its relation to taxa and shell microstructure ~ Toward reconstruction of ancient trophic level using compound specific isotope analysis of amino acids ~

*Naoki Yugami[1], Akiko Goto[2], Robert Jenkins[2] (1.Graduate School of Natural Science & Technology. Kanazawa Univercity, 2.Institute of Science & Engineering . Kanazawa Univercity)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[BPT05-03] Relation of shell form to rocking motion in planispiral cephalopods

*Takao Ubukata[1] (1.Division of Geology & Mineralogy, Department of Earth & Planetary Sciences, Kyoto University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[BPT05-04] Paleoenvironment aross the Meddle Eocene Climatic Optimum

Hiroki Masui[1], *Kazuyoshi Moriya[1] (1.Department of Earth Sciences, Faculty of Education and Integrated Arts and Sciences, Waseda University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[BPT05-05] Reconstruction of the North Pacific subtropical gyre from the Middle to Late Miocene as inferred from radiolarian assemblages

*Shin-ichi Kamikuri[1], Isao Motoyama[2], Taiki Sawada[3] (1.Faculty of Education, Ibaraki University, 2.Faculty of Science, Yamagata University, 3.Japan Petroleum Exploration Co.,Ltd.)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[BPT05-06] Fossilization processes of Pliocene tree fossils from the Yasu River, Shiga Prefecture, Japan: Organic geochemical approach

*Jinya Nakamura[1], Ken Sawada[2], Masashi A Ikeda[1], Hideto Nakamura[3], Minoru Tsukagoshi[4] (1.Graduate School of Science, Hokkaido University, 2.Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University, 3.Faculty of Science, Osaka City Univerisity, 4.Osaka Museum of Natural History)

Cause of accelerated evolution of Earth’s life; four-layered underground robust bio-communities played a critical role for the accelerated genome evolution as a response of mass extinction

*Shigenori Maruyama[1], Akio Kanai[2], Issay Narumi[3]

1. Earth-Life Science Institute, Tokyo Institute of Technology, 2. keio University, 3. Toyo University

It has long been recognized the concept of five kingdom or six kingdom model which shows the life with difference of function and size. If believing Darwinian Evolution, how can we interpret the diversified distribution with primitive small microbes to the most evolved types of large life. If we consider the most evolved metazoans such as human being to be the result of increased free oxygen in atmosphere, why do the anoxic microbes remain on the surface.
We have engaged in the decoding Earth history Program over 30 years, and obtained the following six results, (1)Since the birth of life until 4.0Ga, three times of Great Evolution of Life (GEL) occurred, (2)Those evolutions were predominantly controlled by the pO_2 increase in the environments, (3)Underground bio-communities are present forming 4-layers with boundary layers, (4)Each layer corresponds to different pO_2 levels; the older the lower pO_2 , (5)In between the two, where two-way genome biomes are present, although speculative, and (6)These four layers could have been formed during the 3 GEL times, accompanying many mass extinctions. Those were remained as fossil environments where evolution stopped, because of no significant environmental changes, in spite of extremely severe surface environments with frequent mass extinction and resultant accelerated evolution of life.
The result corresponds to the concept of 5-6 Kingdom which suggests the preservation of biological communities with different level of pO_2 in environments. Through the Earth history, new GEC occurred with great change of pO_2 , the advanced life on the surface suffered mass extinctions due to exponentially decreased pO_2, instead the underground microbes invaded to the surface, and evolved there again. This is the entity of evolution of life on the earth. Therefore, the presence of robust 4 layered underground biological communities must have contributed to evolving life on this planet, in spite of severe environmental change of planets over 4.0 billion of years in the Universe, not by death, but evolved thorough GEL at 4.0Ga, 2.2Ga and 0.6Ga.

Keywords: oxygen level, underground bio-community, accelaration of life's evolution

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Amino acid composition in molluscan shells and its relation to taxa and shell microstructure ~ Toward reconstruction of ancient trophic level using compound specific isotope analysis of amino acids ~

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We may clarify the trophic level of fossils applying “trophic level estimation method using compound specific isotope analysis of amino acids” (Chikaraishi et al., 2009). When applying the method to fossils, we must pay attention to whether amino acids in fossils are original or not, so screening of fossil samples is important. We can apply "amino acid composition conforming to shell microstructure" to the screening of fossi samples. This depends on a study showing the amino acid composition is different for each shell microstructure in the present bivalve (Kobayashi and Samata, 2006). We may determine whether amino acids present in the fossil shell are original or not by confirming “whether there is an amino acid composition specific to the shell microstructure observed in the fossil”. However, Kobayashi and Samata (2006) showed only the difference in amino acid composition each shell microstructures in the bivalvia, and not showed stability in the lineage relationship of the same microstructure. Moreover, there are problems such as the fraction of the amino acid composition, the method used, and the equipment to be used are different for each article, so it is difficult to compare for each article easily. In addition, there are no papers showing amino acid composition of Protbranchia of bivalvia. From the above, the stability of the amino acid composition for each shell microstructures in the lineage is unknown. Therefore, we set the pupose of this research that clarifying the stability of the amino acid composition of each shell microstructure in molluscan from the present raw sample. In this study, we focus on nacreous structure because this structure contain a lot of organic matter and it is primitive structure. We will clarify the stability of the amino acid composition of each taxa and shell microstructure, comparing within each taxa and lineage of bivalve, gastropod, and cephalopod.

As a result of cluster analysis, we found that the amino acid composition can be roughly divided into two groups, "primitive group" and "derivative group", in both the gastropoda and bivalvia. The amino acid composition of *Turbo sazae, Turbo mamoratus* and *Lunella coreensis* of gastropoda belonging to the same family were stable. Moreover, in the bivalvia, the amino acid composition is stable in the Pteriomorpha and Palaeoheterodonta, and in the Protobranchia, respectively. We could find the differences in the amount of alanine etc. in the Pteriomorpha- Palaeoheterodonta lineage and Protobranchia lineage. From this, it can be said that the amino acid composition of the nacreous structure is stable in family in gastropoda and stable in subclass in bivalvia. Cluster analysis showed that "gastropoda group" and "bivalvia group" have relatively close relationships, and their amino acid composition is similar in that alanine and glycine are abundantly included. However, it has been suggested that proteins used for shell formation in bivalvia and gastropoda may have been obtained independently in the process of evolution (Mann et al., 2018). Since amino acids which are likely to be included depending on the function of the protein are determined, it is thought that the amino acid composition converges evolutionarily and is similar even if it has different proteins.

Through this study, both bivalvia and gastropoda are roughly divided into two groups, "primitive group" and "derivative group", and furthermore, we could set the amino acid compositions used for screening of

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fossil samples of nacreous structure to five, "Nautilus", "primitive of Vetigastropoda", "derivative of Vetigastropoda", "primitive of Bivalvia (Protobranchia)", "derivative of Bivalvia (Pteriomorpha, Palaeoheterodonta)". Therefore, we will be able to screen fossil samples of nacreous structure more precisely by using "amino acid composition conforming to lineage-shell microstructure" for trophic level estimation.

Keywords: amino acids, Phylogenetic relationships, trophic level, molluscs

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Relation of shell form to rocking motion in planispiral cephalopods

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In Recent *Nautilus*, thrust force produced by the hyponomic jet acts to rotate the shell resulting in a rocking motion during swimming. This instability is a potential problem for any other ectoconchleate cephalopods with planispiral conchs when they swim. A smaller distance between the center of gravity and center of buoyancy tends to cause a large rotation of the shell. For this reason, it has long been imagined that ammonoids with long body chambers are less stable than *Nautilus* during swimming. In contrast, it has also been considered that a long body chamber places the aperture higher and positions the hyponome at the same level of the center of gravity so that the hyponomic jet can act directly through the center of gravity. Previous discussions on static stability of ectoconchleate cephalopods largely focused on indirect assessment based on the aperture orientation and the position of the center of gravity and center of buoyancy. The present study assessed the angle of rocking motion for various shell forms of planispiral cephalopods to generalize the relationship between conch geometry and static stability. The angle of rocking motion was computed for theoretical morphologic models based on force and moment balance presuming a neutrally buoyant condition. The thrust force of hyponomic jet was assumed to be expelled from the ventral edge of the aperture and to generate a moment which is opposed by the restorative moment produced by inclination of segment between the center of gravity and center of buoyancy. Form drag and shear stress acting on the shell moving with respect to surrounding water were ignored in calculating the opposing moment. The inclination angle of the segment between the center of gravity and center of buoyancy was regarded as the angle of rocking motion and was computed for each theoretical model with given values of whorl expansion rate, relative umbilical width, and relative whorl breadth. The result revealed following: (1) The angle of rocking motion fluctuates with changes in the whorl expansion rate (*W*) if the value of *W* is small enough so that the body chamber is more than one whorl in length. In this condition, the rocking angle varies sensitively to the change in *W*. (2) The rocking angle is large when the shell is slender. (3) The rocking angle does not highly depend on the relative umbilical width. These results indicate that the long body chamber resulting from a small *W* does not always allow the animal stable swimming and a slight intraspecific or ontogenetic variation in *W* may cause drastic change in static stability in such form. The result suggests that such static instability limits swimming ability in some ammonoids with tightly coiled conchs.

Keywords: cephalopods, hydrostatics, stability

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Paleoenvironment aross the Meddle Eocene Climatic Optimum

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The Middle Eocene Climatic Optimum (MECO) is an abrupt short-term global warming event that occurred about 40 Ma. Although this event is now reported from all across the world, the environmental impacts and biotic responses accompanying the event are still poorly understood. Since we are now faced with the threat of global warming, deeper understanding of past global warming events like the MECO is critical.

We present bulk carbonate stable isotope data, coarse fraction accumulation rates (CFAR), and planktic foraminiferal assemblage data spanning the MECO interval from International Ocean Discovery Program (IODP) Site U1408 in the Northwest Atlantic to assess environmental changes and biotic responses across the event. A negative shift in bulk $d^{18}O$ was observed from 40.6 Ma (the MECO onset) to 40.0 Ma (the peak MECO), followed by a sudden return to the background level by 39.9 Ma (the termination). A significant decline of CFAR was observed near the peak of the MECO (40.3 Ma–40.0 Ma). This may reflect a decline in planktic foraminiferal production due to starving caused by elevated metabolism coupled by limited availability of nutrients. In contrast, a sudden increase in bulk $d^{13}C$, CFAR, and eutrophic planktic foraminiferal genus, *Pseudohastigerina*, was observed immediately after the peak of the MECO (40.0-39.9Ma). This may indicate a sudden switch to the eutrophic environment and an increase in primary and planktic foraminiferal production. The termination of the warming might have caused continental aridification and resulted in an increased input of aeolian dust to the ocean. In addition, the relative abundance of photosymbiotic planktic foraminiferal genus, *Acarinina*, declined toward the peak of the MECO, while the relative abundance of another photosymbiotic genus, *Globigerinatheka* remained almost constant throughout the MECO. This may indicate the loss of photosymbiotic algae exclusively affected *Acarinina* during the event.

Keywords: Planktic foraminifers

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Reconstruction of the North Pacific subtropical gyre from the Middle to Late Miocene as inferred from radiolarian assemblages

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A major objective of the present study is to reconstruct gyral circulation patterns of the subtropical North Pacific from the middle to late Miocene based on the radiolarian assemblages. We collected the mudstones from ODP Site 1021 of the California margin in the northern area of the California Current, and from outcrops of the Boso Peninsula (Japan) in the northern area of the Kuroshio.
The middle Miocene subtropical Pacific was dominated by warm-water taxa, and similar taxa in the eastern and western areas. The distribution pattern of radiolarian faunas in the subtropical North Pacific was due to be similar in the surface water structure and temperature, and indicates that the general gyral circulation system was only weakly developed in the middle Miocene. During the late Miocene the cool-water taxa increased and the warm-water taxa declined overall in the subtropical Pacific. At the same time the east-west faunal provincialism increased. This faunal change has been associated with the resultant strengthening of the general gyral circulation in the subtropical Pacific due to the significant high latitude cooling and the closing of the Indo-Pacific Seaway at that time.

Keywords: North Pacific subtropical gyre, Miocene, radiolarian assemblage

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Fossilization processes of Pliocene tree fossils from the Yasu River, Shiga Prefecture, Japan: Organic geochemical approach

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The Pliocene fossil forest (ca. 2.7 Ma) is known to be distributed in the Yasu River, Shiga Prefecture, Japan. The tree fossils in the forest are characterized by blackish coal-like tissues in the surface but living tree-like fresh lignite in their inner part. In the present study, we investigate by organic geochemical analyses to identify the taxonomy and to examine fossilization, diagenesis, and taphonomy of the tree fossil.

The tree fossils used was separated to three parts; surface (outer), intermediate, and inner parts. The outer part is blackish coal-like tissue, but inner part is brownish lignite. The intermediate part is dark brownish lignite-like tissue. Lipids were extracted with dichloromethane/methanol, and separated to aliphatic, aromatic and polar fractions. Lipids were identified and quantified by GC-MS. The residues after extraction were used for pyrolysis and thermochemolysis by GC-MS equipped a Curie-point pyrolyzer. Thermochemolysis was performed with tetramethylammonium hydroxide (TMAH)

By the thermochemolysis, vanillic phenols are predominantly detected in all parts of the tree fossils. Phyllocladane and cuparane were identified as major plant-derived terpenoids in fee (extractable) components of the fossil samples. The phyllocladane is conifer-derived diterpenoid, and cuparane is a specific sesquiterpenoid produced by subfamily Cupressaceae. In addition, sugiol, which originated from family Taxodiaceae, were not detected in the fossil samples. Thus, the tree fossil can be presumably identified as subfamily Cupressaceae.

Polyaromatic hydrocarbon (PAH), which are generated by combustion at high temperature, were hardly detected in the blackish outer sample. Thus, the fossil did not experience burning by wild fire etc. The relative abundances of aldehyde-type lignin phenols are clearly lower in the outer sample, implying that degradation of woody tissues took place in the outer parts of fossil. Interestingly, aromatic and A-ring degraded (des-A) terpenoids were identified as free compounds in the outer sample. The aromatic and des-A terpenoids were reported to be compounds generated by microbial degradation during early diagenesis. The facts indicate that the woody tissues might be degraded by microbial activity in the outer part of the tree fossil. Moreover, the relative abundances of methoxy phenols decrease in the outer part, so that gelification of the degraded woody tissues occurred in the parts.

Keywords: tree fossil, fossilization processe, microbial degradation, plant terpenoid, lignin phenol

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Thu. May 30, 2019 1:45 PM - 3:15 PM JST | Thu. May 30, 2019 4:45 AM - 6:15 AM UTC | 102 1F

[M-IS09] dust

convener:Ishizuka Masahide(Kagawa University), Yasunori Kurosaki(Arid Land Research Center, Tottori University), Thomas Sekiyama(Meteorological Research Institute), Kana Nagashima(Japan Agency for Marine-Earth Science and Technology, Research and Development Center for Global Change), Chairperson:Tsuyoshi Sekiyama

Mineral dust is generated from the ground surface by strong winds, and it transports long distance over the earth. In the process, cloud formation and absorption and scattering of solar radiation cause weather and climate changes. Also, when deposited in the ocean, feeding nutrients to phytoplankton, promoting photosynthesis, and when deposited on snow and ice causes albedo change. This is known as the yellow dust (Asian dust) phenomenon in Asia region including Japan. In order to understand this, integration in a wide range of academic areas is necessary.
 In the emission process, the amount of dust changes greatly depending on the surface condition in dryland area, and in order to know the conditions, it deals with areas such as soil, topography, vegetation, precipitation, desert and soil deterioration. In the transport process, we deal with areas such as weather, atmospheric aerosol, radiation. In the deposition process, we deal with areas such as ocean, snow ice, health to people and livestock. Drying and changes in vegetation also have social scientific aspects such as national policies, management of livestock, and population increase. Dust and sand dunes are common phenomena not only to the Earth but also to other planets such as Mars and Saturn. In this way, it is impossible to understand the dust phenomenon only in one field, it is important for researchers in many areas to discuss and share information through this session, and advance exchange of researchers.

1:45 PM - 1:55 PM JST | 4:45 AM - 4:55 AM UTC

Introduction

1:55 PM - 2:15 PM JST | 4:55 AM - 5:15 AM UTC

[MIS09-01] Global modeling study of atmospheric supply of lithogenic and pyrogenic Fe-containing aerosols to the ocean

★Invited Papers

*Akinori Ito[1], Akitomo Yamamoto[1], Michio Watanabe[1], Maki Noguchi Aita[1], Ying Ye[2] (1.Japan Agency for Marine-Earth Science and Technology, 2.Alfred Wegener Institute for Polar and Marine Research)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MIS09-02] Regional variations in the elemental and mineral compositions of solid particles in rainwater in Iran

*Yoriko Yokoo[1], Chihiro Sakamoto[1], Atsushi Kitamura[1], Ryo Anma[2], Shiva Mehrabani[3] (1.Faculty of Science and Engineering, Doshisha University, 2.Tokushima University, 3.Kurdistan University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MIS09-03] Comparison of airborne microbial variations in air samples from Asian-dust source and arrival regions

*Teruya Maki[1], Tatsuyuki Fujita[1], Yuuma Mastuba[1], Yasunori Kurosaki[2], Masahide Ishizuka[3], Kei Kawai[4], Yasunobu Iwasaka[5] (1.College of Science and Engineering, Kanazawa University, 2.Arid Land Research Center, Tottori University, Tottori University, 3.Faculty of Engineering, Kagawa University, 4.Graduate School of Environmental Studies, Nagoya Universit, 5.Center for Environmental Creative Studies)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MIS09-04] Prediction of health effects of cross-border atmospheric pollutants using the Model of Aerosol Species in the Global Atmosphere (MASINGAR)

*Kazunari Onishi[1], Thomas Sekiyama[2], Yasunori Kurosaki[3], Masato Shinoda[4] (1.Graduate School of Public Health, Support Unit for Conducting Clinically Essential Studies, St.Luke's International University,

2.Meteorological Research Institute, 3.Arid Land Research Center, Tottori University, 4.Graduate School of Environmental Studies Nagoya University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MIS09-05] Dust layer captured by an inversion layer over the Gobi Desert on 29–30 April 2015

*Kei Kawai[1], Yuta Nishio[2], Kenji Kai[1,3], Jun Noda[4], Erdenebadrakh Munkhjargal[1,5], Masato Shinoda[1], Nobuo Sugimoto[6], Atsushi Shimizu[6], Enkhbaatar Davaanyam[5,7], Dashdondog Batdorj[8] (1.Nagoya University, 2.Japan Meteorological Agency, 3.Ibaraki University, 4.Rakuno Gakuen University, 5.Information and Research Institute of Meteorology, Hydrology and Environment, Mongolia, 6.National Institute for Environmental Studies, 7.University of Tsukuba, 8.National Agency for Meteorology and Environmental Monitoring, Mongolia)

Global modeling study of atmospheric supply of lithogenic and pyrogenic Fe-containing aerosols to the ocean

*Akinori Ito[1], Akitomo Yamamoto[1], Michio Watanabe[1], Maki Noguchi Aita[1], Ying Ye[2]

1. Japan Agency for Marine-Earth Science and Technology, 2. Alfred Wegener Institute for Polar and Marine Research

Atmospheric supply of iron (Fe) to the ocean has been suggested to increase the marine primary productivity in large parts of the ocean. However, there are still large uncertainties regarding the effects of atmospheric aerosols on Fe dissolved in the surface ocean and marine productivity. Here, we use an atmospheric chemistry model and two ocean biogeochemistry models to explore the sensitivity to the atmospheric input of dissolved Fe.

The atmospheric model considered the deposition of both lithogenic and pyrogenic Fe-containing aerosols and their chemical transformation due to reactions with gaseous species. Sensitivity simulations are carried out with the deposition of lithogenic Fe only, and both Fe content in mineral dust of 3.5% and solubility of 2% are prescribed in the ocean models.

The results from the sensitivity simulations show that additional sources of dust and combustion aerosols increased the marine phytoplankton biomass in the subarctic north Pacific. The two ocean biogeochemistry models show similar spatial patterns but substantially different magnitude of responses to the atmospheric input of dissolved Fe. Moreover, the atmospheric model underestimated dissolved Fe concentration in aerosols over the North Pacific, although more observations are needed before drawing any firm conclusions on the model performance over the Pacific. Thus, further investigations of processes in emission of Fe from East Asia and transformation of dissolved Fe in the atmosphere and the ocean are needed.

Keywords: Mineral dust, Combustion aerosols, Iron deposition

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Regional variations in the elemental and mineral compositions of solid particles in rainwater in Iran

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1. Faculty of Science and Engineering, Doshisha University, 2. Tokushima University, 3. Kurdistan University

We collected monthly solid particles (air dust; > 0.2 μm) in rainwater samples in four western cities (Hamedan, Ilam, Shiraz, Ahvaz) from October 2014 to July 2015 and three eastern cities (Mashhad, Birjand, Zahedan) from January 2016 to January 2017 in Iran, and determined their elemental and mineral compositions in order to elucidate the regional variation and to consider their provenance. In no-rainfall months, we rinsed the sampler with ultrapure water and collected the trapped air dust. Mineral composition of the collected dust was determined using an XRD. We dissolved the same dust samples using mixed-acids and measured elemental compositions using an ICP-MS.
The amount of dust in eastern cities were higher than those in western cities, especially the samples collected in Birjand. Samples from Mashhad and Zahedan had high amount of dust during dry season. These results suggest that aeolian dust from surrounding deserts such as Dasht-e Kavir and Dasht-e Lut affected atmospheric deposition in eastern Iran.
All of dust samples contained quartz and feldspar. Most of the dust samples in western cities also contained calcite. The concentrations of Ca, Na and K in the dust of western cities were 0.45-29.33%, 0.24-0.82% and 0.49-1.94%, respectively. Those in the dust of eastern cities were 0.97-6.23%, 0.59-2.74% and 0.88-3.15%, respectively. The concentration of Ca in the dust of western cities were higher, and Na and K concentrations were lower than those of eastern cities. High calcite contents were observed in western cities and Birjand : thus, high-Ca in the dust is attributed to calcite originated from the arid area. A part of Ca in the dust of eastern cities could also be attributed to feldspars.
Cd, Sb, Pb and As in the dust of western cities and Ni, Zn, As, Cd and Sb in those of eastern cities had the maximum values of the enrichment factor (EF): $(X/Al)_{sample}/(X/Al)_{crust}$ over ten. These results suggest a part of the dust were originated from anthropogenic substances such as road dust and petroleum industry. The EF values of Pb and As of dust samples in western cities showed higher than those in eastern cities, suggesting that the atmospheric deposition were influenced by anthropogenic substances from petroleum industry, which is generally high in Pb and As.

Keywords: insoluble substance, elemental composition, mineral composition, West Aisa

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Comparison of airborne microbial variations in air samples from Asian-dust source and arrival regions

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Aerosol dust is emerging as a significant vehicle for long-range transport of microorganisms. Nonetheless, many factors relating to this highly influential dispersal mechanisms remain unresolved, including the variation in dispersal bacterial communities during stochastic desert dust events, and the effect of aerosol transit over continental and oceanic surfaces to these communities. Here we elucidated bacterial 16S rRNA gene and fungal ITS-defined changes in airborne microbial communities at Asian-dust source regions (Gobi) and arrival regions (Japan) both lying along the trajectory for dust-event transport. Aerosols collected in the both regions generally reflected local origin from freshwater, marine, plant, or animal sources. In particular, dust events in the Gobi Desert increased these microbial cells and mineral particles to more than ten folds of concentrations. After dust-events occurrences in desert areas, the spore-forming microorganisms (bacteria: Bacillaceae, fungi: Davidiellaceae) and organic-aggregating bacteria (Cytophagaceae) showed high relative abundances, suggesting the survival of some microbes against strict atmospheric stressors over desert. These stress-resistance microbial populations were frequently dominated during Asian-dust evens over Japan, which are located cross China industrial area and Japan Sea. Presumably, atmospheric stressors over desert transit over deserts, anthropogenic polluted areas and oceanic waters strongly selects for airborne microbial populations through atmospheric stressors.

Keywords: bioaerosol, long range transport, microorganisms

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Prediction of health effects of cross-border atmospheric pollutants using the Model of Aerosol Species in the Global Atmosphere (MASINGAR)

*Kazunari Onishi[1], Thomas Sekiyama[2], Yasunori Kurosaki[3], Masato Shinoda[4]

1. Graduate School of Public Health, Support Unit for Conducting Clinically Essential Studies, St.Luke's International University, 2. Meteorological Research Institute, 3. Arid Land Research Center, Tottori University, 4. Graduate School of Environmental Studies Nagoya University

Health effects of cross-border air pollutants and Asian dust are of significant concern in Japan. Currently, models predicting the arrival of aerosols have not investigated the association between arrival predictions and health effects. We investigated the association between subjective health symptoms and unreleased aerosol data from the Model of Aerosol Species in the Global Atmosphere (MASINGAR) acquired from the Japan meteorological agency, with the objective of ascertaining if these data could be applied to predicting health effects.
Subjective symptom scores were collected via self-administered questionnaires and, along with modeled surface aerosol concentration data, were used to conduct a risk evaluation using generalized estimating equations between October and November 2011.
Altogether, 29 individuals provided 1670 responses. Spearman's correlation coefficients were determined for the relationship between the proportion of the participants reporting the maximum score of two or more for each symptom and the surface concentrations for each considered aerosol species calculated using MASINGAR; the coefficients showed significant intermediate correlations between surface sulfate aerosol concentration and respiratory, throat, and fever symptoms (R=0.557, 0.454, and 0.470, respectively; $p < 0.01$). In the general estimation equation (logit link) analyses, a significant linear association of surface sulfate aerosol concentration, with an endpoint determined by reported respiratory symptom scores of two or more,was observed (P trend=0.001, odds ratio [OR] of the highest quartile [Q4] vs. the lowest[Q1]=5.31, 95% CI=2.18 to 12.96), with adjustment for potential confounding. The surface sulfate aerosol concentration was also associated with throat and fever symptoms. Association of surface dust aerosol concentration and respiratory symptom were odds ratio [OR] of the highest quartile [Q4] vs. the lowest[Q1]=3.32, 95% CI=0.90 to 12.27).
In conclusion, our findings suggest that modeled data are potentially useful for predicting health risks of cross-border aerosol arrivals.

Keywords: Atmospheric air pollution, Health forecast, Aerosol forecast

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Dust layer captured by an inversion layer over the Gobi Desert on 29–30 April 2015

*Kei Kawai[1], Yuta Nishio[2], Kenji Kai[1,3], Jun Noda[4], Erdenebadrakh Munkhjargal[1,5], Masato Shinoda[1], Nobuo Sugimoto[6], Atsushi Shimizu[6], Enkhbaatar Davaanyam[5,7], Dashdondog Batdorj[8]

1. Nagoya University, 2. Japan Meteorological Agency, 3. Ibaraki University, 4. Rakuno Gakuen University, 5. Information and Research Institute of Meteorology, Hydrology and Environment, Mongolia, 6. National Institute for Environmental Studies, 7. University of Tsukuba, 8. National Agency for Meteorology and Environmental Monitoring, Mongolia

Asian dust originates in arid and semi-arid regions of East Asia, such as the Gobi Desert and the Taklimakan Desert. If the dust emitted from the ground surface reaches the free troposphere, it can be transported toward the Pacific Ocean over a long range by the westerlies. Therefore, the vertical distribution of dust over the source region is a key factor of the long-range transport of dust. In the Gobi Desert, a ceilometer (compact lidar) observation has been conducted at Dalanzadgad, Mongolia, since the end of April 2013. The ceilometer observed a developed dust storm over the ground and a dust layer at a height of 1.2–1.8 km on 29–30 April 2015. According to SYNOP reports, this dust storm had already developed in the upwind region before arriving at Dalanzadgad. This feature was consistent with the sudden increase of the ceilometer observation values. Then, the dust was lifted to a height of 1.2–1.8 km, and the dust layer was observed at almost the same height for 12 hours by the ceilometer. During this dust event, radiosonde observation at Dalanzadgad showed an inversion layer at a height of 1.2–1.5 km over cold air. These results suggest that the dust layer was captured by the inversion layer, which prevented the dust from reaching the free troposphere and restrained the long-range transport of the dust by the westerlies. This study was supported by Research Fellowships of Japan Society for the Promotion of Science (JSPS) for Young Scientists and by Grants-in-Aid for Scientific Research from the JSPS (16H02703, 17H01616, and 18J12795).

Keywords: Asian dust, dust storm, long-range transport, ceilometer, lidar, Gobi Desert

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Thu. May 30, 2019 3:30 PM - 5:00 PM JST | Thu. May 30, 2019 6:30 AM - 8:00 AM UTC | 102 1F

[M-IS09] dust

convener:Ishizuka Masahide(Kagawa University), Yasunori Kurosaki(Arid Land Research Center, Tottori University), Thomas Sekiyama(Meteorological Research Institute), Kana Nagashima(Japan Agency for Marine-Earth Science and Technology, Research and Development Center for Global Change), Chairperson:Kana Nagashima

Mineral dust is generated from the ground surface by strong winds, and it transports long distance over the earth. In the process, cloud formation and absorption and scattering of solar radiation cause weather and climate changes. Also, when deposited in the ocean, feeding nutrients to phytoplankton, promoting photosynthesis, and when deposited on snow and ice causes albedo change. This is known as the yellow dust (Asian dust) phenomenon in Asia region including Japan. In order to understand this, integration in a wide range of academic areas is necessary.
In the emission process, the amount of dust changes greatly depending on the surface condition in dryland area, and in order to know the conditions, it deals with areas such as soil, topography, vegetation, precipitation, desert and soil deterioration. In the transport process, we deal with areas such as weather, atmospheric aerosol, radiation. In the deposition process, we deal with areas such as ocean, snow ice, health to people and livestock. Drying and changes in vegetation also have social scientific aspects such as national policies, management of livestock, and population increase. Dust and sand dunes are common phenomena not only to the Earth but also to other planets such as Mars and Saturn. In this way, it is impossible to understand the dust phenomenon only in one field, it is important for researchers in many areas to discuss and share information through this session, and advance exchange of researchers.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MIS09-06] Favorable regions for dust haze transport revealed by ensemble simulations

*Kazunori Ogohara[1], Shogo Isoda[1] (1.School of Engineering, University of Shiga Prefecture)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MIS09-07] Measurement of adhesion force of individual aerosol particles by atomic force microscopy

*Kohei Ono[1], Yuki Mizushima[4], Ayumi Iwata[3], Furuya Masaki[1], Nozomu Tsuchiya[1], Atsushi Matsuki[2] (1.Graduate School of Natural Science and Technology, Kanazawa University, 2.Institute of Nature and Environmental Technology, Kanazawa University, 3.Faculty of Science and Technology, Keio University, 4.College of Science and Technology, Kanazawa University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MIS09-08] Occurrence of micro-meso scale dust storms and its relationship to the vegetation and topography in Mongolian grassland and Gobi Desert

*Kenji Kai[1], Kei Kawai[2], Teruya Maki[3], Jun Noda[4] (1.College of Education, Ibaraki University , 2.Nagoya University, 3.Kanazawa University, 4.Rakuno-Gakuen University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MIS09-09] A trial of elucidation for dust emission conditions in East Asia by synoptic data analyses and a field observation

*Yasunori Kurosaki[1], Jing Wu[1], Batjargal Buyantogtokh[1], Ishizuka Masahide[2], Batdelger Gantsetseg[3] (1.Tottori University, 2.Kagawa University, 3.IRIMHE, Mongolia)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MIS09-10] Monitoring and assessing aeolian desertification processes based on a dust erodibility index – A case study in the Xilingol grassland, China

*Jing Wu[1], Yasunori Kurosaki[1], Chunling Du[2], Tao Wang[3] (1. Arid Land Research Center, Tottori University, 2.School of Economics and Management, Inner Mongolia Agricultural University, 3.Northwest Institute of

Eco-Environment and Resources, Chinese Academy of Sciences)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MIS09-11] Influences of land surface conditions and human activities on dust events in Inner Mongolian grasslands, China

*Mei Yong[1], Masato Shinoda[2], Nandintsetseg Banzragch[2] (1.Inner Mongolia normal university, 2.Nagoya university)

Favorable regions for dust haze transport revealed by ensemble simulations

*Kazunori Ogohara[1], Shogo Isoda[1]

1. School of Engineering, University of Shiga Prefecture

Dust is the major source of the solar heating in the Martian atmosphere and then drives the circulation of dust itself. Dust events (dust storms, dust devils and dust haze) are disasters in the Mars atmosphere near the surface because they can generate strong winds and block sunlight almost completely. Statistics of dust events have been studied by analyzing atmospheric temperature, dust optical depth and visible images observed by successive orbiters, landers and rovers. Active areas of local dust storms, including curvilinear and textured storms have been identified observationally. The tendency of such small scale dust events should be affected by the large scale atmospheric conditions such as thermal or dynamical stabilities. Activity of regional dust storms has been investigated using the vast number of images observed by Mars Orbiter Camera onboard Mars Global Surveyor (MGS/MOC) and MARs Color Imager onboard Mars Reconnaissance Orbiter (MRO/MARCI). They tend to break out near the storm zones in the northern mid-latitudes and are probably very linked to baroclinic instability and the fronts. Although mechanisms of the growth, maintenance and decay of global dust storms have not been well investigated, most of global dust storms started in the southern spring to summer seasons as regional storms were merging with each other.
Questions about the mechanisms of dust storms and haze are as follow:
- Why does a dust storm/haze break out?
- Why does the dust storm/haze expand?
Mechanisms of initiation and maintenance of local dust storms will be understood and categorized into a few types in the near future by statistical studies. They can be also inferred from observations and theories of terrestrial dust storms. However, there are local dust storms also in the northern mid-latitudes. Why do not the local storms grow into regional dust storms? Why do not all regional dust storms merge with each other? Ogohara and Satomura (2011) found five favorable regions for expansion of local dust haze (FRs) and revealed what kind of the atmospheric phenomena controls the dust haze transport around such regions. However, it still remains unclear whether these five FRs are also favorable for dust haze transport climatologically because they performed just a single year calculation. Thus, we identify the climatologically robust FRs in this study by ensemble simulations. If such FRs were found, atmospheric phenomena characteristic of the FRs would govern the dust transport around there.
Each ensemble simulation is performed in the same manner as that by Ogohara and Satomura (2011). Although they could not separate injected dust from the background dust due to the model architecture, wee modify the model in this study so that I can treat the injected and background dust separately. The first spin-up run started from an isothermal (220 K) condition with constant surface pressure (6.4 hPa) and no wind over the entire planet. Fifty kinds of small disturbances are added to the temperature output data of the first spin-up run. The small disturbances of temperature at each sigma level are normal random numbers. The standard deviation of the distribution function is 0.01 times of the standard deviation of temperature at the sigma level of the first spin-up result. The second spin-up runs are performed for 1 MY from L_s=180 independently using the 50 kinds of the output data of the first spin-up run with small disturbances as the initial data. After these spin-up runs, fifty global maps of dust haze expansion potential are made using the output data from the 50 kinds of the second spin-up runs as the initial data. The maps of dust haze expansion potential clearly show that there are a few robust FRs in the northern fall season. Also, it turns out that standard deviations of dust haze expansion are significantly

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higher in the northern high latitudes than in the low latitudes. The reasons why dust tends to expand around the robust FRs are the same as those explained by Ogohara and Satomura (2011). However, high ensemble standard deviation in dust haze expansion is clearly shown at the first time by this study. In the presentation, we will show when dust haze tends to spread extensively and when it does not.

Keywords: Mars, dust storm, ensemble simulation

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Measurement of adhesion force of individual aerosol particles by atomic force microscopy

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1. Graduate School of Natural Science and Technology, Kanazawa University, 2. Institute of Nature and Environmental Technology, Kanazawa University, 3. Faculty of Science and Technology, Keio University, 4. College of Science and Technology, Kanazawa University

A new method was developed to quantitatively evaluate the adhesion force of individual aerosol particles. The method involves force-curve-mapping by atomic force microscopy. Firstly, adhesion force of particle surrogates (PSL, ammonium sulfate, quartz) were measured to evaluate the applicability of the new method on individual particles. Spatial distribution and representative adhesion force was successfully obtained. The force-curve-mapping method was then applied on actual ambient samples. The aged Asian dust particles following long-range transport were collected within Kanazawa University campus. The same dust particles were identified under both AFM and SEM-EDX and analyzed for their morphology, adhesion force distribution and elemental composition. It was found that the adhesion force of aged silicate Asian dust was greater than that of fresh dust collected near the source in China. It was suggested that the adhesion force of aged silicate dust increases and becomes comparable to those of inorganic salts (i.e. ammonium sulfate and sea salt particles). Ca-rich Asian dust exhibited even stronger adhesion force. The result revealed difference of adhesion forces between silicate and Ca-rich Asian dust following atmospheric processing during long-range transport. This study also spotted few carbonaceous particles with exceptionally high adhesion force, suggesting certain organic aerosols may be particularly adhesive. This work successfully demonstrated the importance of adhesion force measurement on individual particle basis, and applicability of force-curve-mapping method for characterizing adhesivity of internally mixed particles.

Keywords: Asian dust, Atomic Force Microscopy(AFM), adhesion force, long-range transport, deposition, aging

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Occurrence of micro-meso scale dust storms and its relationship to the vegetation and topography in Mongolian grassland and Gobi Desert

*Kenji Kai[1], Kei Kawai[2], Teruya Maki[3], Jun Noda[4]

1. College of Education, Ibaraki University , 2. Nagoya University, 3. Kanazawa University, 4. Rakuno-Gakuen University

Gobi Desert and Mongolian grassland are one of the main sources of the Asian dust. In order to investigate the occurrence of micro-meso scale dust storms and its relationship to the vegetation and topography, we conducted moving observations running across the Gobi Desert from Ulaanbaatar to Dalanzadgad in springs of 2015-2017. An optical particle counter (OPC: Aerotrak 9306-V2), a sunphotometer (Microtops II) and meteorological instrument were installed in a car.

The vegetation had a suppression effect on the dust emission. Number concentrations of coarse particles (1-10 μm) decreased from the desert to the grassland. They had significant negative correlations with the vegetation (NDVI) from 3 μm to 10 μm, but the number concentration at 0.3 –0.5 μm had little correlation to the vegetation.

During the moving observations, we found a hotspot of dust storms in the Gobi Desert. An analysis of Himawari-8 Dust RGB clearly shows that the hotspot appeared at a jointing point of two valleys, a bottleneck and an exit of a valley.

In summary, the horizontal distribution of number concentrations of aerosol particles reflected the surface vegetation. Locations of the hotspot were determined by a local topography such a jointing point of two valleys.

Keywords: Asian dust, Himawari-8 Dust RGB, Hotspot of dust storms

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A trial of elucidation for dust emission conditions in East Asia by synoptic data analyses and a field observation

*Yasunori Kurosaki[1], Jing Wu[1], Batjargal Buyantogtokh[1], Ishizuka Masahide[2], Batdelger Gantsetseg[3]

1. Tottori University, 2. Kagawa University, 3. IRIMHE, Mongolia

Mineral dust particles are blown up into the free atmosphere by sand-dust storm (SDS) in drylands, and they are broadly distributed by wind in the upper atmosphere. SDS is a type of disaster in drylands, which sometimes kills people and animal, destroys infrastructure, reduces merchandise value of livestock etc. In downwind regions like Japan, there is reports on its health effect. In the global scale, there are many reports about their effects on climate via direct and indirect effects of radiation. Many researchers have developed numerical dust model to avoid such damages, but their accuracy is still low, especially in its emission phase (Uno et al. 2006; Carmichael et al. 2008).

We can divide causes of dust emission (in other words, wind erosion) into erosivity (i.e., ability of wind to cause erosion) and erodibility (i.e., susceptibility of soil and land surface to wind erosion represented by the threshold wind speed for dust emission). Erosivity can be expressed by one parameter, which is wind speed and accuracy for its observation and its forecast is relatively reliable. On the other hand, erodibility has many parameters relating with soil and land surface such as soil particle size, soil wetness, crust, soil freeze, snow cover, vegetation cover, and we have a very big hurdles for monitoring all with high accuracy. This can be a big reason of low accuracy of dust emission modeling.

Tottori University set up a dust monitoring system at Tsogt-Ovoo, Mongolia, which is located in a northern part of the Gobi Desert. We have clarified that effects of soil crust (Ishizuka et al. 2012 SOLA), vegetation cover in topographic depression (Gantsetseg et al. 2017 J. of Arid Land), stone (Buyantogtokh et al. 2019 in preparation), dead leaves on erodibility. We also have conducted analyses of wind and present weather data included in synoptic report to elucidate dust emission conditions, which differs place by place. Kurosaki et al. (2011 GRL) clarified that dust emission frequencies increased at many synoptic meteorological observatories in East Asia from 1990s to 2000s and the major causes are in increased erodibility, which can be shown by reductions of threshold wind speed. Wu et al. (2016 SOLA) clarified that the major causes for dust emission are different station by station in East Asia. Wu et al. (2019 in preparation) clarified that effect of livestock number at Abaga Qi, which is located at Xilingol Grassland, China.

Keywords: drylands, aeolian dust, wind erosion, erosivity, erodibility

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Monitoring and assessing aeolian desertification processes based on a dust erodibility index –A case study in the Xilingol grassland, China

*Jing Wu[1], Yasunori Kurosaki[1], Chunling Du[2], Tao Wang[3]

1. Arid Land Research Center, Tottori University, 2. School of Economics and Management, Inner Mongolia Agricultural University, 3. Northwest Institute of Eco-Environment and Resources, Chinese Academy of Sciences

Aeolian desertification is land degradation characterized by wind erosion, which is dependent on erosivity and erodibility. Progressive aeolian desertification causes dust to occur frequently, which has negative impacts on the environment and human health. To effectively prevent the expansion of aeolian desertification, it is crucial to monitor the processes of aeolian desertification and understand its mechanism(s). However, due to its complexity, it is difficult to apply a common indicator for monitoring desertification status.
In this study, we assessed aeolian desertification by using a dust erodibility index as an indicator that reflects the vulnerability of the land surface to wind erosion. We used dust occurrence ratio (DOR), which was calculated as the ratio of the frequency of dust occurrence to the frequency of strong winds, to represent the status of aeolian desertification. We evaluted aeolian desertification procesess at one site (Abaga-Qi) in the Xilingol grassland during the period 1974–2013. DOR values during 2001–2013 were notably higher than those in 1974–2000, indicating that land surface conditions became vulnerable to wind erosion in recent years. However, the DOR values trended lower from 2001 to 2013, corresponding to periods in which restoration projects were implemented aimed at combating desertification in China. To understand the mechanism(s) underlying aeolian desertification after the implementation of restoration projects, we conducted multiple regression analysis of climatic variables (precipitation and temperature) and an anthropogenic variable (livestock number) on recent variations (2001–2013) in aeolian desertification. Stepwise multiple regression results indicate that the recent decline in DOR values was associated with abundant precipitation and low temperature during summer of the previous year and a small livestock population at the end of the previous year. Livestock reduction made the greatest contribution. Our results suggest that aeolian desertification can be effectively reversed by reducing the number of livestock in the Xilingol grassland.

Keywords: desertification, erodibility, climate change, human activity, livestock

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Influences of land surface conditions and human activities on dust events in Inner Mongolian grasslands, China

*Mei Yong[1], Masato Shinoda[2], Nandintsetseg Banzragch[2]

1. Inner Mongolia normal university, 2. Nagoya university

Aeolian processes in temperate grasslands (TGs) are unique in that the plant growth–decay cycle, soil moisture, and land-use interactivity affect seasonal and interannual variations of dust events. When compared with Mongolian TGs, Inner Mongolian TGs are characterized by unique land-uses (settle grazing and grass mowing). Since 2003, to prevent desertification and dust storms, land-uses have been controlled by the grassland protection law. We used process-based ecosystem (DAYCENT) and statistical models as well as dust event observations during March–June 1981–2015 to (1) identify critical land surface factors that control dust emission (soil moisture and vegetation components; live grasses, standing dead grasses and litter) in Inner Mongolian steppe and desert steppe sites, and (2) estimate the impacts of the controlled land-use law on dust events. The DAYCENT model realistically simulated dynamics of the vegetation components and soil moisture that were captured by observations (2005–2015). Results showed that at both sites, the spring dust events had a similar amplitude of significant correlation with wind speed and a combination of all the surface factors that retained anomalies (memory) of the preceding year. Among the surface factors, vegetation was a critical dust suppressing factor in Inner Mongolian TGs, similar to Mongolian TGs. Importantly, in the desert steppe, the standing dead grasses had the strongest memory and simultaneous significant correlation with the dust events, while no significant correlations were found in the steppe. This suggests that in the steppe, intensive grazing and mowing resulted in smaller dead grasses and a negligible effect on dust events. Moreover, simulations of dust events under controlled land-use (light grazing) and uncontrolled conditions (heavy grazing) showed that since 2003, the grassland protection law resulted in reduced dust events by 25% and 40% in the steppe and desert steppe, respectively.

Keywords: Dust events, DAYCENT model, Vegetation components, Soil moisture, Xilingol grassland

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[J] Oral | M (Multidisciplinary and Interdisciplinary) : M-IS Intersection

Thu. May 30, 2019 9:00 AM - 10:30 AM JST | Thu. May 30, 2019 12:00 AM - 1:30 AM UTC | Convention Hall B 2F

[M-IS12] tsunami deposit

convener:Takashi Chiba(Faculty of Bioresource Sciences, Akita Prefectural University), Tetsuya Shinozaki(Center for Research in Isotopes and Environmental Dynamics (CRiED), University of Tsukuba), Daisuke Ishimura(Department of Geography, Tokyo Metropolitan University), Chairperson:Daisuke Ishimura(Department of Geography, Tokyo Metropolitan University)

The 2011 off the Pacific coast of Tohoku Earthquake and tsunami have an influence on the development of tsunami deposit research. After the tsunami, a lot of findings have been reported on various research fields. However, identification criteria of the tsunami deposit are not yet established. Moreover, it is still uncertain how to use the tsunami deposit in the risk assessment. In this session, we welcome researches from all aspect of sedimentary records of modern and paleo tsunamis both onshore and offshore, and numerical and experimental modeling studies for risk assessment. In addition, we also welcome other event deposits, such as flooding and storm surge, that they are considered to be important for discrimination of tsunami deposit.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[MIS12-01] Geological Record of Tsunamis and Storms Influenced by Relative Sea-Level Change, Southern Hidaka Coast, Hokkaido, Japan.

*RYO NAKANISHI[1], Satoshi Okamura[1,2], Tsumoru Sagayama[3], Yusuke Yokoyama[4], Yosuke Miyairi[4] (1.Hokkaido Edu. Univ., 2.Hokkaido Soil Res. Co-op., 3.HRCG, 4.Univ. Tokyo)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[MIS12-02] Before and after relationship between the seismic uplift and the large tsunami due to the seventeenth-century giant earthquake observed in the seismic barrier systems around the Kuril subduction zone

*Futoshi Nanayama[1,5], Kazuaki Watanabe[1], Keita Fukatsu[2], Takeshi Hasegawa[4], Kiyoyuki Shigeno[3], Masayuki Ishii[6], Kazuhito Ishiwata[7], Shigeto Inokuma[8] (1.Geological Survey of Japan, AIST, 2.Notsuke Peninsula Nature Center, 3.Meiji consultant Co., Ltd., 4.Ibaraki University, 5.CWMD, Kumamoto Univ., 6.Ishii Professional Engineer Office, 7.Betsukai municipal museum, 8.Nemuro City museum history and nature)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[MIS12-03] Coastal landform changes and Washover deposits due to high waves generated by anatmospheric low-pressure system in June 2016 at Horokayanto, Hokkaido, Japan

*Takashi Chiba[1], Yuichi Nishimura[2] (1.Faculty of Bioresource Sciences, Akita Prefectural University, 2.Graduate School of Science, Hokkaido University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[MIS12-04] Survey of tsunami deposits in Kunashiri Island: Results obtained in the 2015-2018 projects

*Yuichi Nishimura[1], Yasuhiro Takashimizu[2], Daisuke Sugawara[3], Takafumi Enya[4], Takashi Chiba[5], Ryo Nakanishi[6], Alexander Shishkin[7], Alexey Gorbunov[8], Victor Kaistrenko[8], Asuka Takahashi[9], Hiroki Muramatsu[10], Yasuyuki Kawazoe[11], Naofumi Takamatsu[11] (1.Graduate School of Science, Hokkaido University, 2.Institute of Humanities, Social Sciences and Education, Niigata University, 3.Museum of Natural and Environmental History, Shizuoka, 4.Hokkaido Museum, 5.Faculty of Bioresource Sciences, Akita Prefectural University, 6.Hokkaido Education University, 7.Shikotan Geophysical Observatory, 8.Institute of Marine Geology and Geophysics, Russian Academy of Sciences, 9.Japan Meteorological Agency, 10.Geospatial Information Authority of Japan, 11.Ministry of Education, Culture, Sports, Science and Technology)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[MIS12-05] Deposit-based assessment of tsunami size: example from Nankai-Trough earthquakes

*Daisuke Sugawara[1], Kentaro Imai[2], Shinsuke Okada[3], Takuto Maeda[4] (1.Museum of Natural and Environmental History, Shizuoka, 2.JAMSTEC, 3.Tohoku University, 4.Hirosaki University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[MIS12-06] Flume experiments for understanding variety of tsunami deposit

★Invited Papers

*Naofumi Yamaguchi[1] (1.Center for Water Environment Studies, Ibaraki University)

Geological Record of Tsunamis and Storms Influenced by Relative Sea-Level Change, Southern Hidaka Coast, Hokkaido, Japan.

*RYO NAKANISHI[1], Satoshi Okamura[1,2], Tsumoru Sagayama[3], Yusuke Yokoyama[4], Yosuke Miyairi[4]

1. Hokkaido Edu. Univ., 2. Hokkaido Soil Res. Co-op., 3. HRCG, 4. Univ. Tokyo

In the last a few hundred years, southern Hidaka coast in Hokkaido was suffered from large tsunamis by subduction of the Pacific Plate along the southern Kuril Trench. 2003 Tokachi-oki earthquake left traces at maximum altitude 4 m in Hyakunin Hama in the eastern part of Cape Erimo, also maximum altitude 3 m in western part of Cape Erimo. It was caused by the edge wave propagating from Cape Erimo along the west coast of the Hidaka area (Tanioka et al., 2004) . On the other hand, geological studies in eastern part of Hokkaido revealed that intervals of outsized tsunamis by Kuril subduction inferred average nearly 400 years but range widely from about 100 to about 800 years (Sawai et al., 2009), and these probably reached western part of Cape Erimo. However, the only 17th century tsunami deposits reported in the western part of Cape Erimo are said to be unknown the trigger. Thus, This study conducted Simple boring survey to reveal tsunamis cycle and age of emergence in Northern Hidaka coast. Consequently, we compared western part and eastern part of Cape Erimo about scale of tsunamis, also examined the relationship with the paleo environment.

As a result of boring survey by a geoslicer in the peat swamp behind the beach, we found three volcanic ash layers and nine event sand layers in the humus and the peat. In order from the top, it was AD 1663 Us-b tephra, AD946 B-Tm tephra, two sand layer (Us1, U1), 2700-2500BP Ta-c2 tephra, seven sand layer (U2-8). Peat layers change to remarkably undegraded humus from the U4 layer downward. The number of sand layers decreased landward, finally being zero at about 500 m from coastline. U1-8 sand layers were similar in particle size and gray color to beach sands, and sorting very well. These common characteristics were from inverse to normal grading and contain rip-up clasts. Also, grain size and thickness were inverse correlation with distance from coastline, but no correlation with distance from river. Because the diatom assemblages from event sand layers contained marine, brackish and terrestrial species in contrast peat occupied by freshwater species, these turn out to derive from seaward. Conversely, the Us1 layer had limited distribution several tens meter from paleo beach ridge, the thickness changed from 20 cm to very thin at only 20m landward. Grain size of the Us1 layer was fine - very coarse, including Φ1cm flat gravel. The Us1 layer can be supposedly distinguished from U1-8 layers from these features similar to storm deposits. A result of measuring ages for the time of sand deposition by AMS radiocarbon dating, we obtained the age of about 5500BP from under the U8 layer, about 2000BP from above the U1 layer. The average recurrence intervals of event is nearly 400 years, the interval is sometime shorter (50 years) or longer (550 years) than the average, so the U1-8 event layers are probably tsunami deposits by subduction earthquakes like seen in eastern Hokkaido.

The U7 layer is the thickest in all sand layers, thickness of event layers tend to become thinner as the upper stratigraphy. The U7 layer is most widely distributed inland, it deposited in about 4900BP, when high-standard period in eastern Hokkaido (Dura et al., 2016). It was found from the result of continuous chemical analysis of peat samples in the vertical direction that Fe and S increased as deeper at the depth deeper than the U5 layer (about 3800BP). In this site, considering the humus layer shows undegraded under the U4 layer, this chemical characteristic imply that the peat was reductive and the sea-level was high at that time. We inferred that tsunamis inundated over the sand ridge in this area only for 5500BP to

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2000BP, because didn’ t find tsunami deposits from the stratigraphy since 2000BP. In conclusion, when restoration of paleo tsunami record, it necessary to consider that changing sea-level and associated topographic change.

Dura, T. et al. (2016) The role of Holocene relative sea-level change in preserving records of subduction zone earthquakes. Curr. Clim. Change. Rep. 2, 86–100.

Sawai, Y., Kamataki, T., Shishikura, M., Nasu, H., Okamura, Y., Satake, K.,… Aung T. T., 2009, Aperiodic recurrence of geologically recorded tsunamis during the past 5500 years in eastern Hokkaido, Japan. Jour. Geophys. Res., 114, B01319.

Tanioka, Y., Nishimura, Y., Hirakawa, K., Imamura, F., Abe, I., Abe, Y……Masaka, S., 2004, Tsunami run-up heights of the 2003 Tokachi-oki earthquake. Earth Planets Space, 56, 359-365.

Keywords: Tsunami deposits, Storm deposits, Kuril subduction, Radiocarbon dating, Paleo environment restoration, Holocene High Standard

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Before and after relationship between the seismic uplift and the large tsunami due to the seventeenth-century giant earthquake observed in the seismic barrier systems around the Kuril subduction zone

*Futoshi Nanayama[1,5], Kazuaki Watanabe[1], Keita Fukatsu[2], Takeshi Hasegawa[4], Kiyoyuki Shigeno[3], Masayuki Ishii[6], Kazuhito Ishiwata[7], Shigeto Inokuma[8]

1. Geological Survey of Japan, AIST, 2. Notsuke Peninsula Nature Center, 3. Meiji consultant Co., Ltd., 4. Ibaraki University, 5. CWMD, Kumamoto Univ., 6. Ishii Professional Engineer Office, 7. Betsukai municipal museum, 8. Nemuro City museum history and nature

The Kuril subduction zone is one of the most frequent earthquakes in Japan. There are many undeveloped plains in this area, unspoiled nature is left, and many barrier coasts and tsunami deposits due to the giant earthquake (17th century type) repeatedly generated at 400 to 500 years intervals can be widely observed around this area. However, the relationship between the timing of both is not clear yet. Especially two tsunami deposits, which are occurred in the 17th century, can be observed in many places around the eastern Pacific coast of Hokkaido. On the other hand, there are many active barrier systems around the coast of Nemuro Strait and Konsen ~ Tokachi coast, and it has recently become evident that a 17th century giant earthquake occurred as a trigger. Our research group examined the relationship between the occurence timing of these uprifting barrier systems and the 17th century tsunami in several areas in detail, and some interesting facts have been found, so we will report the outline in this meeting.

This work was supported by JSPS KAKENHI Grant Number 18K03767.

Keywords: Seventeenth-century giant earthquake, Tsunami, Regional crustal movement, Barrier system, eastern Hokkaido, Kuril subduction zone

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Coastal landform changes and Washover deposits due to high waves generated by anatmospheric low-pressure system in June 2016 at Horokayanto, Hokkaido, Japan

*Takashi Chiba[1], Yuichi Nishimura[2]

1. Faculty of Bioresource Sciences, Akita Prefectural University, 2. Graduate School of Science, Hokkaido University

The lake bottom of Horokayanto, one of the lagoons in eastern Hokkaido, Japan, was partly exposed as a result of sandbar breaching during severe weather in June 2016. The mean lake level fell from approximately 3.1 to 1.2 m above TP, which is equivalent to the height of the MHHTL in the Tokachi area by the breached sandbar. Some erosion forms were recognized in the southwestern breached point of the sandbar. However, the washover fan formed by the high waves from the seaward to the lakeward sides was recognized in the northeastern part of the sandbar. Moreover, characteristic diatom assemblages resulting from coastal environmental changes were also recognized around the lake. The high-tide-level indicator *Pseudopodosira kosugii* was recognized in the emerged lake bottom assemblage together with freshwater–brackish and brackish–marine species. Water pressure or moisture changes caused by either the emergence, the changes in light quantum density and ultraviolet rays, the changes in water quality such as salinity and pH, or a mixture of these factors, may have influenced the increase in *P. kosugii*. Reworked Neogene marine diatoms such as *Denticulopsis* spp. that were presumably derived from nearby Neogene basement rocks were also detected–albeit infrequently–in the modern assemblages. The fossil diatoms were eroded by current inflows into the lake during the severe weather. During the period of emergence, seawater may have been transported into Horokayanto Lagoon by high waves generated by an atmospheric low-pressure system. However, the height of the waves was below that of the central part of the sandbar.

Keywords: washover deposit, sandbar breach, emerged lake bottom, diatom assemblage, Horokayanto

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Survey of tsunami deposits in Kunashiri Island: Results obtained in the 2015-2018 projects

*Yuichi Nishimura[1], Yasuhiro Takashimizu[2], Daisuke Sugawara[3], Takafumi Enya[4], Takashi Chiba[5], Ryo Nakanishi[6], Alexander Shishkin[7], Alexey Gorbunov[8], Victor Kaistrenko[8], Asuka Takahashi[9], Hiroki Muramatsu[10], Yasuyuki Kawazoe[11], Naofumi Takamatsu[11]

1. Graduate School of Science, Hokkaido University, 2. Institute of Humanities, Social Sciences and Education, Niigata University, 3. Museum of Natural and Environmental History, Shizuoka, 4. Hokkaido Museum, 5. Faculty of Bioresource Sciences, Akita Prefectural University, 6. Hokkaido Education University, 7. Shikotan Geophysical Observatory, 8. Institute of Marine Geology and Geophysics, Russian Academy of Sciences, 9. Japan Meteorological Agency, 10. Geospatial Information Authority of Japan, 11. Ministry of Education, Culture, Sports, Science and Technology

Historical and prehistorical tsunami deposits in Kunashir Island, the Northern Territories, were studied as parts of visa-free exchange programs of Japan and Russia. The reconnaissance survey was conducted for 30 days for 4 years from 2015 to 2018, and 105 sites in the ca. 50 km area along the Pacific coastline was examined. As a result, it was confirmed that the sand layer, which can be regarded as a trace of the 1994 Hokkaido Toho-Oki tsunami is well preserved near the surface layer in the eastern lowland from Furukamappu to Ruyobetsu. The 1994 tsunami run-up, estimated from the distribution of the deposits, is 50-150 m from the coast and 3-4 m in height. Furthermore, the chemical composition of the volcanic glass was analyzed for as many as 30 volcanic tephras. Examining the results together with the stratigraphy, it was found that known tephra from volcanoes of Hokkaido, such as Ko-c1 (1856), Ta-a (1739), Ko-c2 (1694), Ta-b (1667), Ma-b (10th Century) and Ta-c (2,700 BP) are deposited at multiple sites on the island. With these volcanic deposits as the key layer, we could estimate the age of the candidates of tsunami deposits. For example, in the wetland of Furukamappu, there is one event in the 17th and 10th centuries, and two in the 10th century and 2700 years ago. It is inferred that the large tsunami that would leave the deposit in Kunashiri occurred at a frequency of once in 1000 years.

Keywords: the Northern Territories, Kunashiri Island, tsunami deposit, paleo earthquake, volcanic tephra

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Deposit-based assessment of tsunami size: example from Nankai-Trough earthquakes

*Daisuke Sugawara[1], Kentaro Imai[2], Shinsuke Okada[3], Takuto Maeda[4]

1. Museum of Natural and Environmental History, Shizuoka, 2. JAMSTEC, 3. Tohoku University, 4. Hirosaki University

Researches on historical documents and geological records, such as tsunami deposits, have clarified the recurrence of the Nankai-Trough earthquakes and tsunamis during the past 6000 years. Magnitudes and source parameters of some historical tsunamigenic earthquakes, such as the 1707 Hoei and 1854 Ansei events, have been examined based on numerical modeling of coseismic crustal deformation and tsunami propagation and inundation. For example, the extent of the rupture area of the Hoei earthquake was revised based on the numerical modeling of tsunami inundation, considering tsunami heights from historical records and tsunami deposits in the Ryujin-ike pond in the eastern coast of Kyushu island (Furumura et al., 2011). The revised rupture area of the Hoei earthquake was extended to the Hyuga-nada, 70 km beyond the previously estimated rupture area.

The magnitude of the presumed largest (Mw=9.0) earthquake which may occur in the Nankai Trough (Disaster Management of Cabinet Office, 2012) is much greater than the size of known historical events. To validate the assumptions of the largest earthquake, information from tsunami deposits, which may record tsunamigenic earthquakes in longer time span, will play an important role. However, most tsunami deposits in the Nankai Trough region have been found from coastal lakes and narrow lowlands. In this region, spatial distribution of tsunami deposits cannot be a good indicator of tsunami inundation. Explorations are needed to correlate spatially-limited data of tsunami deposit with the magnitude information and source parameters of earthquake and tsunami.

In this presentation, deposit-based assessment of the size of earthquake and tsunami will be discussed based on numerical modeling of tsunami and sediment transport in the Ryujin-ike pond. Main interest of the research is that whether or not we can correlate the formation processes, distribution and thickness of tsunami deposit with the source parameters of the tsunami. In addition, results of the modeling will be compared with field observations of the deposits, to discuss the relationship with the historical earthquakes.

Acknowledgement

This research was supported by MEXT (“Research project for compound disaster mitigation on the great earthquakes and tsunamis around the Nankai Trough region”) and JSPS KAKENHI Grant Numbers 16H03146,

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Keywords: Nankai Trough, Tsunami, Deposit

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Flume experiments for understanding variety of tsunami deposit

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Flume experiments, in which sedimentary conditions can be easily controlled, are expected to provide insights into the sedimentary process under tsunami flow. The previous studies using flume experiments have contributed to improvement of numerical models of tsunami sediment transport. By contrast, there is not enough experimental studies to examine sedimentary process in order to improve the identification and interpretation of (paleo) tsunami deposits in geological record. In this presentation, I will summarize previous studies of tsunami deposit using flume experiment, and show the potential for better understanding of sedimentary process of tsunami deposits.

Keywords: Tsunami deposit, Flume experiment, Sedimentary process

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Thu. May 30, 2019 10:45 AM - 12:15 PM JST | Thu. May 30, 2019 1:45 AM - 3:15 AM UTC | Convention Hall B 2F

[M-IS12] tsunami deposit

convener:Takashi Chiba(Faculty of Bioresource Sciences, Akita Prefectural University), Tetsuya Shinozaki(Center for Research in Isotopes and Environmental Dynamics (CRiED), University of Tsukuba), Daisuke Ishimura(Department of Geography, Tokyo Metropolitan University), Chairperson:Tetsuya Shinozaki(Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba)

The 2011 off the Pacific coast of Tohoku Earthquake and tsunami have an influence on the development of tsunami deposit research. After the tsunami, a lot of findings have been reported on various research fields. However, identification criteria of the tsunami deposit are not yet established. Moreover, it is still uncertain how to use the tsunami deposit in the risk assessment. In this session, we welcome researches from all aspect of sedimentary records of modern and paleo tsunamis both onshore and offshore, and numerical and experimental modeling studies for risk assessment. In addition, we also welcome other event deposits, such as flooding and storm surge, that they are considered to be important for discrimination of tsunami deposit.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MIS12-07] **Inverse modeling of Tsunami deposit using Deep Learning Neural Network**

*Rimali Mitra[1], Hajime Naruse[1] (1.Kyoto University, Graduate School of Science)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MIS12-08] Numerical estimation of tsunami size using boulders deposited by the 2011 Tohoku-oki tsunami at Settai, Miyako city, Japan

*Tatsuya Takei[1,4], Kazuhisa Goto[2], Masaki Yamada[3] (1.Department of Earth Sciences, Graduate School of Science, Tohoku University, 2.International Research Institute of Disaster Science (IRIDeS), Tohoku University, 3.Earthquake Research Institute, University of Tokyo, 4.Department of Complexity Science and Engineering, Graduate School of Frontier Sciences, Tokyo University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MIS12-09] Constraint of the ages of historical tsunami deposits on the Ishinomaki Plain

*Hiroshi Tetsuka[1], Kazuhisa Goto[2], Takashi Ishizawa[1], Daisuke Sugawara[3], Yusuke Yokoyama[4], Yosuke Miyairi[4] (1.Department of Earth Science, Tohoku University, 2.International Research Institute of Disaster Science, Tohoku University, 3.Museum of Natural and Environmental History, Shizuoka, 4.Atmosphere and Ocean Research Institute, University of Tokyo)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MIS12-10] Non-destructive analyzes of sediments to discern tsunami-related mud cap and overlying muds to improve age determination of tsunami deposits

*Takashi Ishizawa[1], Kazuhisa Goto[2], Yusuke Yokoyama[3], Yosuke Miyairi[3] (1.Department of Earth Science, Tohoku University, 2.International Research Institute of Disaster Science, Tohoku University, 3.Atmosphere and Ocean Research Institute, The University of Tokyo)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MIS12-11] Sedimentological and paleontological studies of storm surge deposits in intertidal mud floor -case study of Ena Bay on Miura Peninsula, Central Japan.

*Akihisa Kitamura[1], yamamoto yuka[1], Takashi Toyofuku[2] (1.Institute of Geosciences, Faculty of Science, Shizuoka University, 2.Japan Agency for Marine-Earth Science and Technology (JAMSTEC))

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[MIS12-12] Shallow marine tsunami deposits and bioturbation

★Invited Papers

*Koji Seike[1] (1.Geological Survey of Japan, AIST)

Inverse modeling of Tsunami deposit using Deep Learning Neural Network

*Rimali Mitra[1], Hajime Naruse[1]

1. Kyoto University, Graduate School of Science

Tsunami is one of the most catastrophic disasters along coastal zones, and tsunami deposits are layers of sediment formed by hydrodynamic activities of tsunami. These event deposits provide clues to estimate the recurrence intervals and relative magnitude of prehistoric tsunamis that serve as a tool for future tsunami hazard evaluation. Towards the quantitative assessment of hydraulic conditions of tsunamis from deposits, this study applies the inverse model using deep learning neural network (DNN) for tsunami deposit. In order to conduct machine learning of DNN, forward model calculation was repeated at random initial flow conditions (e.g. maximum inundation height, flow velocity, concentration, etc.) to produce artificial training data sets which represent depositional characteristics such as thickness and grain-size distribution. The model serves as the modified version of previously proposed FITTNUSS model, which incorporates nonuniform and unsteady transport of suspended sediment and also turbulent mixing. Then, DNN was trained for establishing the inverse model on the basis of artificial data sets. SGD (Stochastic gradient descent) is used as an optimizer for this DNN model. Tests using artificial data sets successfully indicated that the established DNN can reconstruct the original flow conditions from the characteristics of deposits. Finally, the model was applied to natural data sets taken from the 2011 Tohoku-Oki Tsunami deposit. The deep learning neural network showed promising result for natural data sets. Comparing to existing inverse models, deep learning neural network enables the inversion to employ a forward model that requires higher computational costs, and to avoid a local optimum. The further applicability and validation of this method will be checked with other parameters, and natural data set from different field visits in future endeavour.

Keywords: Tsunami Deposits, Inverse Modeling, Machine Learning

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Numerical estimation of tsunami size using boulders deposited by the 2011 Tohoku-oki tsunami at Settai, Miyako city, Japan

*Tatsuya Takei[1,4], Kazuhisa Goto[2], Masaki Yamada[3]

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Tsunami boulders are important geological evidence to understand paleotsunami activity. Previous studies have intended to extract the information about tsunami size from the distribution of tsunami boulders. However, although several numerical methods have been proposed to estimate tsunami size using tsunami boulders, there have been no studies validating the estimated tsunami size by comparing with the actual tsunami size. Also, it is important to consider the methodology of the estimation of tsunami size using boulders. In this study, we estimated local size of the 2011 Tohoku-oki tsunami at Settai, Miyako City, Japan based on the numerical modeling of boulder transport. We seaerch an incident wave condition of sin waves which could explain the distribution of boulders well. We then compared the estimated results with the tsunami size calculated by existing well-validated tsunami source model. As a result of the simulation, we estimated that the tsunami size was ranging from 9 m to 21 m in wave height and from 60 s to 300 s in period at the point of 5200 m offshore of Settai.This range covers the actual tsunami size; so the tsunami size can be estimated from the boulders in Settai. According to the above results, the method that we proposed was effective. On the other hand, we found that assumption of the initial position of boulders are critically important and it should be constrained by multiple information such as topographic condition and composition of the boulders.

Keywords: Tsunami boulder, Tsunami size, numerical model, simulation

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Constraint of the ages of historical tsunami deposits on the Ishinomaki Plain

*Hiroshi Tetsuka[1], Kazuhisa Goto[2], Takashi Ishizawa[1], Daisuke Sugawara[3], Yusuke Yokoyama[4], Yosuke Miyairi[4]

1. Department of Earth Science, Tohoku University, 2. International Research Institute of Disaster Science, Tohoku University, 3. Museum of Natural and Environmental History, Shizuoka, 4. Atmosphere and Ocean Research Institute, University of Tokyo

The research of tsunami deposit has an important role for understanding the paleo-tsunami history. On the Ishinomaki Plain, where the AD 2011 Tohoku-Oki tsunami inundated widely, at least six paleo-event deposits were found by previous studies (Shishikura et al., 2007; Sawai et al., 2012; Takeda et al., 2017). Sawai et al. (2012) correlate the latest three event deposits (Sand K, A, and B) with the tsunamis generated by the AD 1611 Keicho Ohsyu earthquake, the AD 1454 Kyotoku earthquake, and the AD 869 Jogan earthquake, respectively. Among them, the event age of Sand B is well constrained by the To-a tephra of AD 915 and radiocarbon ages, which ensure the validity of correlation with the historical record. However, the event ages of Sands K and A were not well constrained because accurate estimation of these event ages by radiocarbon dating is theoretically difficult. There remains a need to improve the accuracy of these event ages for understanding recurrence interval of tsunamis and comparing with the age of tsunami events in other sites. Therefore, we conducted multi-proxy analyses including radiocarbon dating, and analyses of diatom and pollens for the samples taken from the Ishinomaki Plain and then discuss the age of event deposits formed during the last 700 years.

The field survey was carried out on the coast area of Higashi-Matsushima City, Miyagi Prefecture. Cultivated soil, silt, and peat layers were found in the core samples. In some sites, one or two medium sand layers were found. Diatom analysis, pollen analysis, X-ray CT scan, and radiocarbon dating were conducted for the clearly identified two sand layers. The radiocarbon dating results were calibrated by OxCal Ver. 4.3.2 (Bronk Ramsey, 2009) with IntCal13 (Reimer et al., 2013) and constrained by stratigraphy (Bronk Ramsey, 2008).
Two sand layers (hereafter we call, Sands 1 and 2 for the upper and lower sand layers, respectively) are closely spaced with sandy silt layer of approximately 1–3 cm between them. Two hypotheses can be considered for the formation of these sand layers; they were deposited by different events, or a single event. Eyewitness observation and X-ray CT scan analysis imply that the sandy silt deposits in between these two sand layers contain many sand grains, and clearly different from the peat layer below Sand 2. The radiocarbon dating revealed that the age of sandy silt layer is intermediate between silt above Sand 1 and peat below Sand 2. In addition, sandy silt includes many freshwater diatoms but does not include marine and marine-brackish diatoms; diatom assemblage is clearly different from peat below Sand 2 that contains marine-brackish diatoms but few freshwater diatoms. Thus, sandy silt between Sands 1 and 2 is probably deposited as normal sediment so that Sands 1 and 2 should have been formed by different events.

The ages of Sands 1 and 2 can be constrained as 11 to 408 cal BP and 357 to 538 cal BP (2σ), respectively. These event ages are consistent with the AD 1611 Keicho Ohsyu earthquake and the AD 1454 Kyotoku earthquake, as interpreted by Sawai et al. (2012). The pollen analysis further shows the extensive increase of *Pinus sp.* and *Cryptomeria sp.* in the sediment above Sand 1. This result can be correlated with the afforestation policy by Sendai Domain after mid-17th century as planting Japanese

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pine and cedar was encouraged by the AD 1621 Sendai domain’ s law (Hanso Date Masamune kensho-kai, 1938). Therefore, Sand 1 has most likely been formed by the AD 1611 tsunami.

Keywords: earthquake, tsunami, AD 1611 Keicho ohsyu earthquake

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Non-destructive analyzes of sediments to discern tsunami-related mud cap and overlying muds to improve age determination of tsunami deposits

*Takashi Ishizawa[1], Kazuhisa Goto[2], Yusuke Yokoyama[3], Yosuke Miyairi[3]

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Age of tsunami deposit is usually determined from dating results of sediments above and below the tsunami derived layers. However, determining the upper boundary of tsunami deposit is often difficult, because the top of tsunami deposit is sometimes comprised of mud-dominated sediment (mud cap) which can be indistinguishable from overlying muddy sediment deposited under normal sedimentary condition. This ambiguity may cause serious problem determining true tsunami ages.

Here we present an examples of non-destructive and destructive analyses of core sample taken from Okirai, Iwate prefecture. Our results indicated that X-CT (X-ray Computed Tomography), XRF (X-ray Fluorescence), and grain size analyses were useful to identify tsunami-related mud cap from overlying muds deposited after tsunami events. Since X-CT and XRF analyses are non-destructive analyses, it is highly recommended to conduct these analyses before subsampling of the sediments for further analyses including radiocarbon dating. Such careful sampling for dating will contribute to improve age estimation of tsunami deposits.

Keywords: Tsunami deposit, Mud cap, Non-destructive analyzes

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Sedimentological and paleontological studies of storm surge deposits in intertidal mud floor -case study of Ena Bay on Miura Peninsula, Central Japan.

*Akihisa Kitamura[1], yamamoto yuka[1], Takashi Toyofuku[2]

1. Institute of Geosciences, Faculty of Science, Shizuoka University, 2. Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Storm surges and tsunamis deposits provide essential information for disaster assessments of coastal lowlands in low- and middle-latitude regions and active margins. However, studying these coastal lowland strata is becoming increasingly difficult, particularly in residential regions, due to extensive anthropogenic disturbances. Consequently, the focus of research has had to extend to shallow marine deposits such as bay sediments, although few studies have examined storm surge deposits related to recent storm events. This study identified storm surge deposits within tidal flat sediments in Ena bay, located in the southern coastal area of metropolitan Tokyo, Central Japan. Identification of the deposits was based on a comparison of surveys undertaken before and after Typhoon Lan (lowest pressure of 915 hPa), which struck the area on 23 October 2017. The results indicate that the storm surge deposits are limited to the supratidal and intertidal zones, demonstrating that the distal extent of sand beds deposited by storm surges is less than that of sand beds typically deposited by larger tsunamis.

Keywords: storm surges deposits, recent muddy tidal flat sediments, benthic foraminifer

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Shallow marine tsunami deposits and bioturbation

*Koji Seike[1]

1. Geological Survey of Japan, AIST

The huge tsunami waves induced by the 2011 off the Pacific coast of Tohoku Earthquake severely affected shallow marine ecosystems along the Pacific coast of northeastern Japan. Among shallow marine settings, subtidal seafloor ecosystems composed of fine-grained sediments are the most heavily disturbed by tsunami waves as they are greatly altered by rapid erosion and deposition processes (Seike et al., 2013). In order to discuss preservation potential of the tsunami deposits in relation to sediment mixing by recolonizing benthic animals, we have monitored temporal changes in the sedimentary structures of the tsunami affected area (Seike et al., 2016, 2017a). Tsunami deposits also provide useful information on the nature of bioturbation because there are no pre-existing burrows in the sediments. We revealed the nature of bioturbation such as burrowing depth, substrate-softening effect by echinoid bioturbation on the basis of observations on the 2011 tsunami deposit (Seike et al., 2017b, 2018).

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Keywords: tsunami deposits, bioturbation, Sanriku

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Thu. May 30, 2019 9:00 AM - 10:30 AM JST | Thu. May 30, 2019 12:00 AM - 1:30 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[M-IS16] Dynamics of eruption cloud and cumulonimbus; modelling and observation

convener:Eiichi Sato(Meteorological Research Institute), Fukashi Maeno(Earthquake Research Institute, University of Tokyo), Takeshi Maesaka(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Eiichi Sato(Meteorological Research Institute)

Volcanic eruption clouds (eruption column, pyroclastic flow, and umbrella cloud) and cumulonimbus are similar phenomena in the atmosphere. Models that can precisely reproduce the physical processes in such phenomena, and accurate observations have been required. Recently, the development of remote sensing techniques such as weather radar and weather satellite are remarkable, and they are being adopted for volcanic eruption monitoring. However, it is indispensable to verify the results of modeling and remote sensing using in-situ observations. In this session, we will discuss the modelling and the observations of eruption clouds and cumulonimbus from the viewpoint of meteorology, volcanology, geology, and other related fields. The related phenomena such as ashfall, rainfall, snowfall, hail and volcanic block will also be discussed.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[MIS16-01] Observations of Volcanic Eruption Columns with Different Types of Weather Radars

★Invited Papers

*Masayuki Maki[1], Takehiko KOBORI[1], Yura Kim[1], Yasushi Fujiyoshi[2], Eiichi Sato[3], Hidehiko Tokushima[4], Masato Iguchi[5] (1.Kagoshima University, 2.Hokkaido University, 3.Meteorological Research Institute, 4.Field Researchers Corporation, 5.Kyoto University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[MIS16-02] Observation of Eruption Plumes by X-Band MP radar and Lidar at Sakurajima and Kuchinoerabujima

*Haruhisa Nakamichi[1], Atsushi Shimizu[2], Makoto Shimomura[1], Magfira Syarifuddin[1], Masato Iguchi[1] (1.Sakurajima Volcano Research Center, Disaster Prevention Research Institute, Kyoto University, 2.National Institute for Environmental Studies)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[MIS16-03] 2018-2019 Kuchinoerabu-jima eruption plume/cloud echoes observed by JMA weather radar network

*Eiichi Sato[1], Keiichi Fukui[2], Toshiki Shimbori[1] (1.Meteorological Research Institute, 2.Japan Meteorological Agency)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[MIS16-04] Numerical Study on the Ejection Conditions of Ash Clouds during Recent Eruptions of Kuchinoerabujima Volcano

*Yasuhiro Ishimine[1], Teruki Oikawa[2], Nobuo Geshi[2] (1.Research and Education Center for Natural Hazards, Kagoshima University, 2.Geological Survey of Japan, AIST)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[MIS16-05] Image analysis of volcanic clouds during the 2011 Kirishima Shinmoedake eruption

*Takehiko KOBORI[1], Kisei KINOSHITA[1], Naoko IINO[2], Masayuki MAKI[1], Seiji FUKUSHIMA[1] (1.Kagoshima University, 2.Kumamoto University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[MIS16-06] Cloud Radar Network for Early Detection of Cumulonimbus Generation

*Takeshi Maesaka[1], Tadayasu Ohigashi[1], Koyuru Iwanami[1], Shin-Ichi Suzuki[1], Yukari Shusse[1], Namiko Sakurai[1] (1.National Research Institute for Earth Science and Disaster Resilience)

Observations of Volcanic Eruption Columns with Different Types of Weather Radars

*Masayuki Maki[1], Takehiko KOBORI[1], Yura Kim[1], Yasushi Fujiyoshi[2], Eiichi Sato[3], Hidehiko Tokushima[4], Masato Iguchi[5]

1. Kagoshima University, 2. Hokkaido University, 3. Meteorological Research Institute, 4. Field Researchers Corporation, 5. Kyoto University

The present paper describes the results of observational studies of volcanic ash columns using different types of weather radars: X-band marine radar, bi-static Ku-band radar, Ka-band Doppler radar, and operational X-band polarimetric radar. In order to observe eruption columns with extremely fine temporal resolution, an X-band marine radar was set up during three months in 2018 at the Kurokami observatory of Kyoto University located about 4km from the vent of Sakurajima volcano. The marine radar has a slot antenna that has the PPI scanning speed of 48 rpm, with a vertical beam width of 22˚ and a horizontal beam width of 1.2˚, and a range resolution of 8m. We carried out observations by physically changing the rotational axis of the slot antenna from vertical (PPI) to horizontal (RHI) to achieve an elevation angle resolution of 1.2˚. The MRI Ku-band radar and Kagoshima University Ku- band radar set up in 2017 in Sakurajima have Luneberg antenna with a horizontal and vertical beam width of 3˚. The antenna rotates spirally from an elevation angle of 0˚ to 90˚ to obtain hemispherical volume data in one minute. The Ka-band Doppler radar of NIED was operating at the Kurokami observatory during 3 months in 2015 to investigate the inner structure with the RHI antenna scanning. The MLIT operational X-band polarimetric radar located approximately 11km from the vent of the Sakurajima volcano can measure volcanic ash columns three-dimensionally at 5-minute intervals, even though it is an operational radar aiming to measure heavy rainfalls in Sakurajima.

Utilizing these different types of radar data, we perform detailed analysis of eruption columns. The marine radar succeeded in detecting eruptions and at the same time detecting falling pyroclastic particles (Fig. 1). The radar also reveals the fine structure of an ascending eruption column at 1.25-second intervals. While the marine radar observes volcanic ash columns with the wider azimuth angel resolution 22˚ due to its fan beam antenna, Ka-band Doppler radar can observe the targets with finer azimuthal resolution using RHI scanning of the parabolic antenna. The Ka-band radar RHI observations also reveal the upward speed of the ash echo top at 2-minute intervals. While both the marine radar and the Ku-band Doppler radar measure eruption column vertically at a fixed azimuthal direction, the Ku-band Doppler radar measures all azimuth and elevation angles every 1 minute. Using this scanning strategy, we can clarify the temporal change of the eruption column during its downwind movement: the radar reflectivity factor of the upper part of the eruption column becomes high 5-minute after the eruption, which is probably due to the aggregation process in water clouds (Fig. 2). The operational X-band MP radar collects 20 tilts PPI scan data at 5-minute interval. We can construct three-dimensional data of ash clouds with time and spatial interpolation method. Then we can obtain the wide-area ash fall distributions.

In conclusion, as mentioned above, different types of weather radars are now available for studying volcanic eruption columns and their applications to disaster prevention are promising.

Keywords: X-band marine radar, Ku-band rapid scanning Doppler radar, X-band polarimetric radar

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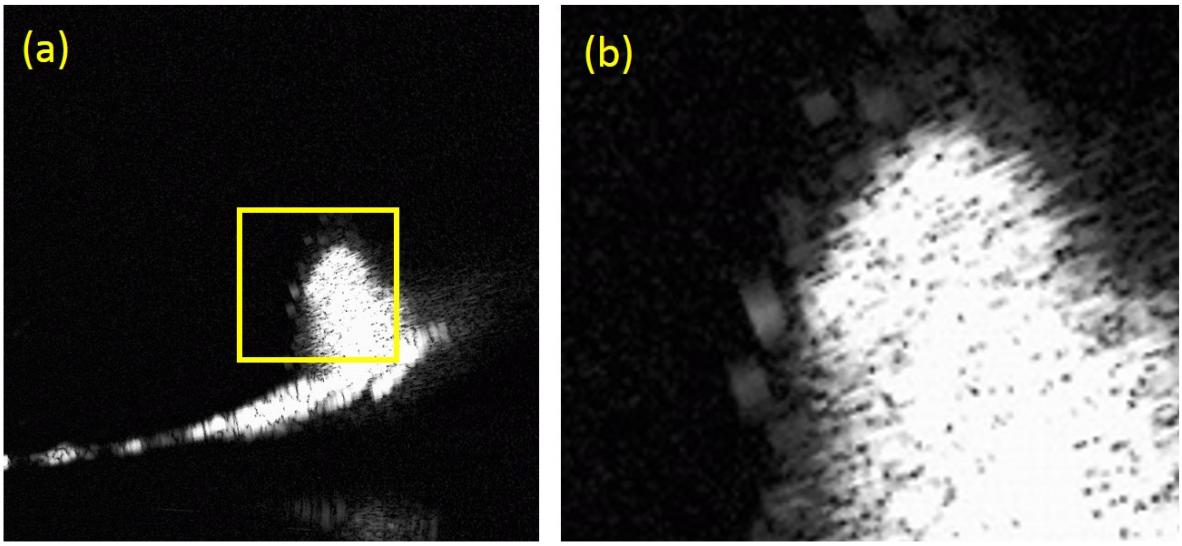


Fig. 1 Volcanic eruption column 2 minute after eruption observed by X-band marine radar. 22:11 LST, May 4, 2018.

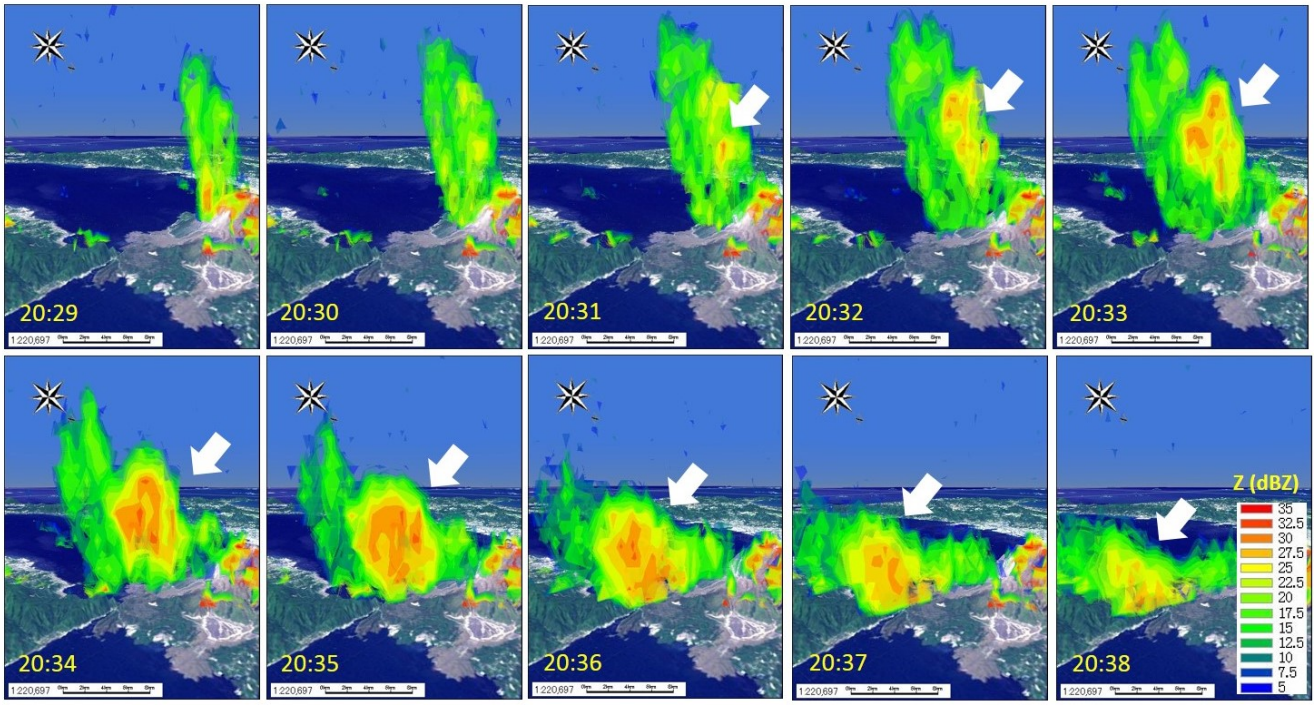


Fig. 2 Temporal change of inner structures of volcanic eruption clouds observed by KuRAD. 20:29-20:38 LST, March 5, 2018.

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Observation of Eruption Plumes by X-Band MP radar and Lidar at Sakurajima and Kuchinoerabujima

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1. Sakurajima Volcano Research Center, Disaster Prevention Research Institute, Kyoto University, 2. National Institute for Environmental Studies

We report the comparison between results by radar and lidar observations of Minamidake eruption on June 16, 2018, at Sakurajima, and the radar observation results of Kuchinoerabujima eruptions since December 2018. The radar reflectivity factor data distribution showed that the plume reached 3,300 m height within 1 min after the onset of the Minamidake eruption and increased to be 5,000 m height, after 3 min from the onset of the eruption. At the same time, it was confirmed from the radar reflectivity factor data that the eruption column shifted 1 km to the west direction. The radar reflectivity factor reincreased vertically above the crater at about 3,000 m height, 5 min after the starting of the eruption, which is corresponding to the second eruption. In the lidar observation, changes corresponding to the movement in the west direction of the eruption column were observed from 3 min after the start of the eruption to 8 min afterward, and the scattering peak corresponded well with the enhancement of the radar reflectivity factor. After 15 min from the onset of the eruption, there was no change in the radar reflectivity factor corresponding to the ash plume, but the significant scattering intensity of the lidar was found at a distance less than 2 km and continued for more than 20 minutes. It reflects that the lidar outperforms the radar in terms of detecting the finer particles exist in the atmosphere. The lidar observation showed that volcanic ash was diffused and moved by the wind. Next, we observed the increase in the radar reflectivity factor corresponding to the eruption columns of the eruptions on December 18, 2018, and January 17 and 29, 2019 at Kuchinoerabujima. One minute after the eruption on December 28, the radar reflectivity factor showed a rise to 3,000 m of ash plume and reached the maximum height at about 5,000 m, 3 min after the onset of the eruption. It was found from the radar reflectivity factor that the maximum height of the plume was 4,000 m, 2 min after the onset of the eruption on January 17. Five minutes after the onset of eruption, the reflectivity factor of the plume reached 4,000 m and did not raise any further. From these facts, we can suggest that by grasping the temporal change of the plume height given by the temporal changes in radar reflectivity factor, we can extract the information of the eruption intensity.

Keywords: X-band MP Radar, Lidar, Eruption, Sakurajima, Kuchinoerabujima

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2018-2019 Kuchinoerabu-jima eruption plume/cloud echoes observed by JMA weather radar network

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At Shindake crater of Kuchinoerabu-jima volcano, a very small eruption occurred on October 21, 2018, and then continued intermittently until December 13. After that, three eruptions accompanied by pyroclastic flow occurred on December 18, 2018, January 17 and 29, 2019. Although Japan Meteorological Agency (JMA) failed to visually confirm the top of the former two eruption plumes, they were observed by Himawari-8, a meteorological satellite of JMA, and X-band MP radar of Disaster Prevention Research Institute (DPRI), Kyoto University. Meanwhile, the eruptions were also observed by JMA's weather radar network. In this presentation, we will report on the analyses using them.
Eruption plume/cloud echo associated with the eruption on January 17, 2019 was observed by Tanegashima radar and Naze radar. The plume echo height observed by Tanegashima radar was about 6.7 km above sea level (ASL), and about 6.5 km ASL by Naze radar. These are consistent with about 6 km above the crater edge (about 6.6km ASL), the result of the analysis with Himawari 8. On the other hand, the eruption plume echo height observed by the DPRI radar was about 4 km above the sea level. This may be due to the vertical wind shear. In other words, the authors think that the 125-degree RHI observation, i.e., vertical cross section observation by DPRI radar, did not capture the top of the plume, because the wind direction observed by the JMA wind profiler at Yakushima was northwesterly or north-northwesterly in the lower troposphere (2km or less), however, the wind was westerly in the middle troposphere (about 3-6km).
Meanwhile, in other cases including eruption cases on December 18, 2018 and January 29, 2019, the JMA radar network did not properly capture the eruption plume/cloud echoes. It is considered that the volcanic ash density especially near the top of the plume was low, and the mismatch occurred between the scan sequence of the radar and the rising process of the plume.
As a result of analysis by weather radar, we captured some of the eruption activity, however, there were many cases that could not be properly caught. We will show the limits of the observation method with weather radar, and show some possible countermeasures.

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Keywords: volcanic eruption, Kuchinoerabu-jima, weather radar

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Numerical Study on the Ejection Conditions of Ash Clouds during Recent Eruptions of Kuchinoerabujima Volcano

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1. Research and Education Center for Natural Hazards, Kagoshima University, 2. Geological Survey of Japan, AIST

Kuchinoerabujima Volcano in Kyushu, Japan have erupted in 2014 and 2015. The volcanic activities intensified again since October 2018 and generated explosive eruptions accompanying pyroclastic density currents on 18 December 2018, 17 and 29 January 2019. The pyroclastic density currents are so hazardous that it is crucial to assess the risk that residential area near the volcano could be affected by the currents.

We performed a series of numerical simulations on the ejection of volcanic ash clods and subsequent density currents with the parameter settings, which were based on the observational data acquired during the explosive eruptions of Kuchinoerabujima volcano from 2014 to 2018. The supercomputer system HOKUSAI, RIKEN was used (Project number: Q18431).

We assumed that the initial temperature, density and ejection speed of ash clouds significantly affect the dynamics of the ash clouds, and thus, we searched plausible combinations of the parameter set of the thee variables by conducting a series of numerical simulations. Some of the simulations yielded the results that are comparable with the observed eruptions accompanying pyroclastic density currents. In particular, the results implies that the pyroclastic density currents are prone to occur when the initial temperature of the ejected ash clouds is lower than 800K.

In addition, the numerical simulations exhibited that the small north-south trending ridge on the east of the volcanic vent of Kuchinoerabujima volcano had the main part of the pyroclastic density currents spread over the western flank of the volcanic edifice. This is consistent with our observation at Kuchinoerabujma volcano.

Keywords: Kuchinoerabujima volcano, Pyroclastic Density Current, Numerical Simulation

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Image analysis of volcanic clouds during the 2011 Kirishima Shinmoedake eruption

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We report the development and spatial scale of the sub-plinian eruption of Kirishima Shinmoedake in January 26-27, 2011. In addition to the multipoint image observation and the cloud diffusion analysis of satellite images in the previous reports [1-3], we analyze Ohnami-ike volcano monitoring camera images [4] and the photographs published.
For the image analysis of the plume, we improved the photo analysis program [5] and developed a method fitting the skyline created from the elevation tile [6] to the image. By considering the curvature of the earth when creating skyline, accurate altitude estimation became possible.
Since 2008, fumes and white vaporous clouds were often observed at Shinmoedake. Then, volcanic ash containing fresh magma was confirmed at the small eruption on January 19, 2011 at 01:27 [7]. After that, it changed to continuous discharge of ash cloud as observed on January 22 and 25. The plume flowed and rose to about 5-7 km downstream, with its top reaching 1700 to 2200 m above sea level, and flowed horizontally. Discharge of the plume continued until around 14:00 on January 26, and reached the highest point of 1700-1900 m above sea level at the downstream 3-4 km. Despite poor visibility due to atmospheric turbidity on January 26th, near-infrared video images and photographs from the observation point of 50 km south-southwest of Shinmoedake, captured the whole plume shape and developmental process of the sub-plinian eruption started at 15:29 on January 26th. The upper part of the large-scale ash cloud was also observed from a southern point of Kagoshima City located in 58 km southwest of Shinmoedake, and the visible web camera in the Hitoyoshi Basin located in 38 km north of Shinmoedake. By sharpening and analyzing these images, the plume height was obtained. On January 26, the plume rose to 7-8 km downstream, the altitude above sea level was 5000-6000 m, rarely 7000 m. This is close to sea level altitude 7000 m (accuracy 1 km) [8] obtained from radar analysis of the Tanegashima and Fukuoka data. On January 27, continuous magmatic clouds were observed since the morning. At the explosion at 15:30 and 15:41, sub-plinian type eruption restarted, and heavy ash cloud reaching 7000-8000 m above sea level was seen from each observation point.
Acknowledgement: We are very grateful to Aira-Isa Promotion Bureau of Development, Kagoshima Pref., for providing us the movie files of the highlight scenes of the 2011 Shinmoedake eruption.

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Keywords: Volcanic Clouds, Image Analysis, Digital Elevation Model

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Cloud Radar Network for Early Detection of Cumulonimbus Generation

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Recently municipal engineers point out that urban city is vulnerable for localized heavy rainfall, and that rainfall monitoring and forecasting are important for water management. A weather radar is a powerful tool for that purpose; however it is only precipitation particles (hydrometeors excluding cloud particles) that current operational radars (S-, C- and X-band) can detect. This means that when the radar catches the echo, the rainfall may have already started. Meanwhile, the heavy rainfall is caused by a mature cumulonimbus which develops from a cumulus. So the detection of the cumulous is expected to make the lead time of heavy rainfall forecasting longer. But the current radar cannot observe the cumulus which consists of the cloud particles. For an early warning of heavy rainfall, we developed the cloud radar network around Tokyo metropolitan area.
The network consists of five Ka-band (35 GHz) radars whose specifications are as follows: azimuth-/elevation-scanning Cassegrain antenna with a diameter of 2 m, 3 kW Extended Interaction Klystron (EIK) as a microwave amplifier, pulse compression by linear frequency modulation, and dual polarimetric capability (simultaneous transmission and reception of H and V; only three of the five radars). The minimum sensitivity we need is -17 dBZ (-20 dBZ) at 20 km range for dual (single) polarimetric type, respectively, because our target is the detection of a conversion from cloud droplets to raindrops. These radars were just deployed in February 2015. We would like to present preliminary results of our cloud radar and to discuss the availability to the early monitoring of cumulonimbus generation.

Keywords: Cloud Radar, Cumulonimbus, Early Detection

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Thu. May 30, 2019 9:00 AM - 10:30 AM JST | Thu. May 30, 2019 12:00 AM - 1:30 AM UTC | 304 3F

[M-IS19] Paleoclimatology and paleoceanography

convener:Yusuke Okazaki(Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University), Akira Oka(Atmosphere and Ocean Research Institute, The University of Tokyo), Michinobu Kuwae(Center for Marine Environmental Studies), Hitoshi Hasegawa(Faculty of Science and Technology, Kochi University), Chairperson:Hitoshi Hasegawa

Past environmental changes and events at multi-decadal to tectonic timescale toward an understanding of Earth climate system by an integration of terrestrial and marine proxy studies and numerical modeling will be discussed. At JpGU2019, a series of presentations on present and future climate and environmental changes from paleo-perspective will be held. We welcome a variety of paleo-environmental studies from a wide range of background. We hope that this session will provide an opportunity to promote communication between participants from multidisciplinary field.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[MIS19-17] Paleotemperature and precipitation history (18.1–4.5 ka) in stalagmite bulk and clumped isotopes from Hiroshima, Japan

*Hirokazu Kato[1], Shota Amekawa[1], Akihiro Kano[1] (1.Department of Earth and Planetary Science, The University of Tokyo)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[MIS19-18] Terrestrial paleoclimate since 80 ka recorded in stable and clumped isotopes of two stalagmites obtained from the Pacific side of the Japanese islands

*Shota Amekawa[1], Hirokazu Kato[1], Akihiro Kano[1], Kenji Kashiwagi[2], Taiki Mori[3], Ryoko Senda[3], Chuan–Chou Shen[4] (1.Graduate School of Science, The University of Tokyo, 2.Graduate School of Science and Engineering for Research, University of Toyama, 3.Graduate School of Integrated Sciences for Global Society, Kyushu University, 4.Department of Geosciences, National Taiwan University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[MIS19-19] Seasonal changes in Li/Ca ratio and inferred phytoplankton abundance as analyzed by daily growth increments of *Pecten albicans* (Bivalvia)

*Kondo Yasuo[1], Hondo Shutaro, Hasegawa Hitoshi[1], Nshio Yoshiro[1], Hirota Takayoshi (1.National University Corporation Kochi University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[MIS19-20] Geological reconstruction of Antarctic Ice Sheet deglaciation on Soya Coast, East Antarctica since the Last Glacial Maximum

*Moto Kawamata[1], Yusuke Suganuma[2,1], Koichiro Doi[2,1], Takanobu Sawagaki[3], Akihisa Hattori[1] (1.Department of Polar Science, School of Multidisciplinary Science, SOKENDAI (The Graduate Unversity for Advanced Studies), 2.National Institute of Polar Research, 3.Hosei University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[MIS19-21] Os isotope record of the Quaternary seawater derived from pelagic sediment in the Lau Basin, western South Pacific Ocean, and its implications for global climate changes

*Yusuke Kuwahara[1], Kazutaka Yasukawa[1,2], Koichiro Fujinaga[2,3], Tatsuo Nozaki[4,3,5,2], Junichiro Ohta[2,6,3], Honami Sato[2,4], Jun-Ichi Kimura[6], Kentaro Nakamura[1], Yasuhiro Kato[3,1,2] (1.Department of Systems Innovation, School of Engineering, The University of Tokyo, 2.Ocean Resources Research Center for Next Generation, Chiba Institute of Technology, 3.Frontier Research Center for Energy and Resources, School of Engineering, The University of Tokyo, 4.Research and Development Center for Submarine Resources, Japan Agency for Marine-Earth Science and Technology , 5.Department of Planetology, Graduate School of Science, Kobe University, 6.Department of Solid Earth Geochemistry, Japan Agency for Marine-Earth Science and Technology)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[MIS19-22] Rapid glaciation and sea level changes during the Last Glacial Maximum and the deglaciation

*Yusuke Yokoyama[1], Tezer M Esat[9], William G Thompson[10], Alexandar L Thomas[11], Jody W Webster[2], Yosuke Miyairi[1], Chikako Sawada[1], Takahiro AZE[1], Hiroyuki Matsuzaki[1], Jun'ichi Okuno[3], Stewart Fallon[9], Juan-Carlos Braga[12], Marc Humblet[4], Yasufumi Iryu[5], Donald C Potts[13], Kazuhiko Fujita[6], Atsushi Suzuki[7], Hironobu Kan[8] (1.Atmosphere and Ocean Research Institute, University of Tokyo, 2.University of Sydney, Australia, 3.National Institute of Polar Research, 4.Nagoya University, 5.Tohoku University, 6.University of the Ryukyus, 7.The Geological Survey of Japan, AIST, 8.Kyushu University, 9.Research School of Earth Sciences, The Australian National University, Australia, 10.Woods Hole Oceanographic Institute, USA, 11.University of Edinburgh, UK, 12.Universidad de Granada, Spain, 13.University of California Santa Cruise, USA)

Paleotemperature and precipitation history (18.1–4.5 ka) in stalagmite bulk and clumped isotopes from Hiroshima, Japan

*Hirokazu Kato[1], Shota Amekawa[1], Akihiro Kano[1]

1. Department of Earth and Planetary Science, The University of Tokyo

Variation in stalagmite $\delta^{18}O$ is basically controlled by two major factors, temperature and isotopic composition of cave dripwater derived from the local precipitation. It is however not easy to separate relative impacts from these two fundamental controls by conventional oxygen isotope alone.
A possible solution is applying carbonate clumped isotope thermometry that can reconstruct the temperature without information of the isotopic compositions of the environmental water. The principle of the clumped isotope thermometry is based on the temperature-dependency of the abundance anomaly of $^{13}C^{18}O^{16}O$ (Δ_{47}) from acid digestion of carbonate.
In this study, carbonate clumped isotope (Δ_{47}) was measured from 50 layers of Hiro-1 stalagmite from Hiroshima Prefecture by purification line and MAT 253 settled at Kyushu University. The growth interval of the stalagmite is from 18.1 to 4.5 ka and includes two hiatuses in 10.8–7.7 ka and 12.8–11.4 ka.
The Δ_{47} values of 50 layers in Hiro-1 range from 0.683 to 0.741‰, which correspond to 3.2–23.4 ºC by temperature calibration on the basis of tufa measurements (Kato *et al.*, 2019).The temperature range of each time-series is 5.2–12.5 ºC (7.4 ºC in average; 18.0–16.0 ka), 10.4–12.8 ºC (11.9 ºC in average; 15.9–14.5 ka), 3.2–9.4 ºC (6.1 ºC in average; 14.2–12.6 ka), 6.8–12.4ºC (9.2 ºC in average; 11.0–10.7 ka), 7.6–23.4 ºC (15.7 ºC in average; 7.7–4.9 ka) and 3.9–9.7 ºC (8.2 ºC in average; 4.9–4.5 ka).
The Δ_{47} temperature record from Hiro-1 is broadly consistent with already-known climatic stages. For instance, the temperature recovery from LGM, lowering around Younger-Dryas, increase into Holocene and the peak of warming around Hypsithermal. Temperature difference between LGM (18.0–16.0 ka) and mid-Holocene (7.7–4.9 ka) is 8.3 ºC. Isotopic data in the period of 15.9–14.5 ka, and also at 10.7 ka has the features from the kinetic effect, i.e., high $\delta^{18}O$ values and low Δ_{47} values comparing to the data of adjacent intervals. These intervals are characteristic in high prior calcite precipitation (PCP) of Hiro-1 stalagmite as suggested by Hori *et al.* (2013) and this shift was likely caused by some disequilibrium effect.
The $\delta^{18}O_{Hiro\text{-}1}$ profile can be corrected by subtraction of temperature effect and $\delta^{18}O_{MW}$ which represents isotopic composition of past meteoric water was obtained. The reconstructed $\delta^{18}O_{MW}$ value shows 1–2‰ rising from the last glacial period to Holocene. The shift has probably reflected an increase of summer precipitation by strengthened EASM in Holocene and the lowering of continentality by advance of Seto Island Sea.

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Keywords: stalagmite, carbonate clumped isotope, temperature reconstruction, last glacial period, Holocene, paleoclimate

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Terrestrial paleoclimate since 80 ka recorded in stable and clumped isotopes of two stalagmites obtained from the Pacific side of the Japanese islands

*Shota Amekawa[1], Hirokazu Kato[1], Akihiro Kano[1], Kenji Kashiwagi[2], Taiki Mori[3], Ryoko Senda[3], Chuan-Chou Shen[4]

1. Graduate School of Science, The University of Tokyo, 2. Graduate School of Science and Engineering for Research, University of Toyama, 3. Graduate School of Integrated Sciences for Global Society, Kyushu University, 4. Department of Geosciences, National Taiwan University

Terrestrial paleoclimate during late Quaternary has been broadly reconstructed by oxygen isotope ($\delta^{18}O$) of stalagmites. Previous studies have pointed out that stalagmite $\delta^{18}O$ is largely associated with change in $\delta^{18}O$ of meteoric water due to amount effect and shift of vapor sources, but also can be influenced by temperature change. One of solutions for evaluating the temperature effect is carbonate clumped isotope thermometer. Clumped isotopes are isotopologues in which rare isotopes are doubly or multiply substituted. In case of CO_2 generated from reaction of carbonate and phosphoric acis, the measuring target is $^{13}C^{18}O^{16}O$ (mass of 47). Previous studies have shown that measured abundance of clumped isotopes is slightly more than the stochastic abundance and its excess or "clumping" (Δ_{47}) comes from thermodynamic stability, which allows us to reconstruct temperature during carbonate precipitation only by Δ_{47} of the generated CO_2. In this study, Δ_{47} and stable isotopes are applied to two stalagmites from the Pacific side of the Japanese islands, which should not be affected by vapor from Indian Ocean and Japan Sea.
Two analyzed stalagmites (KA01 and 03) were obtained from Taiki town, Mie prefecture, Japan. 32 U-Th age points determined at National Taiwan University reveal that KA01 was dated from ca. 14 ka to ca. 1 ka and KA03 (Mori et al., 2018) was from ca. 80 ka to ca. 20 ka as well as the Holocene. $\delta^{18}O$ changes of KA01 and KA03 show similar trends with the cave records in south Chinese (e.g. Hulu cave), but the amplitude of the $\delta^{18}O$ changes was reduced in half.
Results of our Δ_{47} values require reconsideration of the previous interpretation for the Chinese stalagmite $\delta^{18}O$, dominant control by $\delta^{18}O$ of meteoric water. A reconstructed temperature at the top of KA01 is consistent with modern temperature at the cave. The whole trend of reconstructed temperature combined with $\delta^{18}O$ of modern rainfall indicates that $\delta^{18}O$ changes of KA01 are mainly controlled by temperature changes instead of rainfall $\delta^{18}O$. Δ_{47} of KA03 yields higher temperature during cool periods of Heinrich events (HE), which apparently contradicts with previous studies. Before and after HEs, the carbon isotopic value increases by 0.5–1 ‰, indicating degassing of ^{13}C-depleted CO_2 from dripwater and carbonate precipitation in the conduit of the host rock because of reduced water supply. Drying during HEs could have made the surface of the stalagmite dry and resulted in apparent contradictory temperature. This study verifies that $\delta^{18}O$ change should be used together with Δ_{47} for robust interpretation of the stalagmite records.

Keywords: clumped isotope, speleothem paleoclimatology

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Seasonal changes in Li/Ca ratio and inferred phytoplankton abundance as analyzed by daily growth increments of *Pecten albicans* (Bivalvia)

*Kondo Yasuo[1], Hondo Shutaro, Hasegawa Hitoshi[1], Nshio Yoshiro[1], Hirota Takayoshi

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To evaluate the potentials of scallop shells as paleoenvironmental archives, Li/Ca ratio and other geochemical data were obtained using LA-ICP-MS for the *Pecten albicans* specimen (KSG-th001) collected alive on April 29, 2011, from Tosa Bay, and was analyzed in relation to the seasonal changes of environmental parameters including water temperature and Chlorophyll *a* (Hirota and Ichikawa, 2012). In the analysis, fine striae on the left valve of *P. albicans*, were used as daily growth marker.
As a result, the analyzed specimen displayed overall higher rate of shell growth from spring to summer, while shell growth slowed down in fall and winter in 2010. A white band (annual ring) on the generally brown left valve corresponds to the lower rate interval of shell growth. However, another lower shell growth interval is recognized between spring (ca. 50 days) and late summer (ca. 20 days). This corresponds to the lower water temperature interval in late June and early July at 100 m depth in Tosa Bay, which is interpreted as representing upwelling associated with anticlockwise rotational current in Tosa Bay when the Kuroshio current became close to the shore.
These microgrowth patterns of the shell of *Pecten albicans* displayed a close similarity to the Li/Ca profile. Li enrichment in scallop shells is considered to have originated from the frustules of edible species in the digestive tract of scallops, and Li/Ca ratio of *P. maximus* in a bay in France was proposed as a proxy of timing and magnitude of diatom bloom (Thébault and Chauvaud, 2013). Our study confirms the validity of Li/Ca in scallop shells as a proxy of diatom bloom for different scallop species in a distant biogeographic province.
This study was performed under the cooperative research program of Center for Advanced Marine Core Research (CMCR), Kochi University Accept No.18B060 .

Keywords: Li/Ca, Pecten albicans, daily growth increment, seasonal change, plankton bloom

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Geological reconstruction of Antarctic Ice Sheet deglaciation on Soya Coast, East Antarctica since the Last Glacial Maximum

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A robust understanding of the history of ice retreat in East Antarctica since the Last Glacial Maximum (LGM) is important in order to validate ice sheet and glacial-isostatic adjustment models and to anticipate their contribution to global sea-level rise. Geomorphological studies and surface exposure dating (SED) will provide direct evidence of the timing and the history of ice retreat on coastal oases and nunatak regions in East Antarctica. Recent studies have reported retreat ages based on surface exposure dating (SED) in Skarvsnes, southern part of Soya Coast, East Antarctica. However, the history of ice retreat remains unclear, because a limited number of surface exposure ages were reported by a previous study, and the results were not interpreted based on field-based geomorphological survey In this study, we reconstruct the last history of ice retreat of the Skarvsnes based on the field-based geomorphological survey and newly obtained SED samples. As results of the field survey, we distinguish three Phase of the ice sheet retreat at the Skarvsnes. The basement rocks at the highest peak (ca. 400 masl) to ca. 250 masl area of the Skarvsnes was weathered extensively, whereas weathering of the basement rocks below ca. 250 masl was relatively weak. The extensively weathered basement rock feature is quite similar to that of the northern part of Soya Coast, where ^{14}C dating of fossil shells in the raised beaches suggests that the area had remained ice-free throughout the LGM. Therefore, the differences in weathering feature are thought to indicate the upper limit of ice sheet height at LGM at the Skarvsnes (Phase 1). In the other area of Skarvsnes, glacial striations including cross-cutting set were clearly observed. That is, the ice sheet flow direction was changed with ice sheet thickness thinning under the influence of the basement topography after the LGM (Phase 2). Eventually, the ice sheet was flowing down divided in North and South obstructed by the 362 masl mountain (Shirasuso-Yama) near the current ice sheet margin (Phase 3). Several surface exposure ages were obtained from rocks sampled at sites of different altitudes and distances from the current ice margin. These ages are consistent with the above geomorphological interpretation and it suggests that near current ice sheet margin has been exposed from ice about 9 ka. These data are almost consistent with retreat ages at Mac. Robertson Land in East Antarctica.

Keywords: Glacial geomorphology, surface exposure dating

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Os isotope record of the Quaternary seawater derived from pelagic sediment in the Lau Basin, western South Pacific Ocean, and its implications for global climate changes

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Silicate weathering on land has been considered to play an important role in controlling global climate change through the consumption of atmospheric CO_2 on long timescales (>10^6 yr). This process has been working as a negative feedback mechanism, which has prevented the Earth system from runaway warming or cooling. However, whether this system works on even shorter-term global climate changes on the timescale of 10^4–10^5 yr such as Quaternary glacial-interglacial cycles is still controversial. In order to constrain the response time of the solid earth to global climate change, we employed the marine Os isotopic ratios ($^{187}Os/^{188}Os$) as a proxy of continental weathering. The marine Os isotopic ratio reflects the relative intensity of two dominant influxes to the ocean; radiogenic continental-derived materials ($^{187}Os/^{188}Os$ = 1.0–1.4) and unradiogenic mantle-like materials (i.e. hydrothermal fluids and cosmic dust) ($^{187}Os/^{188}Os$ = ~0.12). Owing to the contrasting $^{187}Os/^{188}Os$ values between these two influxes, and short residence time of Os in the ocean (~10^4 yr), the variability in $^{187}Os/^{188}Os$ of seawater constitutes a sensitive tracer for mantle and continental input into the marine environment. By assuming that the fluxes of mantle-derived materials into the ocean were constant during the Quaternary, we can obtain the fluctuation in the intensity of continental silicate weathering on glacial-interglacial timescales from the marine Os isotope record. Here, we report the marine Os isotopic variations during the glacial-interglacial cycles derived from the pelagic sediment in the Lau Basin, western South Pacific Ocean. In the present work, we targeted metalliferous carbonate as the most suitable media preserving marine Os isotope records at the timing of deposition. This sediment is enriched in hydrothermal Fe-oxyhydroxides that absorb Os in seawater efficiently and deposits rapidly without significant contamination of detrital materials from continents. As the result, we observed a clear fluctuation of the marine $^{187}Os/^{188}Os$ value along with the glacial–interglacial cycles. Based on the marine $^{187}Os/^{188}Os$ record, we also present the fluctuation of riverine Os flux calculated by simple 1-box mass-balance modeling, and its implications for the Quaternary climate change.

Keywords: Glacial–interglacial cycle, Global warming, Osmium isotopic ratio, Carbon cycle, Hydrothermal sediment

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Rapid glaciation and sea level changes during the Last Glacial Maximum and the deglaciation

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Studying changes in rates and magnitudes of glaciations/deglaciations during the past is a key to understand global climate system. The Last Glacial Maximum (LGM), centered around 20,000 years ago, as well as period after the LGM, therefore, represents key period to investigate. Sea level observations from sites far from the former ice sheets (far-field) are well suited due to the relatively small influence of surface deformation caused by glacio-hydro-isostatic adjustments (GIA). Australian coastlines are located in such regions and were targeted in this study of sea level changes over the past 30,000 years. The sites are situated off the North Eastern and North Western coasts of Australia respectively the Great Barrier Reef (GBR) and Bonaparte Gulf. Over thirty fossil reef cores were obtained from GBR shelf edge and two transects in northern and southern sites and >1,000 radiometric dating were conducted, in combination with detailed sedimentogic and biologic studies (Yokoyama et al., 2018). GIA modeling was also conducted to deduce global mean sea level (GMSL) from relative sea level records obtained from these regions. The results show that the LGM started when GMSL abruptly dropped by about 40 metres at around 31,000 years ago. The sea level at the shelf edge of the Great Barrier Reef then dropped by around 20 metres between 22,000 and 21,500 years ago, to -118 metres below the present and similar changes are observed in Bonaparte Gulf samples. Sea level began to rise just after the full extent of the LGM, consistent with previous studies. The LGM GMSL obtained from our study is about -125 to -130 metres. Sea level records from the North Australian coasts suggest that glaciers may have behaved more dynamically during the LGM than previously thought. The GBR had been existed despite from severe environmental changes during the last 30,000 years (Webster et al., 2018).

References:
Yokoyama et al. (2018) Nature, v559, p603-607
Webster, Yokoyama et al (2018) Nature Geoscience, v11, p426-432

Keywords: Sea level, ice sheet, the last glacial maximum

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Thu. May 30, 2019 10:45 AM - 12:15 PM JST | Thu. May 30, 2019 1:45 AM - 3:15 AM UTC | 304 3F

[M-IS19] Paleoclimatology and paleoceanography

convener:Yusuke Okazaki(Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University), Akira Oka(Atmosphere and Ocean Research Institute, The University of Tokyo), Michinobu Kuwae(Center for Marine Environmental Studies), Hitoshi Hasegawa(Faculty of Science and Technology, Kochi University), Chairperson:Yusuke Okazaki

Past environmental changes and events at multi-decadal to tectonic timescale toward an understanding of Earth climate system by an integration of terrestrial and marine proxy studies and numerical modeling will be discussed. At JpGU2019, a series of presentations on present and future climate and environmental changes from paleo-perspective will be held. We welcome a variety of paleo-environmental studies from a wide range of background. We hope that this session will provide an opportunity to promote communication between participants from multidisciplinary field.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MIS19-23] Long-chain alkenediones found from marine sediments and their unsaturation ratios: key compounds to study the evolution of alkenone biosynthetic pathway?

*Satoshi Furota[1], Hideto Nakamura[2], Ken Sawada[3] (1.Department of Biogeochemistry, Japan Agency for Marine-Earth Science and Technology (JAMSTEC), 2.Faculty of Science, Osaka City University, 3.Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MIS19-24] **Geomorphic and pedogenic forcing on the distribution of organic matter from vegetation to soil- a concern for paleoenvironment studies**

*Biswajit Roy[1], Kanva Goyal[1], Prasanta Sanyal[1] (1.Indian Institute of Science Education Research Kolkata)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MIS19-25] Sea surface salinity of the Kuroshio Current along the Nansei Islands in the mid-Holocene inferred from fossil corals

*Kohki Sowa[1], Chuki Hongo[2], Kentaro Tanaka[3], Takuma Fujii[4], Saburo Sakai[1], Kosei E. Yamaguchi[6,5] (1.Japan Agency for Marine-Earth Science and Technology, 2.Ryukyu University, 3.The University of Tokyo , 4.Kagoshima University, 5.Toho University, 6.NASA Astrobiology Institute)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MIS19-26] An ocean-dynamic model for the periodic inflow of Tsushima Current in the early Holocene

*Atsuhiko Isobe[1] (1.Research Institute for Applied Mechanics, Kyushu University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MIS19-27] Centennial to millennial scale variability of the Aleutian Low and Westerly Jet during the Holocene

*Kana Nagashima[1], Naomi Harada[1] (1.Japan Agency for Marine-Earth Science and Technology, Research and Development Center for Global Change)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[MIS19-28] **Monsoon-related errors in paleotemperature estimation based on leaf margin analysis in central Japan**

*Yuqing Wang[1], Arata Momohara[1], Yongjiang Huang[2] (1.Graduate School of Horticulture, Chiba University, 2.Key Laboratory for Plant Diversity and Biogeography of East Asia, Kunming Institute of Botany, CAS)

Long-chain alkenediones found from marine sediments and their unsaturation ratios: key compounds to study the evolution of alkenone biosynthetic pathway?

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Long-chain alkenones (C_{37} to C_{39} alkenones) are characteristic compounds produced by haptophyte, and their unsaturation ratios in marine sediments have been used as a proxy for sea surface temperature (SST). Paleocenographic studies using the alkenone proxies are based on the physiological features of the modern alkenone producers such as *Emiliania huxleyi* and *Gephyrocapsa oceanica*. However, these species firstly occurred at ca. 0.29 Ma and ca. 1.85 Ma, respectively, and thus, understandings of the evolutional variations in the alkenone biosynthetic pathway is important to apply the alkenone proxies to the older age. In our recent study, $C_{38:2}$ alkenedione was found in the Miocene to Pliocene marine sediments (Furota et al., 2016). This compound was interpreted to be produced by ancient alkenone producers, because (1) the molecular structure resembles to those of the alkenones, (2) it has not been detected from the extant alkenone producers and sediments, and (3) the relative abundance of the alkenedione to alkenones were significantly higher in the older sediments. Therefore, the alkenedione presumably is a key compound to study the evolutional changes in the biosynthetic pathway of alkenones.
We analyzed the alkenones and alkenediones in the hemipelagic sediments recovered from the NE Atlantic during the IODP exp. 339 to evaluate the variations in their compositions at 100,000-year scale from the late Miocene to Pleistocene. We measured using gas chromatography–flame ionization detector (GC–FID) and GC–mass spectrometry (GC–MS) equipping with a mid-polarity capillary column (VF-200 ms). The GC analysis using the mid-polarity column makes the peak shapes sharp and achieves the well chromatographic separations in the analyses of long-chain alkenones, and thus, several recent studies applied this technique (Longo et al., 2013; Furota et al., 2016).
The long-chain alkenones and the C_{38} alkenediones were detected from all the study samples. Interestingly, the carbon numbers of the alkenediones are only C_{38} in contrast to the alkenones. Mass fragmentogram shows that the C_{38} alkenedione has a methyl-ketone and ethyl-ketone groups at the each terminals of the carbon chain. In addition to $C_{38:2}$ alkenedione as reported previously, we firstly identified tri-unsaturated ($C_{38:3}$) alkenedione in the late Pliocene–Pleistocene sediments.
The relative abundances of the C_{38} alkenediones to alkenones were significantly higher in older sediments, and gradually decreased from the Miocene to Pleistocene. These results support the interpretation that the alkenediones could be produced by the ancient alkenone producers, and imply that those producers decreased from the Miocene to Pleistocene. The unsaturation ratios of C_{38} alkenediones, defines as $C_{38:2}/(C_{38:2} + C_{38:3})$, highly correlate with the unsaturation ratios of the C_{37} alkenones ($U^{K'}_{37}$) ($R^2 = 0.85$). This fact strongly suggests that the alkenediones had a similar biological function and biosynthetic pathway related to the alkenones. Furthermore, the carbon number of alkenediones (C_{38}) is averaged one for those of alkenones (C_{37}–C_{39}), and the positions of ketone groups are equal to those of alkenones. From these results, we conclude that the C_{38} alkenedione had the similar functions with the alkenones, and might be produced by primitive alkenone biosynthetic pathway.

References

Furota et al. (2016) Org. Geochem. 101, 166–175.

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Longo et al. (2013) Org. Geochem. 65, 94-102.

Keywords: Alkenone, Alkenedione, Paleoceanography

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Geomorphic and pedogenic forcing on the distribution of organic matter from vegetation to soil- a concern for paleoenvironment studies

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1. Indian Institute of Science Education Research Kolkata

The $\delta^{13}C$ values of soil organic matter (SOM) have been used to reconstruct the abundance of C_3 and C_4 plants. However, the intimate connection of distribution of vegetation with geomorphic processes and landforms may impart different $\delta^{13}C$ value in the contemporaneous vegetation. Such variation would also get registered in the organic matter composition of the soil, with an erroneous assumption of a significant change in C_3 and C_4 abundance. Therefore, it is important to understand the effect of lateral variation in riverine geomorphic architecture and its impact on the $\delta^{13}C$ value of vegetation and soil. In this study, a lateral transect (6 km) of an undulatory geomorphic surface of north-south trending lateritic alluvium of South Bengal (India) was considered to unveil the effect of topography, and active channel distance on the contemporaneous vegetation and soil. A variation of ca. 50‰ is observed in the n-alkane H-isotopic composition (δD_{C31}) of the dominating tropical deciduous species (Sal- *Shorearo busta*). The $\delta^{18}O$ value of the groundwater and the river water was analysed to understand the source of water for the tropical trees. The D/H ratio suggests that the vegetation near the active channel was mostly influenced by the river water (enriched) and in distal areas by the groundwater (depleted). Preliminary study on the $\delta^{13}C$ values of the Sal species suggests an enrichment of ca. 7‰ away from the active river channel. The difference is attributed to the change in water-availability, canopy, topography, and vegetation density that varied along the transect. Disparity in the efficiency of water use was observed in the long chain n-alkane average chain length (ACL) and carbon preference index (CPI) distribution. The higher ACL (>29) and CPI (>2) values are mostly associated with the badlands or upland soil environment with very low moisture availability. Preservation of the contemporaneous vegetation signals in the litter layer was regulated by the geomorphology, vegetation density, and the soil texture. The upland, and the distal areas with sparse vegetation tend to preserve more positive $^{13}C/^{12}C$ ratio (−24‰) compared to the lowland with well-developed soils (−28‰). The upland and distal soils, with a coarser texture, suggests faster decomposition of OM (TOC% <0.2) due to higher percolation and soil aeration; whereas in fine-textured lowland soils depleted (−4‰) and high TOC% (>0.5) is observed. Further, due to continuous abrasion by the riverine process, the TOC is also low in the soils adjacent to the active river. The nitrogen isotopic composition ($\delta^{15}N_{SOM}$) increases as alteration/decay or leaching of SOM proceeds. The faster decomposition and microbial processing of SOM in upland and distal area soils registered higher $\delta^{15}N$ (+4‰) values whereas lower values are registered in low-lying areas. This geomorphic and pedogenic effect on the plant-soil system may result in ambiguous interpretation about the past vegetation and thus warrants detail vegetation, geomorphic and physical or chemical characterisation of the soil before employing it as a paleo-record archive.

Keywords: Vegetation, Soil organic matter, Geomorphology, Pedogenesis

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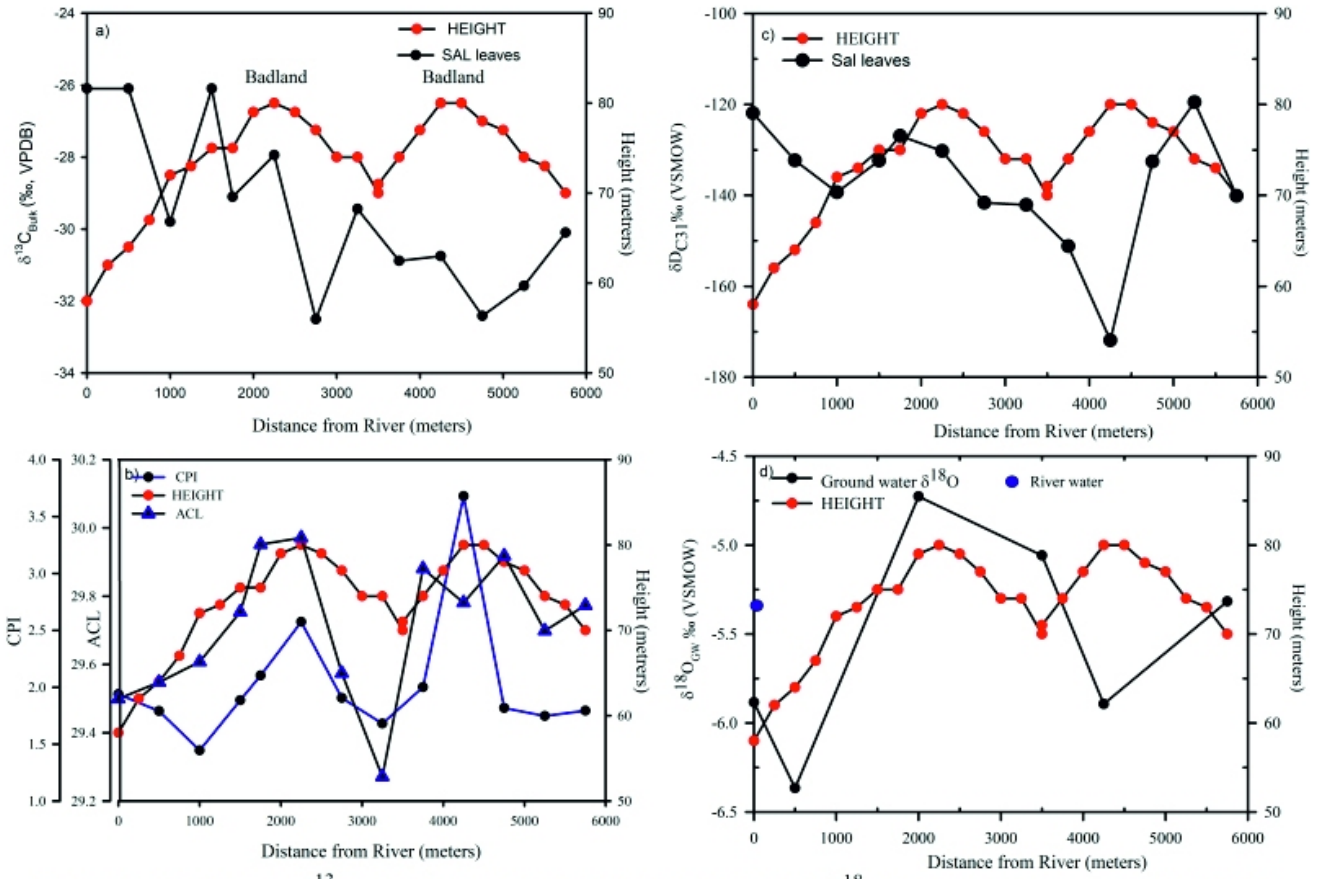


Fig. 1. Variation in the: SAL a) $\delta^{13}C_{Bulk}$, b) δD_{C31}, c)CPI and ACL value; and Groundwater $\delta^{18}O_{GW}$ value along the lateral transect of the river.

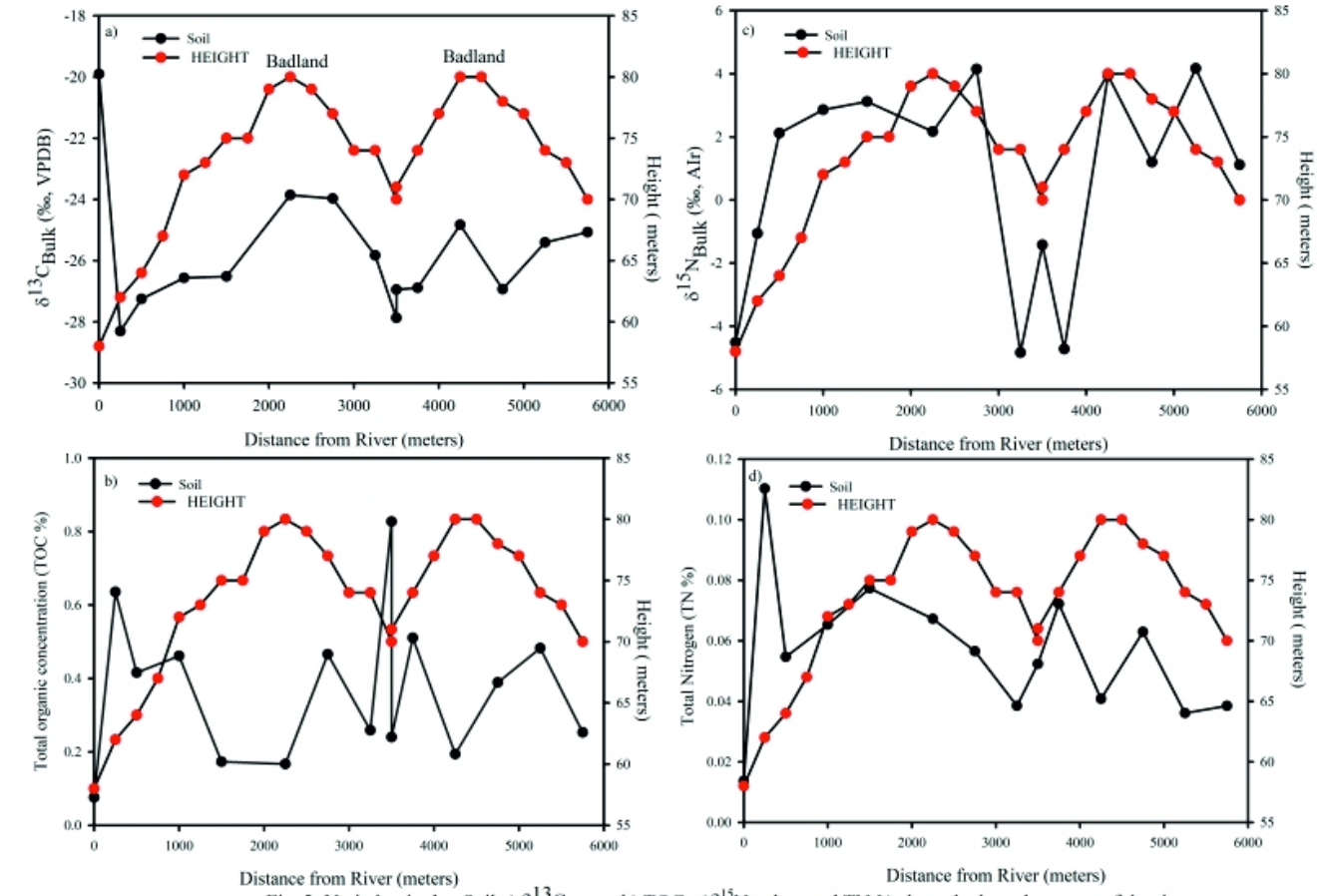


Fig. 2. Variation in the: Soil a) $\delta^{13}C_{Bulk}$, b) TOC, c)$\delta^{15}N$ value; and TN % along the lateral transect of the river.

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Sea surface salinity of the Kuroshio Current along the Nansei Islands in the mid-Holocene inferred from fossil corals

*Kohki Sowa[1], Chuki Hongo[2], Kentaro Tanaka[3], Takuma Fujii[4], Saburo Sakai[1], Kosei E. Yamaguchi[6,5]

1. Japan Agency for Marine-Earth Science and Technology, 2. Ryukyu University, 3. The University of Tokyo , 4. Kagoshima University, 5. Toho University, 6. NASA Astrobiology Institute

Sea surface salinity (SSS), which is the parameters of water mass properties, is one of the crucial tracers for reconstructing water motion and climate system. After the mid-Holocene, a period roughly from 7000 to 5000 years ago, freshening of seawater in the Western Pacific has been reported, and the cause of the salinity variation is under discussion (e.g. Stott *et al.*, 2004). The distribution of annual-mean salinity in the Northwest Pacific is space-dependent on factors such as depth, longitude, and latitude. Therefore, to understand the cause of the freshening, more constraining salinity conditions in time and space are needed. However, most research was limited to tropical areas.

The Kuroshio Current comes from the North Equatorial Current and cultivates the coral ecosystems of the subtropical, temperate area along the Nansei Islands (N24°-31°). Therefore, the Nansei Islands provide a latitudinal constraint to the paleo SSS variation. The $\delta^{18}O_{seawater}$ estimated from $\delta^{18}O$ and Sr/Ca in coral skeletons enables reconstruction of the seasonal SSS for shallow areas. Previous studies reconstruct SSS at Kuroshio Current only for Kikai Island (28°N, 130°E), which is off the main Kuroshio Current. To discuss spatial distribution of SSS during the mid-Holocene, further SSS data at different latitudes along the main Kuroshio Current area of the Nansei Islands are useful.

This study shows SSS for Okinawa Island (26°N, 128°E) and Takara Island (29°N, 129°E) during the mid-Holocene using modern and fossil coral cores. The ^{14}C age is 5400±140 cal. yr BP (Okinawa Island) from fossil *Porites* coral and 6180±180 cal. yr BP (Takara Island) from *Acropora* coral, which was collected near the coring site of the fossil *Porites* coral. For Okinawa Island, the seasonal $\delta^{18}O$ of fossil *Porites* coral (~26-year, N=1) averages -4.36‰, which is ~0.54‰ higher than that of modern coral (~5-year, N=2). XRD analysis and SEM observation imply good preservation of coral skeletons. The average extension rate > 6 mm suggests minor kinetic isotopic effect related to skeletal growth. Previous studies suggested that sea surface temperatures of the Kuroshio Current have been consistent during the past 7500 years, inferred from research on sediment cores (e.g. Lo *et al.* 2013). These imply that SSS was slightly higher in the mid-Holocene than today, at Okinawa Island. In this presentation, we will discuss SSS along the Nansei Island in the mid-Holocene using additional $\delta^{18}O$ and Sr/Ca analyses at Okinawa and Takara Island.

References

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Lo *et al.* (2013) Persistent sea surface temperature and declined sea surface salinity in the northwestern tropical Pacific over the past 7500 years. *Journal of Asian Earth Sciences* 66, 234-239.

Keywords: Salinity, Kuroshio Current, Mid-Holocene, Fossil coral, Nansei Islands

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An ocean-dynamic model for the periodic inflow of Tsushima Current in the early Holocene

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In the early Holocene, the Tsushima Current was a periodic inflow into the Sea of Japan opened to the North Pacific, and thereafter became a steady throughflow after 8,000 years from the present (Oba et al., 1991, Oba, 2006). However, we met some resistance to accept this periodic-inflow idea from ocean dynamics, because the Tsushima Current has been recognized as a linear bypass flow which separates from the subtropical gyre (Minato & Kimura, 1980). Thus, the Tsushima Current could not be a periodic flow unless the subtropical gyre had fluctuated, or unless the Tsushima Strait was periodically opened and closed to the North Pacific. We here proposed an ocean dynamic model in which a periodic inflow generated from the steady subtropical gyre by using a non-linear model based on an island rule in Kida & Qiu (2013). We demonstrate that the volume transport of the Tsushima Current has two solutions which were alternatively revealed in line with the transition of the environment which might appear around the shallow Tsushima Strait in the early Holocene.

Keywords: Tsushima Current, periodic inflow, nonlinear model

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Centennial to millennial scale variability of the Aleutian Low and Westerly Jet during the Holocene

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The Aleutian Low (AL), the semi-permanent low-pressure system located over the Gulf of Alaska, is critically linked to environmental change in the North Pacific and surrounding continental areas. At timescales that exceed the recent instrumental record of the last 100 years, the AL intensity has been reported to vary on centennial to millennial scales from various proxy records (e.g., Anderson et al., 2005, 2016; Fisher et al., 2008; Jones et al., 2014). However, the ultimate trigger of these intensity changes has not been systematically studied.

Recent meteorological records showed that the Westerly Jet (WJ) over East Asia and the North Pacific links strongly to the AL intensity and position through changes in cyclogenesis, monsoon, and storm track activity (e.g. Lau, 1998; Nakamura et al., 2002; Nakamura and Shimpo, 2004). According to Lau (1988), southward displacement of the WJ axis and associated storm track path over the North Pacific results in a southeastward shift and intensification of the AL. At longer timescales, however, the interactions between the AL and the WJ are virtually unknown. This study examines millennial- and centennial-scale linkages between the AL and WJ during the Holocene to better understand the long-term nature of their interaction. We also introduce WJ records from the Southern Hemisphere, because the WJ path in both the Northern and Southern Hemispheres trace the expansion and shrinkage of the Hadley Cell circulation, which helps to understand changes in North Pacific atmospheric circulation.

The proxy records of the AL and WJ revealed millennial-scale coupling of the AL-WJ path with weakened AL and poleward WJ shifts in both hemispheres during 7–5.2 and 2.8–1.2 ka, and an intensified AL and equatorward shift of the WJ path during 5.2–2.8 ka and 1.2 ka onward (Nagashima et al., submitted to Quaternary Research). Centennial scale AL intensification and equatorward shifts of the WJ path in both hemispheres also appeared in the proxy records. Periods of centennial and millennial-scale AL maxima and equatorward shifts of the WJ correlate well with periods of solar activity minima, suggesting solar activity has played a primary role in the generation of the atmospheric circulation changes, possibly through dynamic Hadley cell changes (Nagashima et al., submitted to Quaternary Research).

Keywords: Holocene, Aleutian Low, Westerly Jet, Solar activity

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Monsoon-related errors in paleotemperature estimation based on leaf margin analysis in central Japan

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Paleotemperature reconstruction has important implications for a better understanding of present climate change. Among various paleotemperature estimation methods, Leaf Margin Analysis is a method that has been widely used by paleobotanist. In the modern flora, former researchers found that the percentage of the species with untoothed leaf margin in total woody dicot species of a flora (untoothed%) is strongly correlated to mean annual temperature (MAT). Based on this phenomenon, equations showing relationships between untoothed% and MAT have been used in paleotemperature estimation proposed as the Leaf Margin Analysis. However, untoothed%-MAT relationships are inconsistent among different regions according to previous studies. To date, eight different untoothed%-MAT equations have been proposed for different regions, although several samples from Japan are included, these sites were only obtained from limited areas close to the Pacific Ocean. However, considering various local climate conditions caused by the complex topography in Japan along with the different influence of summer and winter monsoon, the untoothed%-MAT relationship may vary among different areas in Japan, which cannot be reflected in the formerly published equations.

In this study, we aim to detect the untoothed%-MAT relationship in woody floras of central Japan. Two research areas with different climate conditions were chosen: The Pacific Ocean coastal areas and the Sea of Japan coastal areas. Based on the climate data, the Pacific Ocean coastal areas are characterized by less snow condition and higher summer precipitation affected by the activity of the East Asian Summer Monsoon. While the Sea of Japan coastal areas are characterized by heavy snow in winter, which is formed under the influence of Tsushima warm current in the Sea of Japan with East Asian Winter Monsoon, and grown season precipitation in this zone is much lower than the Pacific Ocean coastal areas.

We found that the untoothed%-MAT relationships of the two research areas are obviously different. In the Pacific Ocean coastal areas, a significant positive untoothed%-MAT relationship was detected. Compare to the other regions of the world, floras from central Japan include more species characterized by toothed-margin leaf at a given mean annual temperature. While in deep snow areas along the Sea of Japan, the untoothed%-MAT relationship becomes unclear with the effect of deep snow cover.

According to our results, paleotemperature estimated by the Leaf Margin Analysis of Japanese fossil floras may include inadequacy. The heavy snow condition along the Sea of Japan began since the middle Early Pleistocene, thus fossil floras of interglacial stages younger than that of these areas is not suitable to do the Leaf Margin Analysis. For Japanese fossil localities from areas without thick snow cover, because the untoothed%-MAT relationship of Japanese flora deviates from other regions of the world, applying these fossil floras into the formerly published untoothed%-MAT relationships will receive inaccurate paleotemperature data.

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Thu. May 30, 2019 1:45 PM - 3:15 PM JST | Thu. May 30, 2019 4:45 AM - 6:15 AM UTC | 303 3F

[M-IS26] Arctic and Antarctic Science and Future Plan

convener:Yoshifumi Nogi(National Institute of Polar Research), Takuji Nakamura(National Institute of Polar Research), Atsuko Sugimoto(Arctic Research Center, Hokkaido University), Shin Sugiyama(Institute of Low Temperature Science, Hokkaido University), Chairperson:Tetsuo Sueyoshi(National Institute of Polar Research), Yoshifumi Nogi(National Institute of Polar Research)

This session will be a forum to discuss the scientific program and the framework of the future integrated multidisciplinary study focused on the polar regions, and to consider how a large-scale science plan for Polar Science should be formulated. One of the focus of the discussion will be on the importance in the Master Plan 2020, which will be announced by the Science Council of Japan.
The changes in the polar regions are essential for future projection of the Earth system. The Antarctic and Greenland ice sheet holds most of the ice and is the largest freshwater reservoir on the Earth, which is equivalent to about 70 m height of sea level. Moreover, dense seawater is produced in the polar regions and formed bottom water that drives the thermohaline circulation. Changes in the thermohaline circulation are considered to be a large impact on the global environment. Therefore, the polar regions are the key components that control global climate and sea level changes. However, the polar regions are still poorly unknown components in the Earth system and the systematic various field of scientific observations is required. From such background, the convener believes that polar science is one of the important topics which should be proposed to the Master Plan 2020.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MIS26-01] Antarctic Circumpolar Interdisciplinary Survey - ACIS

★Invited Papers

*Robin Elizabeth Bell[1], Kirsteen Tinto[1], Xiaojun Yuan[1] (1.Lamont Doherty Earth Observatory of Columbia University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MIS26-02] Proposal of Polar Science to Master Plan 2020

*Takuji Nakamura[1], Atsuko Sugimoto[2], Shin Sugiyama[2], Yoshifumi Nogi[1], Tetsuo Sueyoshi[1] (1.National Institute of Polar Research, 2.Hokkaido University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MIS26-03] Towards the understanding of mass balance variation of Arctic and Antarctic ice sheets

Teruo Aoki[1,2,4], Masashi Niwano[4], *Tetsuo Sueyoshi[2,3] (1.Okayama Univ., 2.National Institute of Polar Research, 3.Japan Agency for Marine-Earth Science and Technology, 4.Meteorological Research Institute)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MIS26-04] Modelling Perspective for the Past and Future tipping points of ice-sheets and climate

*Ayako Abe-Ouchi[1,2,3], Fuyuki SAITO[2], Takashi Obase[1], Ralf Greve[4], Sam Sherriff-Tadano[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.JAMSTEC, 3.NIPR, 4.Hokkaido University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MIS26-05] Prediction of sea level rise caused by ice sheet melt

*Takeshi Tamura[1], Junichi Okuno[1], Yusuke Suganuma[1], Tetsuo Sueyoshi[1], Yoshifumi Nogi[1], Takuji Nakamura[1] (1.NIPR National Institute of Polar Research)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MIS26-06] Future Research Plan in the Polar region

*Yoshifumi Nogi[1], Tetsuo Sueyoshi[1], Takuji Nakamura[1] (1.National Institute of Polar Research)

Antarctic Circumpolar Interdisciplinary Survey - ACIS

*Robin Elizabeth Bell[1], Kirsteen Tinto[1], Xiaojun Yuan[1]

1. Lamont Doherty Earth Observatory of Columbia University

Constraining how fast sea levels will rise around the globe in the coming decade requires a vastly improved interdisciplinary understanding of how the heat from the warming circumpolar ocean waters will cause rapid change in the Antarctic ice sheets. Advancing our knowledge of the rates of change requires improved observations of the ice, the ocean and the solid earth and bringing together scientists from these disciplines to address the key questions: (i) How much ice passes over the Antarctic grounding line each year? (ii) How does ocean circulation influence ice flow over the grounding line, and how will it change? And (iii) How will changes in ice mass affect sea level around the world? Like many major problems facing humans, the constraining the future rate of change of the Antarctic ice sheets is a problem that must be addressed through shared resources and coordinated science –across nations and across disciplines.

Here we present the vision of the Antarctic Circumpolar Interdisciplinary Survey that will allow us to better project future sea level rise from Antarctica. To address the questions requires data from all around the Antarctic ice sheet on the thickness of the ice entering the global oceans across the grounding line, the bathymetry surrounding the ice sheets and the dynamics of the warming ocean. Key observations cannot be obtained from space and require collaborative work on the ice sheet and the circumpolar Antarctic ocean. Together the international community has the capacity to address this question. Ongoing international efforts and technological advances have developed a wide range of capabilities for direct and remote sensing of the ice, ocean and rock around Antarctica. Understanding how much ice is flowing across the grounding line can be measured with using small aircraft based at permanent bases or field camps around the continent, long range aircraft based off continent and from drones launched form ships. The water depth close to the ice sheet can be obtained with ground-based explorations, airborne observation submersibles or gliders. Salinity and temperature are measured from a broad span of instruments, with additional sensors measuring current velocity, tidal variation and biogeochemical markers also deployed. Most oceanographic work operates from ships, but coastal sites also provide platforms for ocean observations, and profiling floats can successfully be deployed from aircraft. Like the International Polar Years and other large collaborative project this effort can serve as a future focal point for Antarctic Science through SCAR and other international programs.

Keywords: Antarctica, sea level, interdisciplinary

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Proposal of Polar Science to Master Plan 2020

*Takuji Nakamura[1], Atsuko Sugimoto[2], Shin Sugiyama[2], Yoshifumi Nogi[1], Tetsuo Sueyoshi[1]

1. National Institute of Polar Research, 2. Hokkaido University

The academic large-scale research master plan of the Science Council of Japan is a collection of large-scale research plans that should be tackled in about 10 years, regardless of the field. After the discussion during past two years, we submitted in March 2019 as a proposal to Master Plan 2020 "Prediction of sea level fluctuation caused by ice sheet fluctuation" on behalf of the polar science field.

In the "Frontier of Polar Regions Science" for masterplan 2017, we have proposed a comprehensive and interdisciplinary research plan covering important processes and data acquisition of polar regions, which records the past global environmental changes with high accuracy, having multiple tipping points and great impact on the global environment. There were some critical comments that the focus was not clear enough, and also about stractural issue whether it should be a mission of the National Institute of Polar Research or a national academic projects.

In the master plan of 2020, we have restructured the proposal from a differentiated view point from the recent Arctic environmental research and Antarctic observation projects, as a comprehensive study of the ice sheet change, by setting the future sea level change for the main outcome of the project.

In this presentation we will introduce the situation of large-scale research projects, review the efforts for masterplan of polar science so far, explain the background of examination of this proposal. The aim is to stimulate the discussion at the session and future studies. The Antarctic / Arctic is an important research field that various topics such as space and planetary science, atmospheric and ocean science, solid earth science etc. should collaborate. It is also essential to obtain public understanding on its importance by stakeholders.

Keywords: Antactic, arctic, Sea level rise

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Towards the understanding of mass balance variation of Arctic and Antarctic ice sheets

Teruo Aoki[1,2,4], Masashi Niwano[4], *Tetsuo Sueyoshi[2,3]

1. Okayama Univ., 2. National Institute of Polar Research, 3. Japan Agency for Marine-Earth Science and Technology, 4. Meteorological Research Institute

Greenland and East- and West- Antarctic ice sheets are the largest storage of fresh water on earth. The variation of these ice sheets can effect not only the sea level, but also on global climate through the modulation of the deep water formation in the ocean. The study on ice sheets have therefore a significant importance on studies and projections of global environental change.

In the Arctic, most significant signal of global warming appears by polar amplification, which results in the rapid mass loss of the Greenland ice sheet. The extreme melt event across the entire ice sheet was also observed first time ever in 2012. The cause of mass loss can be attributed to the temperature increase, albedo decrease by snow impurities, and also to the ocean wariming which induces the enhanced melt at the marginal glaciers (Box, 2013; Fettweis et al., 2013). In the Antarctic, while the West Antarctic Ice Sheet is losing its mass rapidly, the signal in the East Antarctic Ice Sheet is not yet clear (Steig et al., 2009, etc.) .

Considering such backgrounds, the following studies are needed to make a breakthrough on our understanding of the surface process of the ice sheets (Aoki, 2015): Expanding and maintenance of the AWS network, Process study by in-situ observations, Modelling efforts of physical processes such as near-surface radiation or snow metamorphose, and Development of the regional polar system model including these processes. Validation of the model performance using satellite observation is further needed. As Japanese research community already has activities on these topics, such studies on snow and ice sheets should be an effective orientation taking an advantage of ongoing research.

Keywords: Arctic, Antarctic, Ice sheet, Surface mass balance, Regional climate system model

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Modelling Perspective for the Past and Future tipping points of ice-sheets and climate

*Ayako Abe-Ouchi[1,2,3], Fuyuki SAITO[2], Takashi Obase[1], Ralf Greve[4], Sam Sherriff-Tadano[1]

1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. JAMSTEC, 3. NIPR, 4. Hokkaido University

Ice sheet volume changes are the largest potential source of sea level change in the past and future. Since ice sheets are vulnerable under climate changes, it is important to carefully understand its dynamics and identify its irreversible behaveour, and critical threshold under climate change. Here I show modeling studies that simulate the past ice sheet change as well as climate change and discuss the implication for the studies needed to understand the tipping points both in past and future.

Keywords: climate, ice sheet, modelling

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Prediction of sea level rise caused by ice sheet melt

*Takeshi Tamura[1], Junichi Okuno[1], Yusuke Suganuma[1], Tetsuo Sueyoshi[1], Yoshifumi Nogi[1], Takuji Nakamura[1]

1. NIPR National Institute of Polar Research

The polar climate system, consisting of atmosphere, ocean, and cryosphere, plays important roles in shaping the global environments through its vast exchange and storage of heat and freshwater. The accelerating ice mass loss in the Greenland and West Antarctica is a significant process affecting the global climate and the understanding of the ice-ocean interaction there is of primary importance. In contrast, the status of ice mass change in East Antarctica is still in debates. Recent studies show some fingerprints of huge mass loss in the past warming world and the ice mass loss from the glaciers including Totten Glacier in East Antarctica is increasing. However, the processes of heat supply and sequent ice-ocean interaction are poorly known for both continental ice sheets.
Now, we need to understand their individual processes in polar regions through observation and modeling, and to investigate the actual states and mechanisms of various interactions. In addition, integrated researches need to be conducted, contributing to the future projection of the global environmental change driven by the polar oceans and continental ice sheets. Toward these goals, we need to clarify the state and interactions between the ocean, ice sheet, crust, ecological system, greenhouse gases, etc. and their variations from the past to the future through the field observations and analyses of samples and conduct various kinds of modeling in cooperation with the observations.

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Future Research Plan in the Polar region

*Yoshifumi Nogi[1], Tetsuo Sueyoshi[1], Takuji Nakamura[1]

1. National Institute of Polar Research

The changes in the polar regions most likely indicate the precursor and driving force of the global environmental changes, and these changes are essential for future projection of the Earth system. The Antarctic and Greenland ice sheet that holds most of the ice is the largest freshwater reservoir on the Earth, equivalent to about 70 m height of sea level. On the other hand, dense seawater produced in the polar regions formed bottom water that drives the thermohaline circulation. Changes in the thermohaline circulation are considered to be significant impacts on the global environment. Therefore, the polar regions are the key to global climate and sea level changes. However, the polar regions are still poorly unknown components in the Earth system due to the harsh weather conditions in these areas.
The interaction among the atmosphere, ice sheet, solid earth, and the ocean is vital to understand the system in the polar regions, and the various systematic field of scientific observations is required to elucidate the interaction. The scientific program and the framework of the integrated multidisciplinary study focused on the polar regions must be developed from the viewpoints of the global climate and sea level changes. Present scientific activities and plans in the polar region are summarized, and the future integrated multidisciplinary research plans in the polar region are discussed.

Keywords: Arctic, Antarctic, ice sheet, ocean circulation, global environment

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-AG Applied Geosciences

Thu. May 30, 2019 1:45 PM - 3:15 PM JST | Thu. May 30, 2019 4:45 AM - 6:15 AM UTC | A10 TOKYO BAY MAKUHARI HALL

[M-AG39] Marine-Earth Informatics

convener:Seiji Tsuboi(JAMSTEC, Center for Earth Information Science and Technology), Keiko Takahashi(Japan Agency for Marine and Earth Science and Technology), Masaki Kanao(National Institute of Polar Research), Daisuke Matsuoka(Japan Agency for Marine-Earth Science and Technology), Chairperson:Daisuke Matsuoka, Seiji Tsuboi

In advancing the research of marine Earth science, observation and computer simulation is an essential element. In recent years, the performance of the observation apparatus is dramatically improved, along with the means of observation is diversified. It is becoming possible to observe in a resolution, which was not imaginable so far. Such data to be generated from the observation is tremendously large in quantity and its quality is drastically improved. To handle these huge and high quality dataset for data analysis, we need to have a high speed and large memory computer system but such a system now becomes within reach in our hands by the recent dramatic improvement of high performance computer system. On the other hand, researchers who can use this kind of large-scale computer in their studies are still quite limited. In this session, we try to review the situation of observation data that has undergone a dramatic change regarded with both quality and quantity in recent years of marine Earth science research. We also try to review the situation from a professional standpoint of simulation about the status of the high performance computer system to analyze these big data. Also we focus on the state of the art data analysis technique and aim to share the outlook from the professional standpoint of computational science and professional position of observation science about the future direction of the marine Earth informatics research.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MAG39-01] Future direction of Marine Earth Informatics

*Keiko Takahashi[1] (1.Japan Agency for Marine and Earth Science and Technology)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MAG39-02] Extraction method of weather informations from camera image using Deep Neural Network

*DAISUKE SUGIYAMA[1], RYO ONISHI[1], HIDENORI FUDEYASU[2] (1.Japan Agency for Marine-Earth Science and Technology, 2.Yokohama National University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MAG39-03] Automatic detection of weather front around Japan using deep convolutional neural network

*Daisuke Matsuoka[1,2], Shiori Sugimoto[1], Yujin Nakagawa[1], Fumiaki Araki[1], Shintaro Kawahara[1], Yosuke Onoue[4], Masaaki Iiyama[3], Koji Koyamada[3] (1.Japan Agency for Marine-Earth Science and Technology, 2.Japan Science and Technology Agency, 3.Nihon University, 4.Kyoto University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MAG39-04] Detection of multiple earthquakes by using theoretical seismograms as training dataset of machine learning

*Seiji Tsuboi[1], DAISUKE SUGIYAMA[1] (1.JAMSTEC, Center for Earth Information Science and Technology)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MAG39-05] Classification with imbalanced cloud data using deep convolutional neural network

*Daisuke Matsuoka[1,2], Masuo Nakano[1], Daisuke Sugiyama[1], Seiichi Uchida[3] (1.Japan Agency for Marine-Earth Science and Technology, 2.Japan Science and Technology Agency, 3.Kyushu University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MAG39-06] discussion

*Seiji Tsuboi[1] (1.JAMSTEC, Center for Earth Information Science and Technology)

Future direction of Marine Earth Informatics

*Keiko Takahashi[1]

1. Japan Agency for Marine and Earth Science and Technology

In advancing the research of marine Earth science, observation and computer simulation is an essential element. In recent years, the performance of the observation apparatus is dramatically improved, along with the means of observation is diversified. It is becoming possible to observe in a resolution, which was not imaginable so far. Such data to be generated from the observation is tremendously large in quantity and its quality is drastically improved. To handle these huge and high quality dataset for data analysis, we need to have a high speed and large memory computer system but such a system now becomes within reach in our hands by the recent dramatic improvement of high performance computer system. On the other hand, researchers who can use this kind of large-scale computer in their studies are still quite limited. In this session, we try to review the situation of observation data that has undergone a dramatic change regarded with both quality and quantity in recent years of marine Earth science research. We also try to review the situation from a professional standpoint of simulation about the status of the high performance computer system to analyze these “big data”. We focus on the state of the art data analysis technique and aim to share the outlook from the professional standpoint of computational science and professional position of observation science about the future direction of the marine Earth informatics research.

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Extraction method of weather informations from camera image using Deep Neural Network

*DAISUKE SUGIYAMA[1], RYO ONISHI[1], HIDENORI FUDEYASU[2]

1. Japan Agency for Marine-Earth Science and Technology, 2. Yokohama National University

In order to further improve precision of numerical forecasts, it is expected to utilize high-density weather information by various IoT (Internet of Things) sensor equipment networks capable of real-time acquisition via the Internet. However, the IoT sensors are installed on the ground, so we can not observe weather information in the sky simply by using the IoT sensor normally. In this study, we used artificial intelligence technology for image recognition, and worked on the development of a system that extracts cloud amount and solar radiation from images of inexpensive consumer cameras. Our method becomes possible to operate low-price camera-equipped devices as remote sensing equipment without using expensive observation equipment. The weather information extracted is not only input values for numerical simulation but also expected to be utilized in, for example, agriculture. In addition, the society of security camera network is spreading in China and others. Our method can be a fundamental technology of high-density weather observation in such society.
In this study, we first constructed a 5-layer convolutional neural network (CNN) model that predicts cloud cover amount from the image. As data to train this network, we used data labeled cloud cover on about 2,000 sky images from the Internet. The cloud cover in this study means the rate of the clouds in the sky area shown in the camera image in 11 steps from 0 to 10. On the other hand, the Japan Meteorological Agency defines the rate of the cloud region to the whole sky as the cloud amount. Attention should be paid to difference in this definition. We used the 80% data as the training data, and the remaining 20% was used for cross validation. Finally, we compared to the MSE: mean square error, of our method to the existing method. It became clear that cloud cover can be estimated with the overwhelmingly small MSE of 3.0 for this CNN, more than the existing segmentation method of 12.7.
Secondly, as training data, this model use long-term high-frequency observation data for 1 minute, observed by Yokohama National University. We chose solar radiation amount, fixed camera image in this data. The model extracts the amount of solar radiation from the sky image in the range of several tens of kilometers ahead of the fixed camera's photographing direction. With 6 years of this data, the number of images reaches max about 3 million images in one direction, and this big training data is used to train Deep Neural Network. Now, intuitively, a high brightness image tends to be considered to have a high solar radiation amount. However, consumer cameras usually have automatic brightness and contrast adjustment functions. Also, such as the slightly cloudy days are almost high brightness value. The correlation coefficient of brightness value and solar radiation, is not large. On the other hand, we can calculate the theoretical maximum solar radiation from the latitude, longitude and time of image's shooting position (Nakajima et al. 2000). Focusing on this point, we constructed a new Multimodal Deep Learning model with image + theoretical maximum solar radiation as input layers. This model estimates the attenuation value from theoretical maximum solar radiation with images of training data. It was clarified that the amount of solar radiation can be estimated with high accuracy by training this model from the image, position and time.

Keywords: Deep Learning, IoT, High-density Weather Observations

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Automatic detection of weather front around Japan using deep convolutional neural network

*Daisuke Matsuoka[1,2], Shiori Sugimoto[1], Yujin Nakagawa[1], Fumiaki Araki[1], Shintaro Kawahara[1], Yosuke Onoue[4], Masaaki Iiyama[3], Koji Koyamada[3]

1. Japan Agency for Marine-Earth Science and Technology, 2. Japan Science and Technology Agency, 3. Nihon University, 4. Kyoto University

In this study, we automatically detect stationary front from weather forecast simulation data (GPV/MSM) using U-Net deep convolutional neural network. Our U-Net trains ten years weather data (precipitation, sea level pressure, relative humidity, air temperature, and wind velocity) and the position of weather front as the ground truth. As a result of applying the trained U-Net to the untrained one year data, our approach succeeded in accurately detecting Baiu front and autumn rain front except when Typhoon occurred. Moreover, wind velocity (zonal and meridional component) and relative humidity at 1000 hPa play an important role to obtain high detection performance. Our approach is also able to apply to weather simulation data which the weather front is not associated with.

Keywords: Deep learning, Convolutional neural network, Weather front detection

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Detection of multiple earthquakes by using theoretical seismograms as training dataset of machine learning

*Seiji Tsuboi[1], DAISUKE SUGIYAMA[1]

1. JAMSTEC, Center for Earth Information Science and Technology

Earthquake Early Warning (EEW) is now routinely used for hazard mitigation purpose in various countries. One of the causes which results false alarm of EEW is earthquakes which happen concurrently in different location. On January 5th, 2018, two earthquakes with magnitude around 5, which separate about 400 km, happened concurrently in Japan and false EEW was issued by JMA. Here we combine numerically computed theoretical seismograms and deep machine learning to properly identify multiple earthquakes to avoid false alarm. We calculate theoretical seismograms for realistic three-dimensional Earth model and use these seismograms to create snapshots of seismic wave propagation images at the surface of the Earth. Then we use these snapshots as training dataset of convolutional neural network. We build neural networks to identify multiple earthquakes and found that this networks may identify multiple earthquakes with 99% accuracy. Advantage of using this approach to identify multiple earthquakes is that we may include any earthquakes in our training dataset and accuracy of hypocenter parameters can be increased by accumulating theoretical seismograms for various earthquake location and size as learning dataset of deep machine learning. We also apply this technique for determination of hypocentral parameters, such as epicenter, depth, origin time and magnitude. We have applied these networks to actual seismograms to show that this procedure works successfully to locate earthquake and determine magnitude.

Keywords: earthquake location, machine learning, synthetic seismograms

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Classification with imbalanced cloud data using deep convolutional neural network

*Daisuke Matsuoka[1,2], Masuo Nakano[1], Daisuke Sugiyama[1], Seiichi Uchida[3]

1. Japan Agency for Marine-Earth Science and Technology, 2. Japan Science and Technology Agency, 3. Kyushu University

Image classification using deep convolutional neural network is effective technique to detect extreme phenomenafrom climate data. However, the number of extreme phenomena such as tropical cyclone (TC) is overwhelmingly small compared with others. It is knon that classification performance decline du to this imbalance between positive (TCs) and negative examples (non-TCs). In the present study, we developed a new negative data selection method for binary classification for cloud images. We analyze the relationship between the ease of classification and the characteristics of data, and optimize the training data in order to decrease the false alarm ratio (FAR). As the results, we succeeded in decrease FAR from 32.8–53.4% to 60.0–70.0% in the western North Pacific in the period from July to November.

Keywords: Deep learning, Classification, Tropical cyclone

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discussion

*Seiji Tsuboi[1]

1. JAMSTEC, Center for Earth Information Science and Technology

Discuss current and future direction of Marine Earth Informatics.

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-AG Applied Geosciences

Thu. May 30, 2019 3:30 PM - 5:00 PM JST | Thu. May 30, 2019 6:30 AM - 8:00 AM UTC | A10 TOKYO BAY MAKUHARI HALL

[M-AG39] Marine-Earth Informatics

convener:Seiji Tsuboi(JAMSTEC, Center for Earth Information Science and Technology), Keiko Takahashi(Japan Agency for Marine and Earth Science and Technology), Masaki Kanao(National Institute of Polar Research), Daisuke Matsuoka(Japan Agency for Marine-Earth Science and Technology), Chairperson:Seiji Tsuboi, Daisuke Matsuoka

In advancing the research of marine Earth science, observation and computer simulation is an essential element. In recent years, the performance of the observation apparatus is dramatically improved, along with the means of observation is diversified. It is becoming possible to observe in a resolution, which was not imaginable so far. Such data to be generated from the observation is tremendously large in quantity and its quality is drastically improved. To handle these huge and high quality dataset for data analysis, we need to have a high speed and large memory computer system but such a system now becomes within reach in our hands by the recent dramatic improvement of high performance computer system. On the other hand, researchers who can use this kind of large-scale computer in their studies are still quite limited. In this session, we try to review the situation of observation data that has undergone a dramatic change regarded with both quality and quantity in recent years of marine Earth science research. We also try to review the situation from a professional standpoint of simulation about the status of the high performance computer system to analyze these big data. Also we focus on the state of the art data analysis technique and aim to share the outlook from the professional standpoint of computational science and professional position of observation science about the future direction of the marine Earth informatics research.

3:30 PM - 3:50 PM JST | 6:30 AM - 6:50 AM UTC

[MAG39-07] Farmed fish management: integration of observation and simulation

★Invited Papers

*Haruka Nishikawa[1] (1.Japan Agency for Marine-Earth Science and Technology)

3:50 PM - 4:05 PM JST | 6:50 AM - 7:05 AM UTC

[MAG39-08] **Q-factor estimation for Greenland ice sheet using 3-D seismic waveform modeling**

*Genti Toyokuni[1], Hiroshi Takenaka[2], Masanao Komatsu[2], Ryota Takagi[1], Masaki Kanao[3], Seiji Tsuboi[4] (1.RCPEVE, Tohoku Univ., 2.Okayama Univ., 3.NIPR, 4.JAMSTEC)

4:05 PM - 4:20 PM JST | 7:05 AM - 7:20 AM UTC

[MAG39-09] CLCL: CAVELib Compatible Library for Head-mounted Displays

*Shintaro Kawahara[1] (1.Japan Agency for Marine-Earth Science and Technology)

4:20 PM - 4:35 PM JST | 7:20 AM - 7:35 AM UTC

[MAG39-10] Super-Resolution Simulation for Real-Time Prediction of Urban Micrometeorology

*Ryo Onishi[1], DAISUKE SUGIYAMA[1], Keigo Matsuda[1] (1.Japan Agency for Marine-Earth Science and Technology)

4:35 PM - 4:50 PM JST | 7:35 AM - 7:50 AM UTC

[MAG39-11] Proposal of adaptation measures for the anthropogenic heat release to improve the summer heat environment in a district

*Toru Sugiyama[1], Xiaoran Tong[2], Satoshi Yoshida[2], Satoru Sadohara[2] (1.Japan Agency for Marine-Earth Science and Technology Center for Earth Information Science and Technology, 2.Yokohama National Univercity Institute of Urban Innovation)

4:50 PM - 5:00 PM JST | 7:50 AM - 8:00 AM UTC

Discussion

Farmed fish management: integration of observation and simulation

*Haruka Nishikawa[1]

1. Japan Agency for Marine-Earth Science and Technology

Since the natural fish resource is constantly decreasing, the importance of fish farming further increases. However, the technique is still depending on the skill of artisans. The feed quantity is determined by looking. Is it truly the best feed quantity? I plan to develop a fish growth simulation model based on observation and to estimate the best feed quantity by using its simulation. This technique will reduce labor cost and enhance the new entry. I will discuss the future fish farming system that is developed by an integration of observation and simulation.

Keywords: Fish farming

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Q-factor estimation for Greenland ice sheet using 3-D seismic waveform modeling

*Genti Toyokuni[1], Hiroshi Takenaka[2], Masanao Komatsu[2], Ryota Takagi[1], Masaki Kanao[3], Seiji Tsuboi[4]

1. RCPEVE, Tohoku Univ., 2. Okayama Univ., 3. NIPR, 4. JAMSTEC

In and around Greenland, 33 seismographs are now in operation by the project “GLISN” (Greenland Ice Sheet Monitoring Network) as an international cooperation with 11 countries. Since the initiation of this project in 2009, broadband and continuous seismic waveform data have been accumulating, and data analyses using seismic interferometry have actively been conducted. For example, Toyokuni et al. (2018) detected a Rayleigh-wave phase-velocity changes over 4.5 years beneath 90 station pairs throughout Greenland, and suggested that the thermal condition (freezing or melting) of the ice-sheet base might be detected using the pattern of the velocity changes. However, the seismic interferometry is a method based on the assumption that the cross-correlation of noise waveforms from two stations yields Green’s function between them, when averaged over a long period. However, it is suggested that this assumption sometimes fails due to inhomogeneous distribution of noise sources, etc.

This study first aims to investigate whether this assumption holds for the cross-correlation waveforms from GLISN stations using 3-D seismic waveform modeling. Furthermore, we estimate the seismic Q factors of the ice sheet which explains observations the best, by performing computations several times with different structural parameters.

The scheme we used for the 3-D modeling is “Quasi-Cartesian FDM” proposed by Takenaka et al. (2017). It numerically solves 3-D elastodynamic equation by the finite-difference method (FDM), taking into account the earth's curvature, topography, sea water layer, and 3-D structures of density, seismic wavespeeds, and attenuation. We used realistic ice sheet / basal rock topography data (ETOPO 1) and 3-D crustal / mantle structures (Crist 1.0). We used FX10 Supercomputer System in Univ. Tokyo (216 nodes, 432 processor, 8 threads).

The results are as follows:
(1) The cross-correlation waveforms obtained by the seismic interferometry show good agreement with synthetic Green’s functions for almost all the pairs, showing validity of the seismic interferometry on this region.
(2) Computations with various Q factors of the ice sheet revealed that (Qp, Qs) = (20, 20) explains the cross-correlation waveforms the best. This is the first example that the high attenuation characteristic of the ice sheet is confirmed for long propagation distance (>100 km).

References:
Takenaka, H. et al. (2017) EPS, 69, 67.
Toyokuni, G. et al. (2018) PEPI, 277, 81-98.

Keywords: Q factor, Greenland ice sheet, 3-D seismic waveform modeling, finite-difference method (FDM)

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CLCL: CAVELib Compatible Library for Head-mounted Displays

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Head-mounted displays (HMDs) are becoming a practical platform for three-dimensional scientific visualization. To reuse existing software assets that have been developed for CAVE-type VR systems (CAVEs), I developed a C++ library called "***CLCL*** (CAVELib Compatible Library)" for porting the application software for CAVEs to HMDs. CLCL emulates the function calls of CAVELib, which is a commercial library for developing application software executable on CAVEs, and it enables us to easily port CAVELib application software to HMDs with minor modifications to the original source code. Executable files built using CLCL are able to launch on major HMDs which are Oculus Rift, HTC VIVE and Windows Mixed Reality devices. Sharing the source code also leads to an improvement in the VR software development efficiency, which is executable on both CAVEs and HMDs.

Keywords: Scientific visualization, Virtual reality, Software development

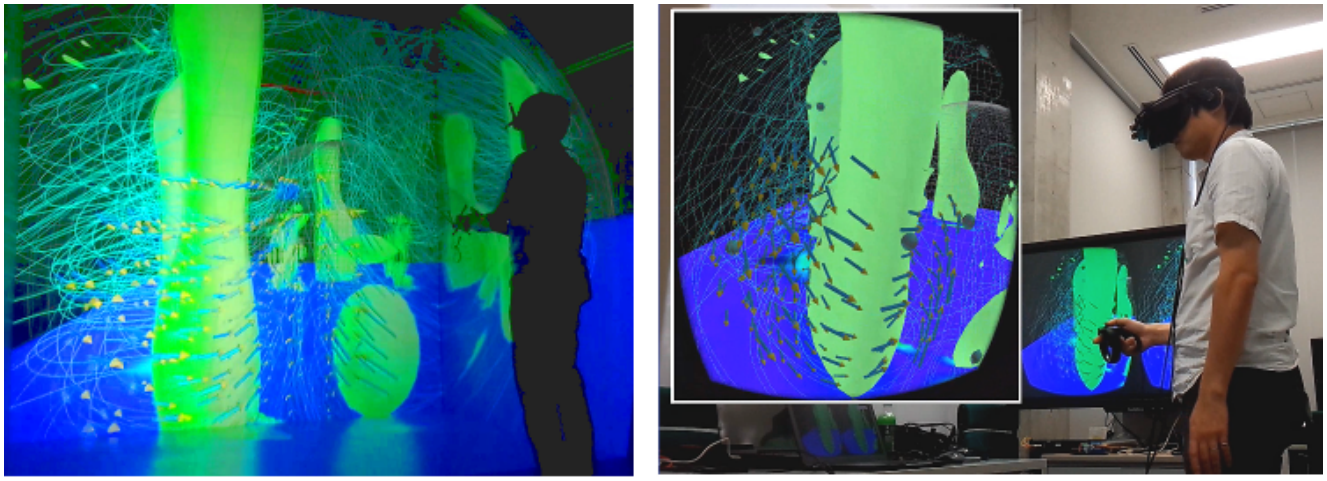


Fig.1 A CAVELib program executed on VR devices.
(Left: CAVE, Right: HMD)

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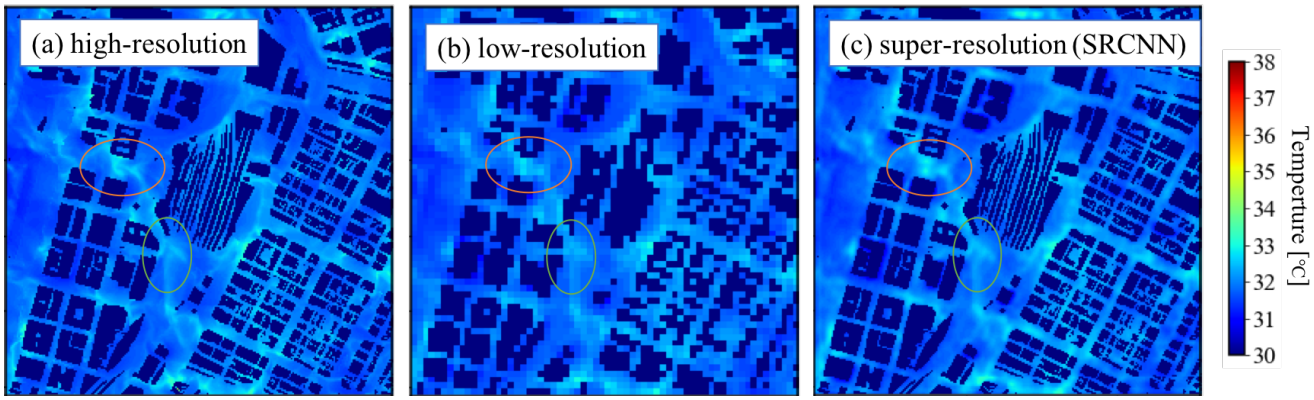
Super-Resolution Simulation for Real-Time Prediction of Urban Micrometeorology

*Ryo Onishi[1], DAISUKE SUGIYAMA[1], Keigo Matsuda[1]

1. Japan Agency for Marine-Earth Science and Technology

We propose a super-resolution (SR) simulation system that consists of a physics-based meteorological simulation and an SR method based on a deep convolutional neural network (CNN). The CNN is trained using pairs of high-resolution (HR) and low-resolution (LR) images created from meteorological simulation results for different resolutions so that it can map LR simulation images to HR ones. The proposed SR simulation system, which performs LR simulations, can provide HR prediction results in much shorter operating cycles than those required for corresponding HR simulation prediction system. We apply the SR simulation system to urban micrometeorology, which is strongly affected by buildings and human activity. Urban micrometeorology simulations that need to resolve urban buildings are computationally costly and thus cannot be used for operational real-time predictions even when run on supercomputers. We performed HR micrometeorology simulations on a supercomputer to obtain datasets for training the CNN in the SR method. It is shown that the proposed SR method can be used with a spatial scaling factor of 4 and that it outperforms conventional interpolation methods by a large margin. It is also shown that the proposed SR simulation system has the potential to be used for operational urban micrometeorology predictions.

Keywords: super-resolution, deep learning, building-resolving urban micrometeorology, multi-scale data assimilation, IoT



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Proposal of adaptation measures for the anthropogenic heat release to improve the summer heat environment in a district

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1. Japan Agency for Marine-Earth Science and Technology Center for Earth Information Science and Technology, 2. Yokohama National Univercity Institute of Urban Innovation

As release technique of the anthropogenic exhaust heat, we propose following cases to produce comfortable districts in the forthcoming climate change era. We have performed numerical simulations to compare the thermal conditions quantitatively.

Keywords: Thermal environment, Numerical simulations, Anthropogenic heat, Energy local production for local consumption, Earth Simulator, MSSG model

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-TT Technology & Techniques

Thu. May 30, 2019 10:45 AM - 12:15 PM JST | Thu. May 30, 2019 1:45 AM - 3:15 AM UTC | 202 2F

[M-TT49] Brand-new scope of coupling geophysics being established by infrasound and associated waves

convener:Masa-yuki Yamamoto(Department of systems engineering, Kochi University of Technology), Mie Ichihara(Earthquake Research Institute, University of Tokyo), Nobuo Arai(Disaster Mitigation Research Center, Nagoya University), Chairperson:Masa-yuki Yamamoto(Kochi University of Technology), Hiroaki Saito(Kochi University of Technology)

Infrasound and associated wave studies are recently focused on coupling waves with long-distance and vertical propagation characteristics. Such kinds of waves, having with coupling process between the atmosphere and the surface of ground and ocean, are linked with elastic waves in lithosphere and oceanic sphere, as well as to atmospheric regions up to the upper atmosphere, playing a role of generating many kinds of wavelike turbulences in thermosphere. Moreover, whole on the globe, these waves excited depending on the latitude regions, as well as on the environmental regions, such as snow ice, desert, rainforest, mountain, ocean, etc., have their own characteristics. These waves can be excited by large-scale geophysical events like volcanic eruptions, tsunami, thunderstorms, etc. as well as artificial explosions, propagating with long distance. In this session, we would like to discuss such "coupling geophysics" by using many new or well-known investigated data and simulations of infrasound and associated low frequency waves. It can combine multiple spheres in geophysics and bring a brand-new scope of geophysics. Your contributions from many regions are welcome!

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MTT49-01] A two-step amplification mechanism of infrasound waves in the ocean-atmosphere system

★Invited Papers

*Hiroyuki Shinagawa[1] (1.National Institute of Information and Communications Technology)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MTT49-02] Propagation of infrasound generated by an explosive eruption of Mt. Shinmoedake on 10 March 2018

*Hiroaki Saito[1], Tetsuo Yamamoto[2], Masa-yuki Yamamoto[1] (1.School of Systems Engineering, Kochi University of Technology, 2.Hokkaido University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MTT49-03] Infrasound observations of atmospheric disturbances due to a sequence of 2018 explosive volcano eruptions in Japan.

*Mario Batubara[1], Masa-yuki Yamamoto[1], Saito Hiroaki[1] (1.Kochi University of Technology)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MTT49-04] Comparison of seismic waveforms observed by co-located seismometer and barometer installed indoors 2nd report

*Makiko Iwakuni[1], Nobuo Arai[2], Takayuki Otsu[1], Masashi Motohashi[1], Toyomi Sakamoto[1], Takanari Fujii[1], Ryohei Emura[1], Mami Nogami[1], Takahiko Murayama[1], Takuma Oi[3] (1.Japan Weather Association, 2.Disaster Mitigation Research Center, Nagoya University, 3.Toho Mercantile co., Ltd.)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MTT49-05] Ionospheric disturbances associated with typhoons and a tornado observed by HF doppler sounding

★Invited Papers

*Hiroyuki Nakata[1], Ryuichi Mashiko[1], Hiroyo Ohya[1], Toshiaki Takano[1], Keisuke Hosokawa[2], Ichiro Tomizawa[3], Hiromichi Nagao[4] (1.Graduate School of Science and Engineering, Chiba University, 2.Graduate School of Communication Engineering and Informatics, the University of Electro-

Communications, 3.Center for Space Science and Radio Engineering, the University of Electro-Communications, 4.Earthquake Research Institute, the University of Tokyo.)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[MTT49-06] Two-year infrasound monitoring by using a prefectural-level sensor network in Kochi

*Masa-yuki Yamamoto[1] (1.Department of systems engineering, Kochi University of Technology)

A two-step amplification mechanism of infrasound waves in the ocean-atmosphere system

*Hiroyuki Shinagawa[1]

1. National Institute of Information and Communications Technology

It is widely recognized that atmospheric acoustic waves (infrasound waves) are generated by seismic waves, propagating upward up to the upper atmosphere. The amplitude of seismically excited acoustic waves in the thermosphere is about 10^4 –10^5 times larger than the amplitude of seismic waves on the ground [Shinagawa et al., 2013; Maruyama and Shinagawa, 2014]. In the ocean, compressibility of water becomes important for seismic waves with a period of 10 seconds or less, and acoustic waves are generated by sudden motion at the sea bottom, propagating upward up to the sea surface. Resonance of the acoustic wave in the vertical direction can occur depending on the period of the acoustic wave, and can result in large oscillations at the sea surface. Previous theoretical studies suggest that the amplitude of sea surface oscillation at resonant frequencies could reach about 100 times larger than the sea bottom oscillation [Williams and Guo, 1991; Izumiya et al., 1996]. The large amplitude oscillation driven by resonant acoustic waves generate atmospheric acoustic waves, which propagate upward into the upper atmosphere, resulting in the amplitude of acoustic waves of about 10^6 –10^7 times larger than the sea bottom oscillation. Therefore, oscillations of micrometer amplitudes at the sea bottom become meter-order oscillations in the thermosphere, and may generate significant variations in the ionosphere. In this talk, I will discuss and present possible effects of the resonant amplification of acoustic waves in the ocean on the upper atmosphere.

References

(1) Shinagawa, H., T. Tsugawa, M. Matsumura, T. Iyemori, A. Saito, T. Maruyama, H. Jin, M. Nishioka, and Y. Otsuka, A simulation study of ionospheric variations in the vicinity of the epicenter of the Tohoku-oki earthquake on 11 March 2011, Geophys. Res. Lett., 40, 5009–5013, doi:10.1002/2013GL057627, 2013.
(2) Maruyama, T., and H. Shinagawa, Infrasonic sounds excited by seismic waves of the 2011 Tohoku-oki earthquake as visualized in ionograms, J. Geophys. Res. Space Physics, 119, doi:10.1002/2013JA019707, 2014.
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(4) Williams, J. E., and Guo, Y. P., Standing waves on a compressible ocean, in "Mathematical Approach in Hydrodynamics" edited by Touvia Miloh, 128-138, 1991.

Keywords: acoustic waves, ocean-atmosphere system, amplification, resonance, ionospheric variation

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Propagation of infrasound generated by an explosive eruption of Mt. Shinmoedake on 10 March 2018

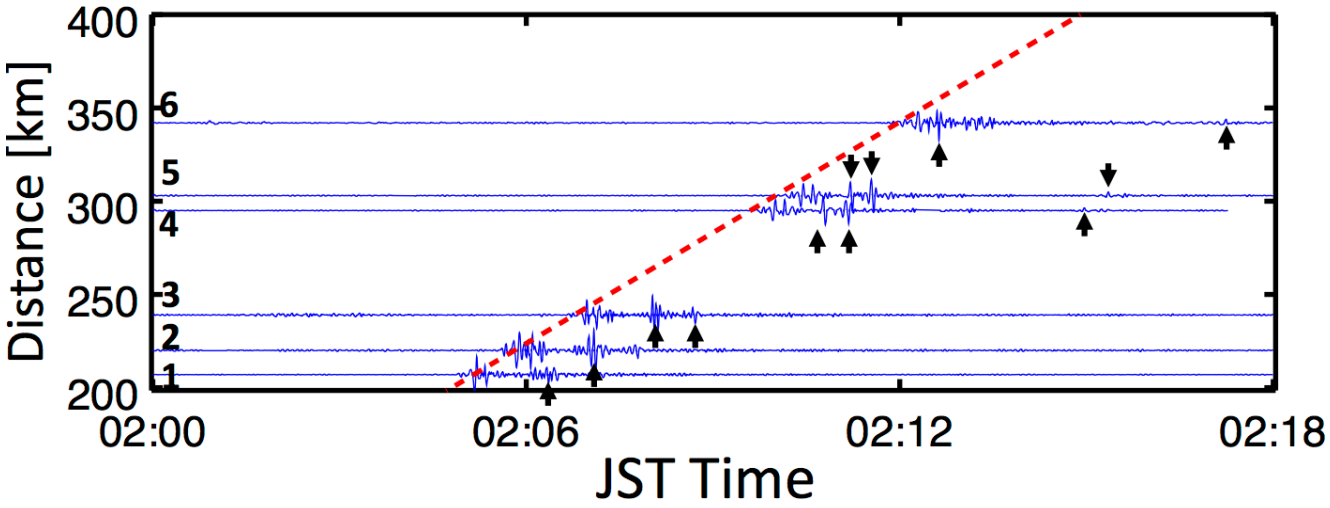
*Hiroaki Saito[1], Tetsuo Yamamoto[2], Masa-yuki Yamamoto[1]

1. School of Systems Engineering, Kochi University of Technology, 2. Hokkaido University

Mt. Shinmoedake is a part of the Mt. Kirishima cluster of volcanoes in Kyushu Island, Japan. It is located at 31.54 N, 130.53 E and its elevation is 1412 m. Explosive eruptions were observed more than 40 times in March 2018. In these events, air vibrations stronger than 100 Pa were observed several times at an air vibration sensor installed by Japan Meteorological Agency at the site within ~3 km from Mt. Shinmoedake. We focus on the explosive eruption at 1:54 (JST) on 10 March 2018. This event is the most significant air vibration (~272 Pa) observed on 10 March 2018. The infrasound sensors in Shikoku Island deployed by Kochi University of Technology detected the infrasound signals from Mt. Shinmoedake. We detected major signals three times at each of the sites 1 to 3, and four times at each of the sites 4 to 6.

We developed a new formulation for three-dimensional wave propagation in a stratified atmosphere and apply it to the analysis of the detected signals. The present formulation is based on the dispersion relation of the wave, which corresponds to Hamiltonian in particle mechanics, and Hamilton equations describing time variations of group velocity of the wave and wavevector. We adopt the dispersion relation $\omega = c_s k + \boldsymbol{u} \cdot \boldsymbol{k}$, where ω is angular frequency of the wave, c_s is sound speed, $\boldsymbol{k}$ is the wavevector, and $\boldsymbol{u}$ is wind velocity. Using the vertical temperature profiles provided by NRL-MSISE00(Picone et al., 2002) and the zonal and meridional wind profiles by HWM14 (Drob et al., 2015), we made ray tracing of the waves emitted at the explosive eruption observed on 10 March 2018. We show results of the ray tracing calculations and compare them with the signals detected by our infrasound sensors deployed in Shikoku Island(see the figure). Discussion is given on the origin and nature of the observed signals.

Keywords: infrasound, ray tracing, volcanic eruption



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Infrasound observations of atmospheric disturbances due to a sequence of 2018 explosive volcano eruptions in Japan.

*Mario Batubara[1], Masa-yuki Yamamoto[1], Saito Hiroaki[1]

1. Kochi University of Technology

In this opportunity, we describe our quantitaive approach for investigating the potential atmospheric effects caused by a sequence of Japanese volcano eruptions in 2018. We used data from a number of infrasound sensors located on Shikoku Island, Japan, to detect the long wave traveling air disturbances likely to have been caused by the explosive eruptions of the volcano. We then identified certain characteristic signatures of the disturbances in individual infrasound pressure records. Based on their arrival times, we have found that the overall propagation speed of the disturbances is in the range of standard sound propagation in the atmospheric boundary layer.

Keywords: Infrasound, propagation speed, irregular array processing

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Comparison of seismic waveforms observed by co-located seismometer and barometer installed indoors 2nd report

*Makiko Iwakuni[1], Nobuo Arai[2], Takayuki Otsu[1], Masashi Motohashi[1], Toyomi Sakamoto[1], Takanari Fujii[1], Ryohei Emura[1], Mami Nogami[1], Takahiko Murayama[1], Takuma Oi[3]

1. Japan Weather Association, 2. Disaster Mitigation Research Center, Nagoya University, 3. Toho Mercantile co., Ltd.

Surface vertical vibration due to earthquake is considered to excite sound, and it has been observed by barometer or microphone. Recorded pressure change response to seismic ground motion is considered to be due to difference of gravitational pressure observed by barograph moving up and down, air vibration (compressional wave) excited by earthquake ground motion around barograph, and internal mechanical response to acceleration by earthquake.

We started observation with co-located seismometer and barometer in Isumi, Chiba-prefecture (I30JP in The IMS Infrasound Network of CTBTO). This time one of barometer's port is close. A magnitude 4.5 earthquake occurred off south of Chiba-prefecture at a depth 44km. The seismic intensity scale in Isumi was 2. The port open barometer recorded pressure change due to the earthquake. Whereas, the port close barometer did not record pressure change due to the earthquake. It seems that the gravitational pressure change and barometer's internal mechanical response is very little at the seismic intensity 2 earthquake.

Keywords: Barometer, Seismometer, Barometer's Internal Mechanical Response by Earthquake

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Ionospheric disturbances associated with typhoons and a tornado observed by HF doppler sounding

*Hiroyuki Nakata[1], Ryuichi Mashiko[1], Hiroyo Ohya[1], Toshiaki Takano[1], Keisuke Hosokawa[2], Ichiro Tomizawa[3], Hiromichi Nagao[4]

1. Graduate School of Science and Engineering, Chiba University, 2. Graduate School of Communication Engineering and Informatics, the University of Electro-Communications, 3. Center for Space Science and Radio Engineering, the University of Electro-Communications, 4. Earthquake Research Institute, the University of Tokyo.

It is reported that ionospheric disturbances are excited in association with natural hazards, such as earthquakes, volcanic eruptions, because the atmospheric waves generated by these natural hazards propagate upward to the ionosphere. Although the extreme weather events, such as typhoons and tornados, also excite the strong atmospheric waves, the ionospheric disturbances associated with these extreme events are not fully examined. In this study, therefore, we have examined ionospheric disturbances associated with typhoons and a tornado using HF doppler sounding system (HFD) and wind data observed by AMeDAS data provided by Japan Meteorological Agency.
We have examined the ionospheric disturbance associated with a tornado occurred on May 5, 2012 which is the largest event in Japan. The fluctuations of Doppler shifts were observed and the spectral intensities at the frequencies of 5-20 mHz were enhanced. However, the ionospheric fluctuations continued after the disappearance of the tornado. The enhancement of the doppler shift had a good correlation with a wind speed below the ground of the reflection point.
The ionospheric disturbances associated with typhoons were also correlated with the wind speed on the ground. Examining typhoons that come closer to Japan in 2013-2017, it is found that spectral intensities of the disturbances of HFD data at the frequencies from 5 mHz to 45 mHz were enhanced. The frequencies of the atmospheric disturbances observed on the ground were also the same as those of HFD disturbances. The spectral intensities of HFD and atmospheric disturbances are proportional to each other and the correlation coefficient between them is larger for higher-frequency disturbance.
From these results, the ground weather condition, especially wind data, is very important to examine the mechanism of the ionospheric disturbances associated with these extreme weather events.

Keywords: ionospheric disturbance, typhoon, tornade, infrasound wave, neutral wind

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Two-year infrasound monitoring by using a prefectural-level sensor network in Kochi

*Masa-yuki Yamamoto[1]

1. Department of systems engineering, Kochi University of Technology

Infrasound, known as pressure waves in atmosphere with its frequency lower than the human audible limit of 20 Hz, can be used as one of the useful remote-sensing methods for atmospheric phenomena especially for large geophysical events such as tsunami, volcanic eruptions, typhoons, etc. In order to construct a dense sensor network in a model region for testing such capabilities and confirming noise level at each site on ground, an infrasound observation network has been installed in Kochi prefecture since 2016, taking account mainly for tsunami disasters. As for the pilot arrangement, we installed 5 sensors in Kuroshio Town in west part of Kochi pref. with a separation of about 2 and 8 km, making two-sized triangle arrays there. Then in 2017, 10 more sensors were added on wider area in whole of prefecture, constructing 25 km scale arrayed deployment in 2 cape areas of Muroto and Ashizuri.
During two years since the sensor network establishment, we have been tested the capability of remote-sensing by using as much as the observed datasets with comparing with the other observations of weather, seismic, optical measurements operated by the other research institutes/agencies.
Tsunami is one of the most dangerous geophysical phenomena for human life and the Japanese originated word of TSUNAMI shows Japan is one of the most dangerous regions for tsunami disasters in the world. Kochi prefecture is located in Shikoku island along its southern coast, namely, in Kochi pref., we have many dangerous sites of tsunami invasion once a huge earthquake happens in Nankai Trough in the pacific ocean. However, in normal situation, no such signals can be detected when we can live there safely from tsunami. We do not need such disaster anymore, but without having phenomena, we cannot check the disaster-mitigation performance in reality.
Thus, we have to investigate the capability of infrasound sensing by using the other geophysical/artificial phenomena such as typhoons, volcanic eruptions, thunders, fireballs (large meteors), and rocket launches. As it is one of the densest infrasound observation networks in prefecture-level area in a nation, we need another analyzing method than that applied for usual arrayed infrasound sensors. Therefore, we tried to develop some methods for getting information from the infrasound datasets, to be useful for future alert system for disaster mitigation.
Recently, multiple typhoon passages, multiple eruption signals from a few volcanoes in Kyushu area, and a bright fireball seen over shikoku island on Jan. 3, 2019 were successfully detected by multiple sensors. In this talk, we will introduce the sensor network in Kochi as a model case and the obtained datasets in consideration of geophysical phenomena.

Keywords: Infrasound, Sensor network, Remote sensing

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