Sat. Jun 5, 2021

[J] Oral | U (Union)：Union

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Ch.01 Zoom Room 01

[U-14] Current status and issues of the earth education necessary for living on the changing earth

convener:Hiroshi Ichikawa, Saori Nakai(kyoto koka womens university department of child education), Hidenori Kumagai(Japan Agency for Marine-Earth Science and Technology), Hiroshi Nishi(The Center for Academic Resources and Archives, The Tohoku Museum Tohoku University), Chairperson:Hiroshi Ichikawa(None)

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

[U14-01] The Essentials of Living on a Changing Planet

★Invited Papers

*Hiroshi Nishi[1] (1.Fukui Prefectural University, Institute of Dinosaur Research)

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

[U14-02] **Variations in the promotions of high schools offering Basic and Advanced Earth Science classes in Prefectures throughout Japan**

★Invited Papers

*Hideo Takagi[1], Kohei Yoshida[2] (1.Department of Earth Science, Faculty of Education and Integrated Arts and Sciences, Waseda University, 2.Higashi Fukuoka High School)

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

[U14-03] Global-Earth education in geography of high school

★Invited Papers

*Yoshiyasu Ida[1] (1.Faculty of Human Sciences,University of Tsukuba)

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

[U14-04] How to support elementary, junior high and high school teachers who are not familiar with Earth Science

★Invited Papers

*Hiroyuki Hoshi[1] (1.Department of Earth Sciences, Aichi University of Education)

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

[U14-05] Issues raised at the meeting for exchanging Information on the Earth Science Education in High Schools

★Invited Papers

*Iwata Makoto[1], Iida Kazuya[2], Satoshi Miyajima[3] (1.Hiroshima Prefectural Ogaki High School, 2.Komaba-Toho Junior and Senior High School, 3.Saitama Prefectural Kumagaya High School)

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

[U14-06] Discussion on the current status and issues of the earth education

★Invited Papers

*Hiroshi Ichikawa[1], Saori Nakai[2], Hidenori Kumagai[3], Hiroshi Nishi[4] (1.Education Committee, JpGU, 2.Kyoto Koka Women's University, 3.Japan Agency for Marine-Earth Science and Technology, 4.Fukui Prefectural University)

[J] Oral | U (Union)：Union

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Ch.01 Zoom Room 01

[U-15] JpGU's mission against giant earthquake and tsunami disasters: last 10 years and the future

convener:Koji Okumura(Graduate School of Letters, Hiroshima University), Yoshinori MIYACHI(Geological Survey of Japan, AIST), Hitoshi SAITO(College of Economics, Kanto Gakuin University), Chairperson:Koji Okumura(Graduate School of Letters, Hiroshima University), Yoshinori MIYACHI(Geological Survey of Japan, AIST), Hitoshi SAITO(College of Economics, Kanto Gakuin University)

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

[U15-01] JpGU's activities on gigantic earthquakes and tsunamis, 10 years since Great East Japan disasters

★Invited Papers

*Koji Okumura[1] (1.Graduate School of Humanities and Social Sciences, Hiroshima University)

2:05 PM - 2:25 PM JST | 5:05 AM - 5:25 AM UTC

[U15-02] The Decade of Progress of the Tohoku Geographical Association following the 2011 Great East Japan Earthquake

★Invited Papers

*ODA TAKASHI[1] (1.Miyagi University of Education)

2:25 PM - 2:45 PM JST | 5:25 AM - 5:45 AM UTC

[U15-03] Correspondence and the BCP (business continuity plan) maintenance situation of the commerce and industry establishment after the East Japan great earthquake disaster

★Invited Papers

*Toshio HATSUZAWA[1] (1.Fukushima University)

2:45 PM - 3:05 PM JST | 5:45 AM - 6:05 AM UTC

[U15-04] Ground motion characteristics during The 2011 off the Pacific coast of Tohoku Earthquake and The 2016 Kumamoto Earthquake

★Invited Papers

*Shinichi Matsushima[1] (1.Disaster Prevention Research Institute, Kyoto University)

3:05 PM - 3:15 PM JST | 6:05 AM - 6:15 AM UTC

[U15-05] Discussion

[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 | Ch.04 Zoom Room 04

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

convener:Megumi Matsumoto(Graduate School of Science, Tohoku University), Shin Ozawa(Department of Earth Science, Graduate School of Science, Tohoku University), Yuki Hibiya(Submarine Resources Research Center, Japan Agency for Marine-Earth Science and Technology), Noriyuki Kawasaki(Department of Earth and Planetary Sciences, Graduate School of Science, Hokkaido University), Chairperson:Yuki Hibiya(Submarine Resources Research Center, Japan Agency for Marine-Earth Science and Technology), Noriyuki Kawasaki(Department of Earth and Planetary Sciences, Graduate School of Science, Hokkaido University)

9:00 AM - 9:30 AM JST | 12:00 AM - 12:30 AM UTC

[PPS07-06] Novel approaches based on correlated short-lived and stable isotope variations for dating nucleosyntheses and early solar system events

★Invited Papers

*Tsuyoshi Iizuka[1], Yuki Hibiya[2], Mitsuru SUZUKI[1], Takehito Hayakawa[3] (1.University of Tokyo, 2.JAMSTEC, 3.National Institutes for Quantum and Radiological Science and Technology)

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

[PPS07-07] Oxygen and Al–Mg isotopic constraints on the cooling rate, age, and precursor of partial melting of an Allende Type B CAI, Golfball

*Noriyuki Kawasaki[1], Shoichi Itoh[2], Naoya Sakamoto[1], Steven B. Simon[3], Daiki Yamamoto[4], Hisayoshi Yurimoto[1] (1.Hokkaido University, 2.Kyoto University, 3.University of New Mexico, 4.JAXA)

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

[PPS07-08] Chemical and isotopic fractionation of Type B CAI caused by evaporation: An experimental study

*Michiru Kamibayashi[1], Shogo Tachibana[1,3], Noriyuki Kawasaki[2], Daiki Yamamoto[3], Hisayoshi Yurimoto[2] (1.The University of Tokyo, 2.Hokkaido University, 3.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

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

[PPS07-09] I-Xe ages of chondrites and its relevance for solar-wind derived noble gas concentrations

*Koharu Arai[1], Hirochika Sumino[1], Atsushi Takenouchi[2], Shogo Tachibana[1,3] (1.The University of Tokyo, 2.National Institute of Polar Research, 3.Institute of Space and Astronautical Science)

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

[PPS07-10] Requirement of turbulent nebula and dust grains for grain size coarsening in chondrule rims

*Hiroaki Kaneko[1], Sota ARAKAWA[2], Taishi Nakamoto[1] (1.Tokyo Institude of Technology, 2.National Astronomical Observatory of Japan)

[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 | Ch.04 Zoom Room 04

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

convener:Megumi Matsumoto(Graduate School of Science, Tohoku University), Shin Ozawa(Department of Earth Science, Graduate School of Science, Tohoku University), Yuki Hibiya(Submarine Resources Research Center, Japan Agency for Marine-Earth Science and Technology), Noriyuki Kawasaki(Department of Earth and Planetary Sciences, Graduate School of Science, Hokkaido University), Chairperson:Shin Ozawa(Department of Earth Science, Graduate School of Science, Tohoku University), Megumi Matsumoto(Graduate School of Science, Tohoku University)

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

[PPS07-11] Nanostructures of iron sulfides in lunar soils and implications for the behavior of sulfur on airless bodies.

*Toru Matsumoto[1], Takaaki Noguchi[1], Yu Tobimatsu[1], Dennis Harries[2], Falko Langenhorst[2], Akira Miyake[3], Hiroshi Hidaka[4] (1.Kyushu University, 2.Friedrich Schiller University Jena, 3.Kyoto University, 4.Nagoya University)

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

[PPS07-12] **Multiple sulfur isotope evidence for the formation of mesosiderite meteorites**

*Shun Mihira[1], Madhusoodhan Satish-Kumar[1], Akira Yamaguchi[2], Tomohiro Usui[3] (1.Department of Geology, Faculty of Science, Niigata University, 2.National Institute of Polar Research, 3.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

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

[PPS07-13] The shock pressure threshold for producing shock melt veins in basaltic rocks

*Haruka Oono[1], Kosuke Kurosawa[1], Takafumi Niihara[2], Takashi Mikouchi[3], Hidenori Genda[4], Naotaka Tomioka[7], Masahiro KAYAMA[5], Mizuho Koike[6], Yuji Sano[8], Wataru Satake[1], Takafumi Matsui[1] (1.Planetary Exploration Research Center, Chiba Institute of Technology, 2.Shool of Engineering, The University of Tokyo, 3.The University of Museum, The University of Tokyo, 4.Earth-Life Science Institute, Tokyo Institute of Technology, 5.Graduate School of Arts and Sciences, The University of Tokyo, 6.Graduate School of Advanced Science and Engineering, Hiroshima University, 7.Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology , 8.Atmosphere and Ocean Research Institute, The University of Tokyo)

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

[PPS07-14] **Shock effects in silica minerals in eucrites**

*Rei Kanemaru[1], Akira Yamaguchi[2,1], Naoya Imae[2,1], Atsushi Takenouchi[2], Hirotsugu Nishido[3] (1.The Graduate University for Advanced Studyies (SOKENDAI), 2.National Institute of Polar Research (NIPR), 3.Okayama University of Science (OUS))

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

[PPS07-15] Effect of ultraviolet C irradiation on surface alteration of basalt due to evaporation of sulfuric acid

*Nobuo Komori[1] (1.The United Graduate School of Education Tokyo Gakugei University)

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

[PPS07-16] Discussion

[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 | Ch.06 Zoom Room 06

[P-EM14] Heliosphere and Interplanetary Space

convener:Kazumasa Iwai(Institute for Space–Earth Environmental Research (ISEE), Nagoya University), Yasuhiro Nariyuki(Faculty of Education, University of Toyama), Ken Tsubouchi(University of Electro-Communications), N Masaki Nishino(Japan Aerospace Exploration Agency, Institute of Space and Astronautical Science), Chairperson:Kazumasa Iwai(Institute for Space–Earth Environmental Research (ISEE), Nagoya University)

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

[PEM14-01] Yearly variation of the Sun’s polar regions during Solar Cycle 24 observed with Hinode

*Daikou Shiota[1], Masumi Shimojo[2] (1.National Institute of Information and Communications Technology (NICT), 2.National Astronomical Observatory of Japan (NAOJ))

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

[PEM14-02] Improvement of the computer assisted tomography of interplanetary scintillation observations

*Munetoshi Tokumaru[1], Ken'ichi Fujiki[1], Masayoshi Kojima[1], Kazumasa Iwai[1] (1.Institute for Space-Earth Environmental Research, Nagoya University)

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

[PEM14-03] Physical properties of fast and slow solar wind studied by spacecraft radio scintillation

*Shota Chiba[1], Takeshi Imamura[1], Munetoshi Tokumaru[2], Daikou Shiota[3], Hiroki Ando[4] (1.Graduate School of Frontier Sciences, The University of Tokyo, 2.Institute for Space-Earth Environment Research, Nagoya University, 3.National Institute of Information and Communications Technology, 4.Kyoto Sangyo University)

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

[PEM14-04] Solar wind density distribution derived from DM measurements of Crab pulsar

*Maeda Ryuya[1], Munetoshi Tokumaru[1], Kaito Tawara[1], Toshio Terasawa[2] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Institute for Cosmis Ray Research,The University of Tokyo)

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

[PEM14-05] Next generation solar wind observation system: science requirements and pathfinders.

*Kazumasa Iwai[1], Munetoshi Tokumaru[1], Ken'ichi Fujiki[1] (1.Institute for Space–Earth Environmental Research (ISEE), Nagoya University)

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

[PEM14-06] Discussion

[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 | Ch.06 Zoom Room 06

[P-EM14] Heliosphere and Interplanetary Space

convener:Kazumasa Iwai(Institute for Space–Earth Environmental Research (ISEE), Nagoya University), Yasuhiro Nariyuki(Faculty of Education, University of Toyama), Ken Tsubouchi(University of Electro-Communications), N Masaki Nishino(Japan Aerospace Exploration Agency, Institute of Space and Astronautical Science), Chairperson:Yasuhiro Nariyuki(Faculty of Education, University of Toyama), Masaki N Nishino(Japan Aerospace Exploration Agency, Institute of Space and Astronautical Science)

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

[PEM14-07] Identification of solar wind regimes using the non-hierarchical cluster analysis

*Shinichi Watari[1] (1.National Institute of Information and Communications Technology)

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

[PEM14-08] Numerical simulation on invasion process of galactic cosmic rays into the heliosphere: Particle orbits and statistics

*Kotaro Yoshida[1], Shuichi Matsukiyo[2,3], Haruichi Washimi[3], Tohru Hada[2,3] (1.Department of Earth System Science and Technology, Interdisciplinary Graduate School of Engineering Sciences, Kyushu University, 2.Faculty of Engineering Sciences, Kyushu University, 3.International Center for Space Weather Science and Education, Kyushu University)

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

[PEM14-09] Kaguya Observations of Solar Wind Electron Modification by Electrostatic Waves Above the Lunar Day Side: Preliminary Results

*Yuki Harada[1], Yoshiya Kasahara[2], Masaki N Nishino[3], Satoshi Kurita[4], Yoshifumi Saito[3], Shoichiro Yokota[5], Futoshi Takahashi[6], Hisayoshi Shimizu[7] (1.Graduate School of Science, Kyoto University, 2.Information Media Center, Kanazawa University, 3.ISAS, JAXA, 4.Research Institute for Sustainable Humanosphere, Kyoto University, 5.Graduate School of Science, Osaka University, 6.Faculty of Sciences, Kyushu University, 7.Earthquake Research Institute, University of Tokyo)

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

[PEM14-10] Elliptically polarized 0.01-0.3 Hz magnetic field variation in the lunar wake

*Tomoko Nakagawa[1], Futoshi Takahashi[2], Hisayoshi Shimizu[3], Yoshifumi Saito[4] (1.Information and Communication Engineering, Tohoku Institute of Technology, 2.Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University, 3.Earthquake Research Institute, University of Tokyo, 4.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

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

[PEM14-11] On the relationship between the cross-helicty and the residual energy in the solar wind MHD turbulence: A phenomenological approach

*Yasuhiro Nariyuki[1] (1.Faculty of Education, University of Toyama)

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

[PEM14-12] Discussion

[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 | Ch.09 Zoom Room 09

[A-OS14] Coastal physical processes associated with mixing, eddies, internal waves

convener:Eisuke Tsutsumi(Atmosphere and Ocean Research Institute, The University of Tokyo), Eiji Masunaga(Ibaraki University), Taira Nagai(Graduate School of Science, The University of Tokyo), Chairperson:Eisuke Tsutsumi(Atmosphere and Ocean Research Institute, The University of Tokyo), Eiji Masunaga(Ibaraki University), Taira Nagai(Graduate School of Science, The University of Tokyo)

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

[AOS14-01] Enhancement of turbulent mixing over tidal sandwaves and formation of front: an observational study in Seto Inland Sea

*Eisuke Tsutsumi[1], Xinyu Guo[2], Naoki Yoshie[2], Takahiro Endoh[3], Takeshi Matsuno[3], Sachihiko Itoh[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Center for Marine Environmental Studies, Ehime University, 3.Research Institute for Applied Mechanics, Kyushu University)

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

[AOS14-02] Dynamics of the upwelling at the upstream of the East Sakhalin Current (ESC)

*Nan Yuan[1] (1.Hokkaido University, the Institute of Low Temperature Science)

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

[AOS14-03] Numerical study of tide-induced deep-ocean mixing near the head of Suruga Trough

*Taira Nagai[1], Toshiyuki Hibiya[1] (1.Graduate School of Science, The University of Tokyo)

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

[AOS14-04] **Amplitude modulation of currents at tidal and inertial bands at the Otsuchi Bay mouth**

*Tongjun Sun[3,1], Sachihiko Itoh[3], Eisuke Tsutsumi[3], Miho Ishizu[2], Kiyoshi Tanaka[3] (1.Graduate School of Agricultural and Life Sciences/Faculty of Agriculture,The University of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology, 3.Atmosphere and Ocean Research Institute, The University of Tokyo)

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

[AOS14-05] Water mass classification off the east coast of Japan mainland using Regional Ocean Modeling System (ROMS)

*Masashi Ikeda[1], Eiji Masunaga[1], Yusuke Uchiyama[2], Yota Suzue[4], Sachihiko Itoh[3] (1.Ibaraki University , 2.Kobe University, 3.The University of Tokyo, 4.CTI Engineering)

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

[AOS14-06] Vertical mixing and mass transport in a shallow lake, Lake Kasumingaura, Japan

*Eiji Masunaga[1], Tatsumi Kitamura[2], Sachihiko Itoh[3] (1.Ibaraki University, 2.Ibaraki Kasumigaura Environmental Science Center, 3.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 | Ch.07 Zoom Room 07

[A-OS16] Global ocean observing systems, their status, research results and future perspective

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: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), Shigeki Hosoda(Japan Marine-Earth Science and Technology)

3:30 PM - 3:35 PM JST | 6:30 AM - 6:35 AM UTC

[AOS16-01] Introduction

3:35 PM - 3:55 PM JST | 6:35 AM - 6:55 AM UTC

[AOS16-02] Biogeochemical Argo: Significances and Challenges

★Invited Papers

*Masao Ishii[1] (1.Meteorological Research Institute, Japan Meteorological Agency)

3:55 PM - 4:15 PM JST | 6:55 AM - 7:15 AM UTC

[AOS16-03] 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, University of Tokyo)

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

[AOS16-04] Two-year seismic observation by hydrophone floats

*Masayuki Obayashi[1], Hiroko Sugioka[2], Junko Yoshimitsu[1] (1.Japan Agency for Marine-Earth Science and Technology, 2. Department of Planetology, Kobe University)

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

[AOS16-05] Discussion toward a New Global Ocean Observing System

*Shuhei Masuda[1] (1.Japan Agency for Marine-Earth Science and Technology)

[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 | Ch.10 Zoom Room 10

[A-OS19] Physical Oceanography (General)

convener:Yoshimi Kawai(Research Institute for Global Change, Japan Agency for Marine-Earth Science and Technology), Kitade Yujiro(Tokyo University of Marine Science and Technology), Chairperson:Yoshimi Kawai(Research Institute for Global Change, Japan Agency for Marine-Earth Science and Technology)

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

[AOS19-01] Frontal waves in the east of the Tsugaru Strait revealed by the high-frequency radar observation

*Hitoshi Kaneko[1], Takahiro Tanaka[2], Hiroto Abe[1,3], Masahide Wakita[1], Ken'ichi Sasaki[1], Daisuke Hasegawa[2], Takeshi Okunishi[2], Shuichi Watanabe[1], Shoko Tatamisashi[1], Yoshiaki Sato[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Japan Fisheries Research and Education Agency, 3.Graduate School/Faculty of Fisheries Sciences, Hokkaido University)

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

[AOS19-02] 17 year observation of bottom water current on deep seafloor offshore of Tokachi in Hokkaido: Recovery of acoustic Doppler current profiler (ADCP) data of cabled observatory

*Ryoichi Iwase[1] (1.National Research and Development Agency, Japan Agency for Marine-Earth Science and Technology)

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

[AOS19-03] Winter large-scale atmospheric circulation during La Niña events: A comparison between the first year and second year of events

*Gaku Nishihira[1], Shusaku Sugimoto[1] (1.Graduate School of Science, Tohoku University)

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

[AOS19-04] Decadal variation of the asymmetry of SSTA in the tropical Atlantic and its relations with midlatitude atmosphere circulation

*Yoshinobu Furukawa[1], Shusaku Sugimoto[1] (1.Graduate School of Science, Tohoku University)

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

[AOS19-05] Nearshore wave–current interaction effects on wave power density near Japan

*Adrean Webb[1], Takuji Waseda[2] (1.Kyoto University, Disaster Prevention Research Institute, Coastal Disaster Research, 2.The University of Tokyo, Graduate School of Frontier Sciences, Department of Ocean Technology Policy and Environment)

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

[AOS19-06] Medium-term oceanic transport of microplastics in and around the South China Sea analyzed with climatological and synoptic models

*Kosei Matsushita[1], Yusuke Uchiyama[1], Naru Takaura[1], Taichi Kosako[2] (1.Kobe University, 2.Port and Airport Research Institute)

[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 | Ch.08 Zoom Room 08

[A-CG37] 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(Arid Land Research Center, Tottori University)

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

[ACG37-01] Temporal and spatial variation of soil CO_2/CH_4 fluxes in two cool-temperate forests in Japan

*Lifei Sun[1], Naishen Liang[1], Takashi Hirano[2], Yoshiyuki Takahashi [1], Munemasa Teramoto[3], Kentaro Takagi[2], Toshiaki Kondo[4], Jun Koarashi[5], Mariko Atarashi-Andoh[5], Reiko Ide[1], Xin Zhao[1], Sachinobu Ishida[6], Masahiro Takagi[7], Tomotsugu Yazaki[8] (1.National Institute for Environmental Studies Japan, 2.Hokkaido University, 3.Tottori University, 4.Japan International Research Center for Agricultural Sciences , 5.Japan Atomic Energy Agency , 6.Hirosaki University, 7.University of Miyazaki, 8.Meji University)

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

[ACG37-02] Decomposition of coarse woody debris produced through land conversion from a forest to an oil palm plantation

*Takashi Hirano[1], Shoko Murata[2], Guan Xhuan Wong[3], Joseph Wenceslaus Waili[3], Kim San Lo[3], Frankie Kiew[3], Edward Baran Aeries[3], Ryuichi Hirata[4], Tomohiro Shiraishi[4], Masato Hayashi[6], Masayuki Itoh[5], Lulie Melling[3] (1.Research Faculty of Agriculture, Hokkaido University, 2.Japan Science and Technology Agency, 3.Sarawak Tropical Peat Research Institute, 4.National Institute for Environmental Studies, 5.University of Hyogo, 6.Japan Aerospace Exploration Agency)

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

[ACG37-03] Anticipation of research development on the atmosphere-land interactions of the terrestrial nitrogen cycle

*Kentaro Hayashi[1] (1.Institute for Agro-Environmental Sciences, NARO)

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

[ACG37-04] Simulation of snow algal blooming in the global scale using a land surface model

*Yukihiko Onuma[1], Kei Yoshimura[1], Nozomu Takeuchi[2] (1.Institute of Industrial Science, The University of Tokyo, 2.Graduate School of Science, Chiba University)

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

[ACG37-05] Intercomparison of Data-Driven Estimation of Soil Respiration in Japan

*Hina Yamanuki[1], Kazuhito Ichii[1,2], Naishen Liang[2], Munemasa Teramoto[3], Yoshiyuki Takahashi[2], Jiye Zeng[2], Kentaro Takagi[4], Takashi Hirano[4], Sachinobu Ishida[5], Masahiro Takagi[6], Masaaki Naramoto[7], Kaneyuki Nakane[8], Toshiaki Kondo[9], Jun Koarashi[10], Mariko Atarashi-Andoh[10] (1.Center for Environmental Remote Sensing, Chiba University, 1-33 Yayoi-cho, Inage-ku, Chiba-shi, Chiba 263-8522, Japan, 2.Center for Global Environmental Research, National Institute for Environmental Studies, Tsukuba, Ibaraki 305- 8506, Japan, 3.Arid Land Research Center, Tottori University, 1390 Hamasaka, Tottori, Tottori 680-0001, Japan, 4.Hokkaido University, Kita 8, Nishi 5, Kita-ku, Sapporo, Hokkaido 060-0808, Japan, 5.Hirosaki University, 3 Bunkyo-cho, Hirosaki-shi, Aomori 036-8561, Japan, 6.University of Miyazaki, Gakuen-kibanadai-nishi-1-1, Miyazaki, Miyazaki 889-2192, Japan, 7.Shizuoka University, 836, Ohya, Suruga-ku, Shizuoka-Shi, Shizuoka 422-8529, Japan, 8.Hiroshima University, 1-3-2 Kagamiyama, Higashi-Hiroshima-Shi, Hiroshima 739-8511, Japan, 9.Japan International Research Center for Agricultural Sciences, 1-1 Ohwashi, Tsukuba, Ibaraki 305-8686, Japan, 10.Japan Atomic Energy Agency, 2-4 Shirakata, Tokai-mura, Naka-gun, Ibaraki 319-1195, Japan)

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

[ACG37-06] Overview of the Regional Carbon Budget Assessment and Processes (RECCAP2), and activities on Southeast Asia

*Masayuki Kondo[1] (1.Center for Global Environmental Research, National Institute for Environmental Studies)

[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 | Ch.08 Zoom Room 08

[A-CG37] 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(Arid Land Research Center, Tottori University)

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

[ACG37-07] Influence of fire and drainage on evapotranspiration in a tropical ex-peat swamp forest

*Shinjiro Ohkubo[1], Takashi Hirano[1], Kitso Kusin[2] (1.National University Corporation, Hokkaido University, 2.University of Palangkaraya)

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

[ACG37-08] Ground-Based Measurement of Solar-Induced Chlorophyll Fluorescence in Wetland by High-Spectral Resolution

*Kitpanuwat TANATARAKEREE[1], Tomomichi Kato[2,3], Tomoki Morozumi[3], KANOKRAT BUAREAL[2], Masahito Ueyama[4], Naohisa Nakashima[3], Hideki Ninomiya[2], Lan Wu[5] (1.Graduate School of Agriculture, Hokkaido University, 2.Graduate School of Global Food Resources, Hokkaido University, 3.Research Faculty of Agriculture, Hokkaido University , 4.Graduate School of Life and Environmental Science, Osaka Prefecture University, 5.Hainan University)

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

[ACG37-09] Accounting for the emissions of tree stems in the methane budget of forests: upscaling chamber measurements to the stand

*Daniel EPRON[1], Ayaka Sakabe[1], Kenshi Takahashi[1], Takeshi Ise[1] (1.Kyoto University)

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

[ACG37-10] Estimation of non-photosynthetic vegetation amount in the northern Gobi Desert using MODIS satellite data

*Jing Wu[1], Yasunori Kurosaki[1], Gantsetseg Batdelger[2], Batjargal Buyantogtoh[1], Ishizuka Masahide[3], Thomas Sekiyama[4], Jiaqi Liu[1] (1. Arid Land Research Center, Tottori University, 2.Information and Research Institute of Meteorology, Hydrology and Environment, 3.Kagawa University, 4.Meteorological Research Institute)

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

[ACG37-11] **Mapping Peatland Fires in Indonesia Using a Drone Equipped with an Infrared Camera**

*Taishin Kameoka[1], Osamu Kozan[2,3] (1.Educational Unit for Studies on Connectivity of Hills, Humans and Oceans, Kyoto University, 2.Center for Southeast Asian Studies, Kyoto University, 3.Research Institute for Humanity and Nature)

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

[ACG37-12] Incorporating non-structural carbon dynamics in individual-based vegetation model SEIB-DGVM

*Hideki Ninomiya[1], Tomomichi Kato[1] (1.Hokkaido University)

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

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Ch.16 Zoom Room 16

[H-QR04] Quaternary, Diachronic dynamics of human-environment interactions

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Yusuke Yokoyama(Atmosphere and Ocean Research Institute, University of Tokyo), Koji Okumura(Graduate School of Letters, Hiroshima University), Yasufumi Satoguchi(Lake Biwa Museum), Chairperson:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Tsutomu Nakazawa(Geological Survey of Japan, AIST)

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

[HQR04-01] Distribution and classification of buried flat surfaces beneath the post-LGM deposits in central Tokyo

*Junko Komatsubara[1], Yoshinori Miyachi[1], Susumu Nonogaki[1], Toshio Nakayama[2] (1.National Institute of Advanced Industrial Science and Technology, 2.Civil Engineering Support and Training Center)

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

[HQR04-02] 240 ka Ata-Th tephra layer found in Tokyo and its geological significance

*Kunihiko Endo[1], Mari Sumita[2], Toshihiko Sugai[4], Hisashi Fujine[3], Masaaki Suzuki[5], Kyota Uemura[6], Yusuke Suginaka[7], Marie Noguchi[3], Shigeko Ishiwata[8], Reisuke Kondo[9], Takato Takemura[10] (1.Nihon University, 2.GEOMAR, 3.Paleo Labo, 4.Tokyo University , 5.Education Center of Bunkyo, 6.The Institute of Natural Sciences, College of Humanities and Sciences, Nihon University, 7.RCCM, 8.GaNT, 9.Atmosphere and Ocean Research Institute, The University of Tokyo, 10.Nihon University college of humanities and sciences)

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

[HQR04-03] Estimation of sedimentary condition in Kinu River and Kokai River lowland using micro tremor survey

*Mamoru Koarai[1], Kanaho Miki[1], Keiichi Takami[1], Shigeki Senna[2] (1.Earth Science course, College of Science, Ibaraki University, 2.National Research Insutitute of Earth Science and Disaster Resilience)

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

[HQR04-04] Ground-type classification based on Quaternary stratigraphy and sedimentary facies and the corresponding ground motion characteristics, with special reference to the 3D Urban Geological Map of Central Tokyo

★Invited Papers

*Tsutomu Nakazawa[1], Ikuo Cho[1], Junko Komatsubara[1], Tomonori Naya[1], Susumu Nonogaki[1], Yoshinori Miyachi[1], Masanori Ozaki[1], Kentaro Sakata[1], Hiroomi Nakazato[2], Takehiko Suzuki[3], Toshio Nakayama[4] (1.Geological Survey of Japan, AIST, 2.NIRE, NARO, 3.Tokyo Metropolitan University, 4.Civil Engineering Support and Training Center, Bureau of Construction, Tokyo Metropolitan Government)

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

[HQR04-05] Stratigraphic division, age and distribution pattern of the Middle to Upper Pleistocene Shimosa Group in central Tokyo area

*Tomonori Naya[1], Tsutomu Nakazawa[1], Susumu Nonogaki[1], Kentaro Sakata[1], Hiroomi Nakazato[2], Takehiko Suzuki[3], Toshio Nakayama[4] (1.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2.Institute for Rural Engineering, NARO, 3.Tokyo Metropolitan University , 4.Civil Engineering Support and Training Center, Bureau of Construction, Tokyo Metropolitan Government)

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

[HQR04-06] Paleoenvironmental change in Paleo-Tokyo Bay during MIS 5e inferred from ostracode assemblages of the Pleistocene Kioroshi Formation, Shimosa Group, northern Chiba Prefecture, central Japan.

*Mai Harashima[1], Tsutomu Nakazawa[2], Hirokazu Ozawa[3], Minoru Kaneko, Hiroyuki Ishikawa, Masahiro Nomura[4], Sachiko Agematsu[1] (1.University of Tsukuba, 2.Geological Survey of Japan, AIST, 3.Nihon University, 4.Surugadai University)

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

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Ch.16 Zoom Room 16

[H-QR04] Quaternary, Diachronic dynamics of human-environment interactions

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Yusuke Yokoyama(Atmosphere and Ocean Research Institute, University of Tokyo), Koji Okumura(Graduate School of Letters, Hiroshima University), Yasufumi Satoguchi(Lake Biwa Museum), Chairperson:Koji Okumura(Graduate School of Letters, Hiroshima University), Yusuke Yokoyama(Atmosphere and Ocean Research Institute, University of Tokyo)

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

[HQR04-07] Middle Pleistocene terraces in the Chita Peninsula, near Nagoya, central Japan

*Taku Komatsubara[1], Misao Hongo[2], Yoshiki Sato[1] (1.Institute of Geology and Geoinformation, Advanced Industrial Science and Technology, 2.Alps Technical Research Laboratory Co., Ltd.)

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

[HQR04-08] **Unveiling the black box: monthly measurements on dissolved inorganic radiocarbon in Fuji Five lakes water to understand the lake specific reservoir ages**

*Ota Kosuke[1,2], Yusuke Yokoyama[1,2], Yosuke Miyairi[2], Shinya Yamamoto[3], Toshihiro Miyajima[2] (1.Earth and Planetary Science Department, Graduate school of Science, University of Tokyo, 2.Atmosphere and Ocean Research Institute, University of Tokyo, 3.Mount Fuji Research Institute, Yamanashi Prefectural Government)

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

[HQR04-09] Eventual sediments presumed in lake deposits of coastal lakes along the western coast of Kyushu Island, Japan

*Kaoru Kashima[1], Yu Fukumoto[2], Tsuyoshi Haraguchi[2] (1.Department of Earth and Planetary Sciences, Kyushu University, 2.Osaka City University)

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

[HQR04-10] Origin and evolution of a delta-margin mangrove in Can Gio, southern Vietnam

★Invited Papers

Daniel S Collins[1,6], Lap V Nguyen[2], Oanh TK Ta[2], Limi Mao[3], Yuji Ishii[1], Hiroyuki Kitagawa[4], Rei Nakashima[1], *Toru Tamura[1,5] (1.Geological Survey of Japan, AIST, 2.HCMC Institute of Resources Geography, Vietnamese Academy of Science and Technology, 3.Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, 4.Institute for Space-Earth Environmental Research, Nagoya University, 5.Graduate School of Frontier Science, The University of Tokyo, 6.Shell International Ltd)

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

[HQR04-11] Discussion

[J] Oral | H (Human Geosciences)：H-DS Disaster geosciences

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Ch.16 Zoom Room 16

[H-DS10] Geohazards in humid, tectonically active countries and their precursors

convener:Satoru Kojima(Department of Civil Engineering, Gifu University), Taro Uchida(University of Tsukuba), Yoshihiko Kariya(Department of Environmental Geography, Senshu University), Chairperson:Yoshihiko Kariya(Department of Environmental Geography, Senshu University), Satoru Kojima(Department of Civil Engineering, Gifu University)

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

[HDS10-01] Weathering styles and landslide types of granite

*Masahiro Chigira[1], Yasuto Hirata[2] (1.Fukada Geological Institute, 2.Central Research Institute of Electric Power Industry)

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

[HDS10-02] Slope failures induced by the 2020 July heavy rain in the Chubu Region

*Hidehisa Nagata[1] (1.Fu-Sui-Do Company Limited)

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

[HDS10-03] **Landslides in humid-temperate mountainous areas in northwestern Vietnam perceived by satellite images**

*Takahisa Furuichi[1,2,3], Hiromu Daimaru[1], Wataru Murakami[1], Takashi Okamoto[1] (1.Forest and Forest Products Research Institute, 2.University of the Sunshine Coast, 3.Miyagi University of Education)

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

[HDS10-04] Estimation of subsurface structure in the linear depression spreading over the landslide crown

*Hikaru Osawa[1], Issei Doi[2], Noriyuki Arai[2], Yosuke Yamakawa[1], Takuma Watakabe[3] (1.Mountain Science Center, University of Tsukuba, 2.DPRI, Kyoto University, 3.Forestry and Forest Products Research Institute)

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

[HDS10-05] Study on the landslide mechanism of the Iya area where the deep-seated landslide occurred by Typhoon Talas in 2011 using Drone Airborne TEM

*Atsuhiko Kinoshita[1,2], Suguru Shibata[2], Takao Yamakoshi[1], Hiroaki Nakaya[1], Yasumasa Fujiwara[3], Hideki Nakano[3], Akira Jomori[4], Katsushi Kawato[5], Muneki Mitamura[6], Tamotsu Matsui[7] (1.National Institute for Land and Infrastructure Management, 2.Sediment Disaster Prevention Technology Center, 3.Eight-Japan Engineering Consultants Inc., 4.NEOSCIENCE CO.LTD., 5.NIPPON ENGINEERING CONSULTANTS CO.,LTD., 6.Osaka City University, 7.Osaka University)

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

[HDS10-06] Creating a Landslide risk map of the Nachi River basin

*Makoto Msatsuzawa[1], Tatsuya Ito[1], Chiyoshi Minami[1], Atsuhiko Kinoshita[2], Suguru Shibata[2], Taku Yamada[3], Toshiaki Kotake[3], Yasutaka Tanaka[4] (1.PACIFIC CONSULTANTS CO., LTD., 2. Sediment Disaster Prevention Technology Center, 3.Kiisankei sabo office, 4.HOKKAIDO UNIVERSITY)

[J] Oral | H (Human Geosciences) : H-DS Disaster geosciences

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Ch.16 Zoom Room 16

[H-DS10] Geohazards in humid, tectonically active countries and their precursors

convener:Satoru Kojima(Department of Civil Engineering, Gifu University), Taro Uchida(University of Tsukuba), Yoshihiko Kariya(Department of Environmental Geography, Senshu University), Chairperson:Taro Uchida(University of Tsukuba), Satoru Kojima(Department of Civil Engineering, Gifu University)

3:30 PM - 3:50 PM JST | 6:30 AM - 6:50 AM UTC

[HDS10-07] Back analysis for landslide occurrence based on the relationship between the rain and the slope condition.

★Invited Papers

*Reiko AKIYAMA[1], Kuniaki MIYAMOTO[2] (1.Oriental Consultants Co., Ltd., 2.Nippon Koei Co., Ltd.)

3:50 PM - 4:05 PM JST | 6:50 AM - 7:05 AM UTC

[HDS10-08] Spatial Variability of Rainfall-runoff Characteristics in a Large-scale Landslide-prone Area Underlain by Accretionary Sedimentary Rocks

*Yosuke Yamakawa[1], Kouji Koshimizu[2], Taro Uchida[1] (1.Faculty of Life and Environmental Sciences, University of Tsukuba, 2.Graduate School of Science and Technology, University of Tsukuba)

4:05 PM - 4:20 PM JST | 7:05 AM - 7:20 AM UTC

[HDS10-09] Observation of an effect of interstitial water saturation and water quality on changes in formation resistivity

*Yamato SUZUKI[1], Hiroaki NAKAYA[1], Atsushi FUNAYAMA[2], Toshihiko SAKASHIMA[2], Koushiro TANAKA[2], Akira JOMORI[3], Tetsuya TOYAMA[3] (1.National Institute for Land and Infrastructure Management, 2.Pacific Consultants Co., Ltd., 3.Neo-science Co. Ltd.)

4:20 PM - 4:35 PM JST | 7:20 AM - 7:35 AM UTC

[HDS10-10] Valley floor environmental changes and disasters associated with glacial collapse of mountain glaciers
-A case study of the 2003, 04 and 2021 floods in the Himalayas -

*Jiro Komori[1] (1.Teikyo Heisei University)

4:35 PM - 4:50 PM JST | 7:35 AM - 7:50 AM UTC

[HDS10-11] Characteristics of slope disasters triggered by sudden topographic deformation in the Himalayan region

*Hiroshi YAGI[1], Daisuke Higaki[2], Ching-Ying Tsuo[3], Akihiko Wakai[4], Yusuke Yamamoto[5] (1.Faculty of Art, Science and Education, Yamagata University, 2.Nippon Koei Co.,Ltd., 3.Faculty of Agriculture and Life Science, Hirosaki University, 4.Graduate School of Polytechnics, Gunma University, 5.Geoscience Research Laboratory Co.,Ltd.)

4:50 PM - 5:00 PM JST | 7:50 AM - 8:00 AM UTC

[HDS10-12] Discussion

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

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Ch.17 Zoom Room 17

[H-CG23] Nuclear Energy and Geoscience

convener:Eiji Sasao(Tono Geoscience Center, Japan Atomic Energy Agency), Shinji Takeuchi(Department of Earth and Environmental Sciences, College of Humanities & Sciences, Nihon University), Takuma HASEGAWA(Central Research Institute of Electric Power Industry), Chairperson:Takuma HASEGAWA(Central Research Institute of Electric Power Industry)

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

[HCG23-01] Recent trends on long-term supply of uranium resources

*Eiji Sasao[1] (1.Tono Geoscience Center, Japan Atomic Energy Agency)

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

[HCG23-02] Geological Descriptive Model and AI Geo-Database of Coastal Area by Using Published data from National Public Research Institutes in Japan

*Atsunao Marui[1], Norikazu Imai[2], Teruhiko Suzuki[2], Akinari Honda[2] (1.Goelogical Survey of Japan, AIST, 2.GMLabo Co. LTD)

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

[HCG23-03] Attempt to identify the origin of deep-seated fluids in terms of hydrogeochemical characteristics

*Yuichi Tomioka[1], Hirofumi Kondo[1], Fumitake Kusuhara[1], Ayumi Sugiyama[1,2] (1.Central Research Institute of Electric Power Industry, 2.Asano Taiseikiso Engineering Co., Ltd.)

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

[HCG23-04] Characterization and Distribution of fractures in Granite, Ningyo-Toge, Okayama Pref., Japan

*Takesue Norito[1], Tsuyoshi Nohara[1] (1.Japan Atomic Energy Agency)

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

[HCG23-05] Study on the hydro-mechanical characterization of the calcareous concretion

*Shinji Takeuchi[1], Hidekazu Yoshida[2], Sachiko Nakamura[1] (1.Department of Earth and Environmental Sciences, College of Humanities & Sciences, Nihon University, 2.Nagoya University Museum)

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

[HCG23-06] Estimation of ^{137}Cs uptake from forest floor in Japanese cedar and Japanese konara oak stands of the Abukuma Mountains, Fukushima

*Tadafumi Niizato[1], Yoshito Sasaki[1], Satomi Ito[1], Takayoshi Watanabe[1], Hiroki Amamiya[2] (1.Japan Atomic Energy Agency, 2.QJ Science)

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

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Ch.17 Zoom Room 17

[H-CG23] Nuclear Energy and Geoscience

convener:Eiji Sasao(Tono Geoscience Center, Japan Atomic Energy Agency), Shinji Takeuchi(Department of Earth and Environmental Sciences, College of Humanities & Sciences, Nihon University), Takuma HASEGAWA(Central Research Institute of Electric Power Industry), Chairperson:Shinji Takeuchi(Department of Earth and Environmental Sciences, College of Humanities & Sciences, Nihon University)

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

[HCG23-07] Relationship between velocities in a single fracture and retardation effects by sorption investigated with laboratory tracer experiments

*Shunichi Okamoto[1], Kotaro Nakata[1], Takuma Hasegawa[1], Yasuharu Tanaka[1] (1.Central Research Institute of Electric Power Industry)

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

[HCG23-08] Evaluation on isotope and component separation by diffusion experiment

*Takuma HASEGAWA[1], Kotaro NAKATA[1], Rhys Gwynne[2] (1.Central Research Institute of Electric Power Industry, 2.University of Waterloo)

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

[HCG23-09] A study of U(VI) sorption on illite under carbonate-rich environments: Batch experiments, TRLFS and modeling

*Huiyang Mei[1], Noboru Aoyagi[1], Takumi Saito[2], Naofumi Kozai[1], Yukio Tachi[3] (1.Advanced Science Research Center, Nuclear Science Research Institute, Japan Atomic Energy Agency, Ibaraki, 2-4 Shirakata, Tokai-mura, Ibaraki 319-1195, Japan, 2.Nuclear Professional School, School of Engineering, The University of Tokyo, 2-22 Shirakata Shirane, Tokai-mura, Ibaraki 319-1188, Japan, 3.Nuclear Fuel Cycle Engineering Laboratories, Japan Atomic Energy Agency, 4-33 Muramatsu, Tokai-mura, Ibaraki 319-1194, Japan)

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

[HCG23-10] **Immobilization of Iodide and Iodate in Layered Double Hydroxide, Magnesium oxide and Silver embedded into Metakaolin-Based Alkali Activated Materials**

*CHAERUN Raudhatul Islam[1], Manami ISHIMURA[1], Kanako TODA[1], Tsubasa OTAKE[1], Ryosuke KIKUCHI[1], John PROVIS[2], Yogarajah ELAKNESWARAN[1], Tsutomu SATO[1] (1.Hokkaido University, 2.The University of Sheffield)

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

[HCG23-11] **Evolution of reaction and alteration of mudstone with cement leachate: Flow experiments and reactive-transport modelling**

*Keith Bateman[1], Yuki Amano[1], Yukio Tachi[1] (1.Radionuclide Migration Research Group, Japan Atomic Energy Agency, 4-33 Muramatsu, Tokai-Mura, IBARAKI, 319-1194 Japan)

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

[HCG23-12] Discussion

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

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Ch.17 Zoom Room 17

[H-CG27] Nuclear Power and Geoscience in Japan: 10 years after the 3.11 complex disaster

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

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

[HCG27-01] How was the long-term forecast of tsunami earthquake distorted?

★Invited Papers

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

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

[HCG27-02] Changes in the Treatment of Scientific Issues in Nuclear Power Plant Trials

★Invited Papers

*Kazuki Koketsu[1] (1.Earthquake Research Institute, University of Tokyo)

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

[HCG27-03] Human Capacity Building at The University of Tokyo towards Knowledge Base Development for Nuclear Risk Management

*Tatsuya Itoi[1], Naoto Sekimura[1], Tsuyoshi Takada[1,2], Takumi Saito[1], Kenji Satake[1] (1.The University of Tokyo, 2.Japan Atomic Energy Agency)

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

[HCG27-04] Scientific characteristics of high-level nuclear waste disposal site -Geological perspective at Suttsu and Kamoenai areas, Hokkaido -

★Invited Papers

*Satoshi Okamura[1] (1.Hokkaido Education University)

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

[HCG27-05] Selection of high-level radioactive waste disposal site in Japan

★Invited Papers

*Masahiro Chigira[1] (1.Fukada Geological Institute)

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

[HCG27-06] Discussion

*Daisuke Suetsugu[1] (1.institute for Marine Geodynamics, Japan Agency for Marine-Earth Science and Technology)

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

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Ch.18 Zoom Room 18

[S-SS09] Seismic wave propagation: Theory and Application

convener:Kaoru Sawazaki(National Research Institute for Earth Science and Disaster Resilience), Kiwamu Nishida(Earthquake Research Institute, University of Tokyo), Takao Nibe(JAPEX), Kyosuke Okamoto(National Institute of Advanced Industrial Science and Technology), Chairperson:Kaoru Sawazaki(National Research Institute for Earth Science and Disaster Resilience), Kurama Okubo(National Research Institute for Earth Science and Disaster Resilience)

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

[SSS09-01] **Estimation of the elastic wave velocity in rock fractures revealed by the digital rock physics and energy approach**

*Kazuki Sawayama[1], Osamu NISHIZAWA[2], Tatsunori Ikeda[3], Fei Jiang[4], Takeshi Tsuji[3], Yasuhiro Fujimitsu[3] (1.Department of Earth Resources Engineering, Graduate school of engineering, Kyushu University, 2.International Institute of Carbon Neutral Energy Research, Kyushu University, 3.Department of Earth Resources Engineering, Faculty of engineering, Kyushu University, 4.Department of Mechanical Engineering, Faculty of Engineering, Yamaguchi University)

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

[SSS09-02] SH-wave propagation through the random distribution of aligned line cracks

*Haruo Sato[1] (1.Tohoku Unvieristy)

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

[SSS09-03] **Continuous monitoring of seismic velocity change at Parkfield towards identifying the strain accumulation**

*Kurama Okubo[1,2], Brent Delbridge[2], Marine Denolle[3,2] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Harvard University, 3.University of Washington)

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

[SSS09-04] Changes in attenuation and its anisotropy associated with seismic ground motion

*Shuhei Tsuji[1], Koshun Yamaoka[2], Ryoya Ikuta[3] (1.Graduate School of Environmental Studies, Nagoya University, 2.Earthquake and Volcano Research Center Graduate School of Environmental Studies, Nagoya University, 3.Department of Geosciences, Shizuoka University)

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

[SSS09-05] **Seismic velocity response to ground water level revealed by ACROSS and seismic array**

*hiromu oba[1], Ryoya Ikuta[1], Shuhei Tsuji[2], Chen Feng[2], Koshun Yamaoka[2], Toshiki Watanabe[2] (1.Shizuoka University, 2.Nagoya University)

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

[SSS09-06] On the relationship between the streamflow due to snowmelt flood and ambient seismic noise observed by Hi-net stations

*Kaoru Sawazaki[1], Shakti P.C.[1] (1.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 | Ch.18 Zoom Room 18

[S-SS09] Seismic wave propagation: Theory and Application

convener:Kaoru Sawazaki(National Research Institute for Earth Science and Disaster Resilience), Kiwamu Nishida(Earthquake Research Institute, University of Tokyo), Takao Nibe(JAPEX), Kyosuke Okamoto(National Institute of Advanced Industrial Science and Technology), Chairperson:Kyosuke Okamoto(National Institute of Advanced Industrial Science and Technology), Shunsuke Takemura(Earthquake Research Institute, the University of Tokyo)

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

[SSS09-07] Effects of subsurface heterogeneities and surface topography on long-period surface wave monitoring

*Shunsuke Takemura[1], Ryo Okuwaki[2], Takanori Matsuzawa[3] (1.Earthquake Research Institute, the University of Tokyo, 2.Moutain Science Center, Faculty of Life and Environmental Sciences, University of Tsukuba, 3.National Research Institute for Earth Science and Disaster Resilience)

11:00 AM - 11:30 AM JST | 2:00 AM - 2:30 AM UTC

[SSS09-08] Fracture detection and properties estimation using fiber optic sensors

★Invited Papers

*Keisuke Teranishi[1], Naoshi Aoki[1], Moeto Fujisawa[1], Hidehiko Shimizu[1], Shinya Onodera[2] (1.JGI, 2.JOGMEC)

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

[SSS09-09] Connection between the correlation of strain and rotation seismograms and Green's function: Surface-wave case

*Hisashi Nakahara[1] (1.Solid Earth Physics Laboratory, Department of Geophysics, Graduate School of Science, Tohoku University)

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

[SSS09-10] Ambient Noise Differential Adjoint Tomography Applied to a Linear Array in Los Angeles Basin

*Xin Liu[1,2], Gregory C Beroza[1] (1.Stanford Earth, 2.JAMSTEC)

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

[SSS09-11] Estimating finite fault slip distributions of large earthquakes based on time-reversal wave propagation simulation with data assimilation

*Yugo Shibata[1], Takashi Furumura[1], Takuto Maeda[2] (1.Earthquake Research Institute, the University of Tokyo, 2.Hirosaki University)

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

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Ch.18 Zoom Room 18

[S-SS09] Seismic wave propagation: Theory and Application

convener:Kaoru Sawazaki(National Research Institute for Earth Science and Disaster Resilience), Kiwamu Nishida(Earthquake Research Institute, University of Tokyo), Takao Nibe(JAPEX), Kyosuke Okamoto(National Institute of Advanced Industrial Science and Technology), Chairperson:Kiwamu Nishida(Earthquake Research Institute, University of Tokyo), Takashi Hirose(National Research Institute for Earth Science and Disaster Resilience)

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

[SSS09-12] Imaging the solar interior using noise tomography

★Invited Papers

*Shravan Hanasoge[1] (1.Tata Institute of Fundamental Research)

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

[SSS09-13] Incorporating wind information in the inversion of co-located pressure and seismic data for shallow elastic structure

*Toshiro Tanimoto[1] (1.Department of Earth Science, University of California, Santa Barbara, CA93106, USA)

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

[SSS09-14] Study on Microseisms excited by Typhoons around Japan

*Hiroki Kawakami[1], Naoki Suda[1] (1.Hiroshima University)

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

[SSS09-15] Extraction of P-wave reflections of mantle discontinuities from ambient seismic noise beneath Japan

*Shota Kato[1], Kiwamu Nishida[1] (1.Earthquake Research Institute, the University of Tokyo)

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

[SSS09-16] A centroid catalog of P-wave microseisms

*Kiwamu Nishida[1], Ryota Takagi[2] (1.Earthquake Research Institute, University of Tokyo, 2.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of 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 | Ch.18 Zoom Room 18

[S-SS11] Strong Ground Motion and Earthquake Disaster

convener:Kazuhiro Somei(Geo-Research Institute), Yasuhiro Matsumoto(Kozo Keikaku Engineering), Chairperson:Tomohisa Okazaki(RIKEN Center for Advanced Intelligence Project), Kentaro Emoto(Graduate School of Science, Tohokuk University)

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

[SSS11-01] High-density estimation of site amplification characteristics from DAS observation along Route 4

*Kentaro Emoto[1], Hisashi Nakahara[1], Takeshi Nishimura[1], Mare Yamamoto[1] (1.Graduate School of Science, Tohokuk University)

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

[SSS11-02] Long-term fluctuation of microtremor at a permanent observation site in Tottori University

*Takao Kagawa[1], Soma Nishigaki[1], Tatsuya Noguchi[1] (1.Tottori University, Faculty of Engineering)

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

[SSS11-03] Numerical elucidation of the Aso Caldera graben mechanism focusing on stratum irregularities, soft clay and two consecutive earthquakes

*Kentaro Nakai[1], Toshihiro Noda[2], Akira Asaoka[3], Shinya Fukuda[1] (1.Graduate School of Engineering, Nagoya University, 2.Disaster Mitigation Research Center, Nagoya University, 3.Association for The Development of Earthquake Prediction)

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

[SSS11-04] Estimation of site amplification and S-wave velocity structure in Kumamoto Prefecture based on spectral inversion analysis of strong motion records

*Tomomi IIDA[1], Hiroaki Yamanaka[1], Kosuke Chimoto[1], Daiki Shinoyama[2], Seiji Tsuno[3], Masahiro Korenaga[3], Nobuyuki Yamada[4], Hiroe Miyake[5], Tatsuo Kanno[6], Michiko Shigefuji[6], Masayuki Yoshimi[7], Shinichi Matsushima[8], Hiroshi Kawase[8], Kimiyuki Asano[8], Tomotaka Iwata[8] (1.Tokyo institute of Technology, 2.Central Research Institute of Electric Power Industry, 3.Railway Technical Research Institute, 4.Kochi University, 5.The University of Tokyo, 6. Kyushu University, 7.National Institute of Advanced Industrial Science and Technology, 8. Kyoto University)

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

[SSS11-05] Toward Development of Spectral Inversion Method Considering with Rupture Directivity

*Kazuhiro Somei[1,2], Kimiyuki Asano[3], Tomotaka Iwata[3] (1.Graduate School of Science, Kyoto University, 2.Geo-Research Institute, 3.Disaster Prevention Research Institute, Kyoto University)

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

[SSS11-06] Broadband Ground Motion Synthesis Using Wasserstein Interpolation of Acceleration Envelopes

*Tomohisa Okazaki[1], Hirotaka Hachiya[1,2], Asako Iwaki[3], Takahiro Maeda[3], Hiroyuki Fujiwara[3], Naonori Ueda[1] (1.RIKEN Center for Advanced Intelligence Project, 2.Wakayama University, 3.National Research Institute for Earth Science and Disaster Resilience)

[J] Oral | S (Solid Earth Sciences)：S-GL Geology

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Ch.24 Zoom Room 24

[S-GL23] Geologic structure and tectonic history of East Asia and Japanese Islands

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(Geological Survey of Japan, Research Institute of Earthquake and Volcano Geology)

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

[SGL23-01] Age spectra of detrital zircons of Paleogene fore-arc sandstones in Japan and the irreversible major change in mid-Eocene relevant to the initiation of Median Tectonic Line.

*Yukio Isozaki[1], Yukiyasu Tsutsumi[2], Tomohito Nakano[1] (1.Department of Earth Science and Astronomy, Graduate School of Arts and Sciences, The University of Tokyo, 2.Deprtment of Geology and Paleontology, National Musem of Nature and Science)

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

[SGL23-02] Zircon U-Pb ages of Momonoki Subgroup in the Koma Mountains

*Takashi Hakomori[1], Kenichiro Tani[2], Junichiro Kuroda[1], Asuka Yamaguchi[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.National Museum of Nature and Science)

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

[SGL23-03] Tectonostratigraphic characterization of Maizuru back-arc basin during its closure: geochemical and U-Pb detrital geochronological approaches.

*Larissa NGOMBI MAVOUNGOU[1], Kaushik Das[1,2], Yasutaka Hayasaka[1,2], Haruna Kuriu[1], Kenta Kawaguchi[3] (1.Department of Earth and Planetary Systems Science, Graduate School of Science, Hiroshima University, 2.HiPeR, Hiroshima, 3.Chonbuk National University, Korea)

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

[SGL23-04] Southwest Japan rotated clockwise during opening of the Japan Sea: Evidence from Miocene sediments in the Outer Zone

*Hiroyuki Hoshi[1], Hideki Iwano[2], Tohru Danhara[2] (1.Department of Earth Sciences, Aichi University of Education, 2.Kyoto Fission-Track Co., Ltd.)

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

[SGL23-05] Provenance of sandstones from the Eocene Urahoro Group, Hokkaido, Northern Japan: Tectonic Implications

*Toru Takeshita[1], Hiromi Kaji[1,2] (1.Department of Natural History Sciences, Graduate School of Science, Hokkaido University, 2.Oyo Co. Ltd.)

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

[SGL23-06] Shallow structure and late Quaternary slip rate on the Osaka Bay Fault: Aspects of climate-tectonic interaction

*Mari Hamahashi[1], Hironori Otsuka[1], Yoshiaki Suzuki[2], Jun Arimoto[2], Tetsuo Matsuno[1,3], Nobukazu Seama[1,3], Satoshi Shimizu[1,4], Hikaru Iwamaru[1,4], Mamoru Sano[1,4], Keita Suzuki[1,4], Katsuya Kaneko[1,3], Kazuo Nakahigashi[5], Itsuko Hidaka[1], Yuzuru Yamamoto[1,3], Yoshiyuki Tatsumi[1] (1.Kobe University, Ocean-Bottom Exploration Center, 2.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 3.Department of Planetology, Graduate School of Science, Kobe University, 4.Nippon Marine Enterprises, Ltd. , 5.School of Marine Resources and Environment, Tokyo University of Marine Science and Technology)

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

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Ch.25 Zoom Room 25

[S-VC28] Active Volcanism

convener:Yuta Maeda(Nagoya University), Takahiro Miwa(National research institute for earth science and disaster prevention), Takeshi Matsushima(Institute of Seismology and Volcanology, Faculty of Science, Kyushu University), Chairperson:Taketo Shimano(Graduate School of Environment and Disaster Research, Tokoha University), Takahiro Miwa(National research institute for earth science and disaster prevention)

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

[SVC28-19] Temporal variation of conduit process during the 2018 eruptive activity at Shinmoedake volcano, Japan: Implications from a time series of ash characteristics

*Takahiro Miwa[1], Masashi NAGAI[1], Hideki Ueda[1], Taku Ozawa[1], Eisuke Fujita[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

[SVC28-20] An emplacement mechanism of submarine pyroclastic products: insight form the seismic studies on Kikai caldera

*Satoshi Shimizu[1,2], Nobukazu Seama[3,1], Reina Nakaoka[1], Keiko Suzuki-Kamata[1], Koji Kiyosugi[1], Katsuya Kaneko[3,1], Tetsuo Matsuno[1], Yoshiyuki Tatsumi[1] (1.Kobe Ocean-Bottom Exploration Center, Kobe University, 2.Nippon Marine Enterprises, Ltd., 3.Department of Planetology, Graduate School of Science, Kobe University)

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

[SVC28-21] Comparison of subaerial and submarine deposits from the Kikai Akahoya eruption

*Reina NAKAOKA[1], Keiko Suzuki-Kamata[1], Satoshi Shimizu[1], Katsuya Kaneko[2], Nobukazu Seama[2], Koji Kiyosugi[1], Takeshi Hanyu[3], Yoshiyuki Tatsumi[1], CK20-S01 Leg2 Cruise Scientists, KS19-17 Cruise Scientists, KR20-11 Cruise Scientists (1.Kobe Ocean-Bottom Exploration Center, Kobe University, 2.Department of Planetology, Kobe University, 3.Japan Agency for Marine-Earth Science and Technology)

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

[SVC28-22] Tephrostratigraphy of drilled core C9010E off the Boso Peninsula: Estimated source volcano for 9th century eruption events

*Kaori Aoki[1], Makoto Kobayashi[2,1], Masanori Murata[1], Takehiko Suzuki[1] (1.Research Center for Volcanic Hazards and Their Mitigation, Tokyo Metropolitan University, 2.Mt.Fuji World Heritage Centre, Shizuoka)

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

[SVC28-23] Caldera structure and formation at Atosanupuri and Akaigawa, Hokkaido, northern Japan: A comparison of analogue sandbox experiments and field data

*Ryuhei Sanjo[1] (1.Institute of Geography, Graduate School of Science, Tohoku University)

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

[SVC28-24] Current state evaluation and long-term prediction of volcanic activity based on historical tracking of volcanic ash deposits at Suwanosejima volcano

*Taketo Shimano[1], Atsushi Yasuda[2], Masato Iguchi[3] (1.Graduate School of Environment and Disaster Research, Tokoha University, 2.Earthquake Research Institute, University of Tokyo, 3.Sakurajima Volcano Research Center, Disaster Prevention Research Institute, Kyoto University)

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

10:45 AM - 11:30 AM JST | 1:45 AM - 2:30 AM UTC | Ch.25 Zoom Room 25

[S-VC28] Active Volcanism

convener:Yuta Maeda(Nagoya University), Takahiro Miwa(National research institute for earth science and disaster prevention), Takeshi Matsushima(Institute of Seismology and Volcanology, Faculty of Science, Kyushu University), Chairperson:Urumu Tsunogai(Graduate School of Environmental Studies, Nagoya University), Takeshi Ohba(Department of chemistry, School of Science, Tokia University)

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

[SVC28-25] Behavior of magmatic components in fumarolic gases related to the 2018 phreatic eruption at Ebinokogen Ioyama volcano, Kirishima Volcanic Group, Kyushu, Japan

*Takeshi Ohba[1], Muga Yaguchi[2], Urumu Tsunogai[3], Masanori Ito[3], Ryo Shingubara[3] (1.Department of chemistry, School of Science, Tokia University, 2.Meteorol. Res. Inst., 3.Grad. School of Envir. Studies Nagoya University)

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

[SVC28-26] Time variation in the composition of volcanic gases at Mt Hakone (2018-2020)

*Seiya Toyoshima[1], Nozomi Numanami[1], Takeshi Ohba[1], Muga Yaguchi[2] (1.Tokai University, 2.Meteorological Research Institute, JMA)

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

[SVC28-27] **Development of an automatic volcanic plume sampler SelPS for UAS**

*Urumu Tsunogai[1], Ryo Shingubara[1], Masanori Ito[1], Yuhei Morishita[1], Fumiko Nakagawa[1], Shin Yoshikawa[2], Mitsuru Utsugi[2], Akihiko Yokoo[2] (1.Graduate School of Environmental Studies, Nagoya University, 2.Graduate School of Science, Kyoto University)

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

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Ch.25 Zoom Room 25

[S-VC31] Dynamics of volcanic eruptions and their physical and chemical processes

convener:Yujiro Suzuki(Earthquake Research Institute, The University of Tokyo), Atsuko Namiki(Graduate School of Environmental Studies, Nagoya University), Masatoshi Ohashi(Earthquake Research Institute, the University of Tokyo), Chairperson:Yujiro Suzuki(Earthquake Research Institute, The University of Tokyo), Masatoshi Ohashi(Earthquake Research Institute, the University of Tokyo)

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

[SVC31-01] Experimental constraint on redox evolution of magma during decompression

★Invited Papers

*Satoshi Okumura[1], Hidemi Ishibashi[2], Shoichi Itoh[3], Akimasa Suzumura[3], Yoshihiro Furukawa[1], Takahiro Miwa[4], Hiroyuki Kagi[5] (1.Division of Earth and Planetary Materials Science, Department of Earth Science, Graduate School of Science, Tohoku University, 2.Department of Geosciences, Fuculty of Science, Shizuoka University, 3.Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University, 4.National Research Institute for Earth Science and Disaster Resilience, 5.Geochemical Research Center, Graduate School of Science, The University of Tokyo)

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

[SVC31-02] Factors affecting the sequence of Asama volcano 1783 eruption inferred from rock texture

*Tatsuki Mizuno[1], Fukashi Maeno[1], Atsushi Yasuda[1] (1.Earthquake Research Institute, Department of Earth and Planetary Science, University of Tokyo)

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

[SVC31-03] Genesis of vesiculation in dolerite sills of the Shimokawa ophiolite in the northern Hidaka belt, Hokkaido: Genesis of trachyte in the MORB

*Kato Satomi[1], Sumio Miyashita[2] (1.Graduate School of Science and Technology, Niigata University, 2.Hokkaido Research Center of Geology)

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

[SVC31-04] Discussion time

*Yujiro Suzuki[1] (1.Earthquake Research Institute, 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 | Ch.25 Zoom Room 25

[S-VC31] Dynamics of volcanic eruptions and their physical and chemical processes

convener:Yujiro Suzuki(Earthquake Research Institute, The University of Tokyo), Atsuko Namiki(Graduate School of Environmental Studies, Nagoya University), Masatoshi Ohashi(Earthquake Research Institute, the University of Tokyo), Chairperson:Atsuko Namiki(Graduate School of Environmental Studies, Nagoya University), Masatoshi Ohashi(Earthquake Research Institute, the University of Tokyo)

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

[SVC31-05] The run-out distance of large-scale pyroclastic density currents in magmatic and phreatomagmatic eruptions: Numerical simulations of a two-layer depth-averaged model

*Hiroyuki A. Shimizu[1], Takehiro Koyaguchi[2], Yujiro J. Suzuki[2] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Earthquake Research Institute, The University of Tokyo)

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

[SVC31-06] Effects of the dynamics of conduit flow with a plug on pre-eruptive crustal deformation

*Tomofumi Kozono[1], Chihiro Matsuno[2] (1.Department of Geophysics, Graduate School of Science, Tohoku University, 2.IDAJ Co., LTD.)

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

[SVC31-07] Volcanic glow fluctuation prior to vulcanian eruptions at Showa Crater, Sakurajima volcano, Japan

*Dan Muramatsu[1], Koki Aizawa[2], Akihiko Yokoo[3], Masato Iguchi[4] (1.Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2.Institute of Seismology and Volcanology, Faculty of Science, Kyushu University, 3.Aso Volcanological Laboratory, Institute for Geothermal Sciences, Kyoto University, 4.Sakurajima Volcano Research Center, Disaster Prevention Reserach Institute, Kyoto University)

4:15 PM - 4:45 PM JST | 7:15 AM - 7:45 AM UTC

[SVC31-08] Discussion time

*Atsuko Namiki[1] (1.Graduate School of Environmental Studies, Nagoya University)

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

[SVC31-09] Discussion

[J] Oral | S (Solid Earth Sciences)：S-GC Geochemistry

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Ch.24 Zoom Room 24

[S-GC33] Solid Earth Geochemistry, Cosmochemistry

convener:Gen Shimoda(Geological Survey of Japan, AIST), Katsuhiko Suzuki(Submarine Resources Research Center, Japan Agency for Marine-Earth Science and Technology), Katsuyuki Yamashita(Graduate School of Natural Science and Technology, Okayama University), Akira Ishikawa(Department of Earth and Planetary Sciences, Tokyo Institute of Technology), Chairperson:Katsuhiko Suzuki(Submarine Resources Research Center, Japan Agency for Marine-Earth Science and Technology), Katsuyuki Yamashita(Graduate School of Natural Science and Technology, Okayama University), Akira Ishikawa(Department of Earth and Planetary Sciences, Tokyo Institute of Technology), Gen Shimoda(Geological Survey of Japan, AIST)

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

[SGC33-01] Highly siderophile elements in Earth's oldest rocks from Acasta Gniess Complex, Canada: an impact melt origin or not?

*Akira Ishikawa[1,2], Keiko Koshida, Katsuhiko Suzuki[2], Tetsuya Yokoyama[1], Tsuyoshi Komiya[3] (1.Department of Earth and Planetary Sciences, Tokyo Institute of Technology, 2.Submarine Resources Research Center, Japan Agency for Marine-Earth Science and Technology, 3.Graduate School of Arts and Sciences, The University of Tokyo)

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

[SGC33-02] Estimation of highly siderophile element abundances in the primitive mantle from the perspective of the pyrolite model

*Tetsu Kogiso[1], Akira Ishikawa[2], Norikatsu Akizawa[3] (1.Kyoto University, 2.Tokyo Institute of Technology, 3.The University of Tokyo)

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

[SGC33-03] Chromium and titanium stable isotope measurements for volcanic rocks derived from deep mantle

*Yuki Hibiya[1], Tsuyoshi Iizuka[2], Katsuhiko Suzuki[1], Shigekazu Yoneda[3] (1.Submarine Resources Research Center, Japan Agency for Marine-Earth Science and Technology, 2.The University of Tokyo, 3.National Museum of Nature and Science)

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

[SGC33-04] $^{182}W/^{184}W$ of the komatiites from Dharwar and Singhbhum cratons, India: implications for the early evolution of the mantle

*Katsuhiko Suzuki[1,5], Madhusoodhan Satish-Kumar[2], Trisrota Chaudhuri[3], M. Jayananda[4] (1.Submarine Resources Research Center, Japan Agency for Marine-Earth Science and Technology, 2.Department of Geology, Faculty of Science, Niigata University, 3.Department of Geology, University of Calcutta, 4.Centre Earth and Space Sciences, University of Hyderabad, 5.Department of Earth Sciences, Graduate School of Science, Tohoku University)

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

[SGC33-05] The magma generation process of the North Sredinny Range, Kamchatka – Insights from highly siderophile elements and Re-Os isotope system

Yuri Mitsude[1], *Tatsuji Nishizawa[2], Hitomi Nakamura[3], Tatiana Churikova[4], Boris Gordeychik[5], Akira Ishikawa[6], Hikaru Iwamori[1] (1.Earthquake Research Institute, The University of Tokyo, 2.Volcanic Fluid Research Center, School of Science, Tokyo Institute of Technology, 3.Institute of Earthquake and Volcano Geology, Geological Survey of Japan, AIST, 4.Institute of Volcanology and Seismology, Far East Branch, RAS, 5.Institute of Experimental Mineralogy, RAS, 6.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

[SGC33-06] The characteristics of highly siderophile elements in the high-Mg andesite and basalts and its implications for the origin of the Quaternary arc magmatism in the forearc region, Kamchatka

*Tatsuji Nishizawa[1], Yuri Mitsude[2], Hitomi Nakamura[3], Tatiana Churikova[4], Boris Gordeychik[5], Akira Ishikawa[6], Hikaru Iwamori[2] (1.Volcanic Fluid Research Center, School of Science, Tokyo Institute of Technology, 2.Earthquake Research Institute, The University of Tokyo, 3.Institute of Earthquake and Volcano Geology, Geological Survey of Japan, AIST, 4.Institute of Volcanology and Seismology, Far East Branch, RAS, 5.Institute of Experimental Mineralogy, RAS, 6.Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology)

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

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Ch.22 Zoom Room 22

[S-TT36] Synthetic Aperture Radar and its application

convener:Yohei Kinoshita(University of Tsukuba), Takahiro Abe(Graduate School of Bioresources, Mie University), Shoko Kobayashi(Tamagawa University), Yuji Himematsu(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Takahiro Abe(Graduate School of Bioresources, Mie University), Yohei Kinoshita(University of Tsukuba)

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

[STT36-01] Automatic error-term estimation approach for improving the accuracy of InSAR time-series analysis - Example on the Arima-Takatsuki Fault Zone, Japan

*Yo Fukushima[1] (1.International Research Institute of Disaster Science, Tohoku University)

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

[STT36-02] Correlation between surface displacement and groundwater level displacement in the periods before and after the 2018 Northern Osaka earthquake

*Yutaro Shigemitsu[1], Kazuya Ishitsuka[1], Weiren Lin[1] (1.Kyoto University Graduate School of Engineering)

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

[STT36-03] Landslide and its displacement along the Marsyangdi River, Nepal detected by differential interferometric SAR

*Seiya Usami[1], Hiroshi, P. Sato[2], Hiroshi YAGI[3] (1.Grad student, Graduate School of Science and Technology, Nihon University, 2.College of Humanities and Science, Nihon University, 3.Faculty of Art, Science and Education, Yamagata University)

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

[STT36-04] Road blockage detection due to landslides using Sentinel-1 intensity images

*Keisho Ito[1], Yohei Kinoshita[1] (1.Tsukuba University)

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

[STT36-05] Short-term glacier velocity changes in the Southern Patagonian Ice Field detected by the Sentinel-1 satellite

*Yuya Ito[1], Masato Furuya[2] (1.Graduate School of Science, Hokkaido University, 2.Department of Earth and Planetary Hokkaido University)

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

[STT36-06] Discussion of the colour map for SAR interferograms

*Morishita Yu[1] (1.Geospatial Information Authority of Japan)

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

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Ch.22 Zoom Room 22

[S-TT36] Synthetic Aperture Radar and its application

convener:Yohei Kinoshita(University of Tsukuba), Takahiro Abe(Graduate School of Bioresources, Mie University), Shoko Kobayashi(Tamagawa University), Yuji Himematsu(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Masatsugu otsuki(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Yuji Himematsu(National Research Institute for Earth Science and Disaster Resilience)

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

[STT36-07] Examination of extraction method of topographical change due to eruption of Nishinoshima using time series SAR

*Daiki Inano[1], Masanobu Shimada[2] (1.Tokyo Denki University, graduate school of science and engineering ,division of architectural, civil and environmental engineering, 2.Tokyo Denki University, division of architectural, civil and environmental engineering)

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

[STT36-08] Tropospheric Dispersive Phase Anomalies during Heavy Rain Detected by L-band InSAR and Their Interpretation

Naufal Setiawan[1], *Masato Furuya[1] (1.Department of Earth and Planetary Sciences Hokkaido University)

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

[STT36-09] Error level evaluation of L-Band InSAR Water Vapor Observation by Comparison with GNSS Observations

*Keita Matsuzawa[1], Yohei Kinoshita[1] (1.University of Tsukuba)

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

[STT36-10] **Comparison of atmospheric delay correction methods in InSAR: Case study in Japan**

*Sardila Nurulhikmah Sailellah[1], Yo Fukushima[2] (1.Geophysics Department, Graduate School of Science Tohoku University, 2.International Research Institute of Disaster Science, Tohoku University)

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

[STT36-11] Development of ground-based radar interferometer for volcano deformation monitoring

*Taku Ozawa[1], Yuji Himematsu[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

[STT36-12] Small SAR satellite development and solution services

★Invited Papers

*Shuji Fujimaru[1] (1.Synspective Inc.)

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

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Ch.21 Zoom Room 21

[S-TT38] 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), Ryoichiro Agata(Japan Agency for Marine-Earth Science and Technology), Chairperson:Takane Hori(R&D Center for Earthquake and Tsunami, Japan Agency for Marine-Earth Science and Technology), Ryoichiro Agata(Japan Agency for Marine-Earth Science and Technology)

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

[STT38-01] On large-scale numerical simulation of earthquake generation, wave propagation and soil amplification aiming for comprehensive earthquake damage estimation

Takane Hori[1], Tsuyoshi Ichimura[2,3,4], Kohei Fujita[2,3], *Ryoichiro Agata[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Earthquake Research Institute, 3.Riken Center for Computational Science, 4.Riken Center for Advance Intelligence Project)

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

[STT38-02] Large-scale earthquake simulation with supercomputing and data-learning

★Invited Papers

*Tsuyoshi Ichimura[1] (1.the University of Tokyo)

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

[STT38-03] Comparison of E-wave FEM and GMS in Calculation of Long-Period Ground Motion in 3D Heterogeneous Underground Structures

*Ryoichiro Agata[1], Yoshihisa Hiyoshi[1], Sayako Hirobe[1], Takahiro Maeda[2], Asako Iwaki[2], Kohei Fujita[3,4], Hiroyuki Fujiwara[2], Tsuyoshi Ichimura[3,4,5], Takane Hori[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.National Research Institute for Earth Science and Disaster Resilience, 3.Earthquake Research Institute, 4.Riken Center for Computational Science, 5.Riken Center for Advance Intelligence Project)

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

[STT38-04] Three-dimensional thermal structure modeling in the Alaska subduction zone

*Kaya Iwamoto[1], Nobuaki Suenaga[2], Shoichi Yoshioka[2,1] (1.Department of Planetology, Graduate School of Science, Kobe University, 2. Research Center for Urban Safety and Security, Kobe University,)

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

[STT38-05] Sensitivity analysis with large-scale 3D finite element crust structure model for seafloor geodetic constraints on coseismic slip and interseismic slip-deficit distributions

*Sota Murakami[1], Tsuyoshi Ichimura[1], Kohei Fujita[1], Takane Hori[2], Yusaku Ohta[3] (1.Earthquake Research Institute, The University of Tokyo, 2.R&D Center for Earthquake and Tsunami, Japan Agency for Marine-Earth Science and Technology, 3.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University)

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

[STT38-06] Discussion

[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Ch.19 Zoom Room 19

[S-CG45] Ocean Floor Geoscience

convener:Kyoko Okino(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Yukari Kido(Japan Agency for Marine-Earth Science and Technology), Asuka Yamaguchi(Atomosphere and Ocean Research Institute, The University of Tokyo)

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

[SCG45-01] JAMSTEC Contribution to the NIPPON FOUNDATION-GEBCO SEABED2030 Project

*Yukari Kido[1], Mitsuko Hidaka[1], Daisuke Matsuoka[1], Tatsu Kuwatani[1], Junji Kaneko[1], Takafumi Kasaya[1], Yoichi Ishikawa[1], Eiichi Kikawa[1] (1.Japan Agency for Marine-Earth Science and Technology)

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

[SCG45-02] The new tectonic model between the Madagascar Ridge and the Del Cano Rise in the southern Indian Ocean

*Taichi Sato[1], Yoshifumi Nogi[2], Hiroshi Sato[3], Masakazu Fujii[2] (1.National Institute of Advanced Industrial Science and Technology, 2.National Institute of Polar Research, 3.Senshu University)

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

[SCG45-03] Sedimentation process at the South Shetland Trench in the Antarctic Ocean

*Asuka Yamaguchi[1] (1.Atomosphere and Ocean Research Institute, The University of Tokyo)

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

[SCG45-04] Highly refractory dunite formation in Gibbs Island and Bruce Bank, and its role in the evolution of the circum-Antarctic continent

*Norikatsu Akizawa[1], Asuka Yamaguchi[1], Chihiro Ohshima[1], Kenichiro Tani[2], Akira Ishikawa[3], Ryo Fujita[3], SUNG HI CHOI[4] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.National Museum of Nature and Science, 3.Tokyo Institute of Technology, 4.Chungnam National University)

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

[SCG45-05] Magmatic evolutions erupted on the Cretaceous seamount province, western Pacific Plate

*Naoto Hirano[1], Hirochika Sumino[2], Taisei Morishita[3] (1.Center for Northeast Asian Studies, Tohoku University, 2.Graduate School of Arts and Sciences, The University of Tokyo, 3.Hydrographic and Oceanographic Department, Japan Coast Guard)

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

[SCG45-06] **Pre-stack depth imaging and pore-fluid pressure estimation along the Nankai Trough subduction zone off the Kii Peninsula, SW Japan**

*YU FAN[1], Ehsan Jamali Hondori[1], Jin-Oh Park[1] (1.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 | Ch.19 Zoom Room 19

[S-CG45] Ocean Floor Geoscience

convener:Kyoko Okino(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Ryuta Arai(Japan Agency for Marine-Earth Science and Technology), Masakazu Fujii(National Institute of Polar Research and SOKENDAI)

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

[SCG45-07] Marine and earth science surveys in the Okinawa Trough for the IODP Scientific Drilling: Hakuhomaru KH-21-3 cruise preliminary reports

*Makoto Otsubo[1], Yoshimi Kubota[2], Ayanori Misawa[1], Ken Ikehara[1], Saki Ishino[1], Masataka Kinoshita[3], Kenji Matsuzaki[4], Katsura Kameo[4], Chiori Tamura[4], Ryuta Arai[5], Tomohiro Toki[6], Yuki Mitsudome[6], Zhirong Cai[7], Keiko Takehara[8], Kodai Kato[8], Daisuke Kuwano[9], Koshiro Matsuo[10], Keita Suzuki[11], Misaki Horiuchi[11], Yohei Katayama[12], Satoshi Okumura[13] (1.Geological Survey of Japan, AIST, 2.National Museum of Nature and Science, 3.The University of Tokyo, ERI, 4.The University of Tokyo, AORI, 5.JAMSTEC, 6.University of Ryukyus, 7.Kyoto University, 8.Kochi University, 9.Chiba University, 10.Kyushu University, 11.Nippon Marine Enterprises, Ltd., 12.Marine Works Japan, Ltd., 13.MOL Marine Co., Ltd.)

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

[SCG45-08] Structure and seismicity in the southern part of the Okinawa Trough and their implications for rifting and volcanic processes

*Ryuta Arai[1], Ayanori Misawa[2], Makoto Otsubo[2], Saki Ishino[2], Masataka Kinoshita[3], KH-21-3 Shipboard Scientists (1.Japan Agency for Marine-Earth Science and Technology, 2.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 3.Earthquake Research Institute, The University of Tokyo)

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

[SCG45-09] Heat flow anomaly in the southern part of Okinawa Trough – A preliminary result from the KH-21-3 cruise-

*Masataka Kinoshita[1], Ryuta Arai[2], Chiori Tamura[3], Ayanori Misawa[4], Saki Ishino[4], Makoto Otsubo[4], Shipboard Scientists KH-21-3 (1.Earthquake Research Institute, The University of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology, 3.Atmospheric and Ocean Research Institute, the University of Tokyo, 4.National Institute of Advanced Industrial Science and Technology)

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

[SCG45-10] GNSS/Acoustic geodetic measurement at the southern end of Ryukyu Trench 2014-2020

*Akihiro Nagaya[1], Ryoya Ikuta[2], Mamoru Nakamura[3], Masataka Ando[4] (1.Undergraduate school of department of Geoscience, Shizuoka University, 2.Faculty of Science, Shizuoka University, 3.Faculty of Science, University of the Ryukyu, 4.Center for Natural Hazards of Integrated Education and Research, Shizuoka University)

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

[SCG45-11] Fluid-flow simulation for clarifying ore generation processes in the Izena Hole hydrothermal field, Okinawa Trough

*Shohei Albert Tomita[1], Katsuaki Koike[1], Tada-nori Goto[2], Katsuhiko Suzuki[3], Takafumi Kasaya[3] (1.Graduate School of Engineering, Kyoto University, 2.Graduate School of Life Science, University of Hyogo, 3.Research and Development Center for Submarine Resources, Japan Agency for Marine-Earth Science and Technology (JAMSTEC))

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

[SCG45-12] Examining the origin and depositional process of turbidites in the southern part of Okinawa Trough based on cores from Expedition KH-21-3

*Cai Zhirong[1], Hajime Naruse[1], Ken Ikehara[2], KH-21-3 Shipboard Scientists - (1.Department of Geology and Mineralogy, Graduate School of Science, Kyoto University, 2.Institute of Geology and Geoinformation, National Institute of Advanced Industrial 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 | Ch.19 Zoom Room 19

[S-CG45] Ocean Floor Geoscience

convener:Kyoko Okino(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Motoyuki Kido(International Research Institute for Disaster Science, Tohoku University), Fumiaki Tomita(Japan Agency for Marine-Earth Science and Technology)

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

[SCG45-13] Preliminary results of ocean bottom pressure observation around Kikai submarine caldera, SW Japan

Yuko Asai[1], *Nobukazu Seama[1,2], Tomoko Hanyu[2], Tetsuo Matsuno[2,1], Hitoshi Hirose[3,1], Takuto Minami[1], Hiroko Sugioka[2,1] (1.Department of Planetology, Graduate School of Science, Kobe University, 2.Kobe Ocean Bottom Exploration Center, Kobe University, 3.Research Center for Urban Safety and Security, Kobe University)

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

[SCG45-14] Characteristic of depth dependence and annual variation of OBP time series in DONET

*Hideto Otsuka[1], Yusaku Ohta[1], Ryota Hino[1], Tatsuya Kubota[2], Daisuke Inazu[3] (1.Department of Geophysics, Graduate School of Science, Tohoku University, 2.National Research Institute for Earth Science and Disaster Resilience, 3.Department of Marine Resources and Energy, Tokyo University of Marine Science and Technology)

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

[SCG45-15] GNSS-Acoustic observations using a Wave Glider and their results

*Fumiaki Tomita[1], Takeshi Iinuma[1], Motoyuki Kido[2], Yusaku Ohta[3], Chie Honsho[3], Tatsuya Fukuda[1], Takane Hori[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.International Research Institute of Disaster Science, Tohoku University, 3.Graduate School of Science, Tohoku University)

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

[SCG45-16] Semi-realtime transmission of GNSS-A data using a Wave Glider

*Motoyuki Kido[1], Tatsuya Fukuda[2], Yusaku Ohta[3], Fumiaki Tomita[2], Chie Honsho[3], Takeshi Iinuma[2] (1.IRIDeS, Tohoku University, 2.JAMSTEC, 3.Sci. Division, Tohoku University)

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

[SCG45-17] Operation experiment of the system for seafloor crustal deformation observation system using a buoy

*Keiichi Tadokoro[1], Natsuki Kinugasa[1], Teruyuki Kato[2], Yukihiro Terada[3], Kenjiro Matsuhiro[4], Haruno Koike[4] (1.Research Center for Seismology, Volcanology and Earthquake and Volcano Research Center, Nagoya University, 2.Hot Springs Research Institute of Kanagawa Prefectural Government, 3.National Institute of Technology, Kochi College, 4.Technical Center, Nagoya University)

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

[SCG45-18] Initial results of sea trials on bathymetric survey performance of “AUV-NEXT”: aiming to acquire higher-quality bathymetric data

*MASANAO SUMIYOSHI[1], Ryosuke Nagasawa[1], Takashi Hashimoto[1], Kenji Nagahashi[2], Takao Sawa[2], Tadahiro Hyakudome[2], Takeshi Nakatani[2], Tatsuya Aso[2], Yusuke Yokota[3] (1.Hydrographic and Oceanographic Department, Japan Coast Guard, 2.JAMSTEC, 3.Institute of Industrial Science, 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 | Ch.20 Zoom Room 20

[S-CG46] Rheology, fracture and friction in Earth and planetary sciences

convener:Shintaro Azuma(Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology), Ichiko Shimizu(Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University), Osamu Kuwano(Japan Agency for Marine-Earth Science and Technology), Miki Tasaka(Shizuoka University), Chairperson:Shintaro Azuma(Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology), Miki Tasaka(Shizuoka University)

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

[SCG46-01] Low stress power-law creep of olivine

★Invited Papers

*Kosuke Yabe[1], Kenta Sueyoshi[1], Takehiko Hiraga[1] (1.Earthquake Research Institute, the University of Tokyo)

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

[SCG46-02] Vickers indentation tests on olivine: grain size and indentation size effects

*Sanae Koizumi[1], Takehiko Hiraga[1] (1.Earthquake Research Institute,The University of Tokyo)

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

[SCG46-03] Extremely slow grain growth of albitic feldspar

*Norio Shigematsu[1], Masanori Kido[1], You Zhou[2], Hideki Hyuga[2], Yuichi Yoshizawa[2] (1.Research Institute of Earthquake and Volcano Geology, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2.Multi-material Research Institute, National Institute of Advanced Industrial Science and Technology)

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

[SCG46-04] The effect of grain size and porosity on compaction localisation in high-porosity sandstones

*Elliot Rice-Birchall[1], Daniel R Faulkner[1], John D Bedford[1,2] (1.University of Liverpool, 2.Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology (JAMSTEC))

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

[SCG46-05] Deformation of simulated quartz-feldspar faults at the brittle-ductile transition zone

*Miho Furukawa[1], Berend A. Verberne[2], Jun Muto[1], Miki Takahashi[2], Hiroyuki Nagahama[1] (1.Department of Earth Sciences, Tohoku University, 2.Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology (AIST))

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

[SCG46-06] Initial results on high Pc-Pp-T rock deformation experiments under drained conditions

★Invited Papers

*Keishi Okazaki[1], Jun Muto[2] (1.Japan Agency for Marine-Earth Science and Technology, 2.Department of Earth Sciences, 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 | Ch.20 Zoom Room 20

[S-CG46] Rheology, fracture and friction in Earth and planetary sciences

convener:Shintaro Azuma(Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology), Ichiko Shimizu(Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University), Osamu Kuwano(Japan Agency for Marine-Earth Science and Technology), Miki Tasaka(Shizuoka University), Chairperson:Ichiko Shimizu(Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University), Osamu Kuwano(Japan Agency for Marine-Earth Science and Technology)

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

[SCG46-07] Dehydration experiments of antigorite serpentinite under slab-mantle conditions

Sakurako Okude[1], *Ichiko Shimizu[1] (1.Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University)

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

[SCG46-08] Variation of stick-slip behaviors controlled by dehydration kinetics of simulated gypsum gouges

*Mikihiro Kawabata[1], Rei Shiraishi[1], Jun Muto[1], Hiroyuki Nagahama[1], Yuto Sasaki[2] (1.Department of Earth Science, Graduate School of Science and Faculty of Science, Tohoku University, 2.Earthquake Research Institute, The University of Tokyo)

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

[SCG46-09] Experimental study on drainage process of liquid film between bubbles during bubble growth

★Invited Papers

*Masatoshi Ohashi[1], Atsushi Toramaru[1], Atsuko Namiki[2] (1.Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2.Graduate School of Environmental Studies Department of Earth and Environmental Sciences)

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

[SCG46-10] Transition from viscous to inertial regime in dense frictional suspensions

*Franco Antonio Tapia[1], Olivier Pouliquen[3], Elisabeth Guazzelli[2] (1.Department of Mechanical Systems Engineering, Tokyo University of Agriculture and Technology, 2.Université de Paris, CNRS, Matière et Systèmes Complexes (MSC) UMR 7057, Paris, France, 3.Aix-Marseille Université, CNRS, IUSTI, Marseille, France)

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

[SCG46-11] Peridodic fluctation in a compressed dust-aggregate layer

*Hiroaki Katsuragi[1], Felipe Pacheco Vazquez[2], Tomomi Omura[3] (1.Department of Earth and Space Science, Osaka University, 2.BUAP, Mexico, 3.Osaka Sangyo University)

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

[SCG46-12] Elasto-plastic behavior of carbonate rocks under high strain rate deformation

★Invited Papers

*Kosuke Kurosawa[1], Hidenori Genda[2], Shintaro Azuma[3], Keishi Okazaki[4], Haruka Oono[1], Takafumi Niihara[5], Takashi Mikouchi[6], Naotaka Tomioka[4], Tatsuhiro Sakaiya[7], Tadashi Kondo[7], Masahiro KAYAMA[8], Mizuho Koike[9], Yuji Sano[10], Takuya Matsuzaki[11], Masafumi MURAYAMA[11], wataru Satake[1], Takafumi Matsui[1,12] (1.Planetary Exploration Research Center, Chiba Institute of Technology, 2.Earth–Life Science Institute, Tokyo Institute of Technology, 3.Department of Earth and Planetary Sciences, Tokyo Institute of Technology, 4.Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology, 5.Department of Systems Innovation, School of Engineering, The University of Tokyo, 6.The University Museum, The University of Tokyo, 7.Department of Earth and Space Science, Graduate School of Science, Osaka University, 8.Department of General Systems Studies, Graduate School of Arts and Sciences, The Univ. of Tokyo, 9.Department of Earth and Planetary Systems Science, Graduate School of Science, Hiroshima University, 10.Atmosphere and Ocean Research Institute, The University of Tokyo, 11.Center for Advanced Marine Core Research, Kochi University, 12.Institute of Geo-Cosmology, Chiba 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 | Ch.02 Zoom Room 02

[M-IS12] Planetary Volcanology

convener:Rina Noguchi(Faculty of Science, Niigata University), Nobuo Geshi(Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Tomokatsu Morota(Department of Earth and Planetary Science, The University of Tokyo), Chairperson:Rina Noguchi(Faculty of Science, Niigata University), Nobuo Geshi(Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Tomokatsu Morota(Department of Earth and Planetary Science, The University of Tokyo)

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

[MIS12-01] Structures and formation age of lunar linear gravity anomalies constrained by impact simulations

*Gaku Nishiyama[1], Noriyuki Namiki[2], Seiji Sugita[1] (1.University of Tokyo, 2.National Astronomical Observatory of Japan)

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

[MIS12-02] Laboratory investigations of salt precipitation upon decompression and degassing of volatile-containing brines: Implication for carbonate mineral formations on Solar system icy bodies

*Masahiro Yoda[1,2], Yasuhito Sekine[2,3] (1.Department of Earth and Planetary Science, The University of Tokyo, 2.Earth-Life Science Institute of Tokyo Tech, 3.Institute of Nature and Environmental Technology, Kanazawa University)

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

[MIS12-03] Rootless cones in the southwest of Emuruangogolak Volcano, Kenya

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

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

[MIS12-04] Conditions for the formation of rootless cones on Mars and Earth

*Kei Kurita, Rina Noguchi[1] (1.ISAS/JAXA)

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

[MIS12-05] Development of an efficient geological survey method for volcanoes on extraterrestrial bodies

★Invited Papers

*Junichi Haruyama[1], Rina Noguchi[1], Nobuo Geshi[2], Motomaro Shirao[3], Keiichiro Fujimoto[1], Daigo Shoji[1] (1.Japan Aerospace Exploration Agency, 2.National Institute of Advanced Industrial Science and Technology, 3.Institute of Planetary Geology)

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

[MIS12-06] Discussion

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Ch.02 Zoom Room 02

[M-IS14] Aqua planetology

convener:Yasuhito Sekine(Earth-Life Science Insitute, Tokyo Institute of Technology), Takazo Shibuya(Japan Agency for Marine-Earth Science and Technology), Hidenori Genda(Earth-Life Science Institute, Tokyo Institute of Technology), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Chairperson:Takazo Shibuya(Japan Agency for Marine-Earth Science and Technology), Yasuhito Sekine(Earth-Life Science Insitute, Tokyo Institute of Technology), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Tomohiro Usui(Japan Aerospace Exploration Agency), Hidenori Genda(Earth-Life Science Institute, Tokyo Institute of Technology)

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

[MIS14-01] Internal heating of icy ocean worlds

*Shunichi Kamata[1], Kento Nakanishi[1], Kiyoshi Kuramoto[1] (1.Faculty of Science, Hokkaido University)

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

[MIS14-02] Field investigations on salt partitioning in frozen closed-basin lakes in Mongolia as terrestrial analogues of subsurface brine reservoirs on Solar System icy bodies

*Masahiro Yoda[1,2], Yasuhito Sekine[2,3], Keisuke Fukushi[3], Takuma Kitajima[4], Baasansuren Gankhurel[4], Davaadorj Davaasuren[5], Tuvshin Gerelmaa[5], Shuukhaaz Ganbat[4], Daigo Shoji[6], Yoshio Takahashi[1] (1.Department of Earth and Planetary Science, The University of Tokyo, 2.Earth-Life Science Institute of Tokyo Tech, 3.Institute of Nature and Environmental Technology, Kanazawa University, 4.Division of Earth and Environmental Sciences, Graduate School of Natural Science and Technology, 5.Department of Geography, The National University of Mongolia, 6.Institute of Space and Astronautical Science, Japan Astronautical Exploration Agency)

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

[MIS14-03] In-situ observation of gas hydrate formation as a simulation of the bottom of ice crust in icy bodies

*Atsushi Tani[1], Kenshiro Moriyama[1] (1.Department of Human Environmental Science, Graduate School of Human Development and Environment, Kobe University)

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

[MIS14-04] Evolution processes of asteroid Ryugu inferred from orbit and spin dynamics

*Masanori Kanamaru[1], Ryuki Hyodo[1], Tomohiro Usui[1], Tatsuaki Okada[1] (1.Japan Aerospace Exploration Agency)

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

[MIS14-05] Oxygen isotopic systematics of chondrules in Tagish Lake (C2) and implications of volatiles in the protoplanetary disk

*Takayuki Ushikubo[1], Makoto Kimura[2] (1.Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology, 2.National Institute of Polar Research)

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

[MIS14-06] Development of a technique for a multi-isotopic analyses of asteroid materials (small amount samples ~ 30 mg) returned by the Hayabusa2 mission

*Tetsuya Yokoyama[1], Ikshu Gautam[1], Yusuke Ohkuma[1], Tsuyoshi Iizuka[2], The Hayabusa2 initial analysis team “Isotopes and Chemistry” (1.Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology, 2.Department of Earth and Planetary Science, School of Science, 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 | Ch.02 Zoom Room 02

[M-IS14] Aqua planetology

convener:Yasuhito Sekine(Earth-Life Science Insitute, Tokyo Institute of Technology), Takazo Shibuya(Japan Agency for Marine-Earth Science and Technology), Hidenori Genda(Earth-Life Science Institute, Tokyo Institute of Technology), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Chairperson:Yasuhito Sekine(Earth-Life Science Insitute, Tokyo Institute of Technology), Takazo Shibuya(Japan Agency for Marine-Earth Science and Technology), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Tomohiro Usui(Japan Aerospace Exploration Agency), Hidenori Genda(Earth-Life Science Institute, Tokyo Institute of Technology)

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

[MIS14-07] Comparative metagenomic studies of diverse serpentinized ecosystems

★Invited Papers

*Shino Suzuki[1], Shunichi Ishii[2], Nealson H. Kenneth[3] (1.JAXA, 2.JAMSTEC, 3.USC)

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

[MIS14-08] Thioester synthesis through geoelectrochemical CO2 fixation on Ni and Mo sulfides.

*Norio Kitadai[1] (1.Japan Agency for Marine-Earth Science and Technology)

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

[MIS14-09] Effects of pH on the ribose synthesis in the formose reaction: implication for abiotic synthesis on ancient Mars

*Chinatsu Ono[1], Takeshi Kakegawa[1], Yoshihiro Furukawa[1] (1.Graduate School of Science, Tohoku University)

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

[MIS14-10] Elucidation of the mechanism of organic matter synthesis process by reducing reaction of clay minerals on the surface of the planet by STXM

*Takahiro Kawai[1], Hiroki Suga[2], Yasuo Takeichi[3], Yoshio Takahashi[1,3] (1.University of Tokyo, 2.JASRI, 3.KEK-PF)

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

[MIS14-11] Solubility of amorphous magnesium carbonate: rarity of Mg-carbonate on surface of closed-basin lakes that existed on early Mars

*TAKUMA KITAJIMA[1], Keisuke Fukushi[2], Yasuhito Sekine[2,3], Masahiro Yoda[3,4], Baasansuren Gankhurel[1], Davaadorj Davaasuren[5] (1.Kanazawa university, 2.The Institute of Nature and Environmental Technology, Kanazawa University, 3.Earth-Life Science Institute, Tokyo Institute of Technology, 4.Department of Earth and Planetary Science, The University of Tokyo, 5.Department of Environment and Forest Engineering, The National University of Mongolia)

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

[MIS14-12] **Parent body processes reproduce soluble organics in carbonaceous chondrites via geo-electrochemistry**

★Invited Papers

*LI Yamei[1], Yasuhito Sekine[1], Norio Kitadai[1,2] (1.Earth-Life science Institute, Tokyo Institute of Technology, 2.Japan Agency for Marine-Earth Science and Technology)

[J] Oral | M (Multidisciplinary and Interdisciplinary) : M-IS Intersection

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Ch.02 Zoom Room 02

[M-IS14] Aqua planetology

convener:Yasuhito Sekine(Earth-Life Science Insitute, Tokyo Institute of Technology), Takazo Shibuya(Japan Agency for Marine-Earth Science and Technology), Hidenori Genda(Earth-Life Science Institute, Tokyo Institute of Technology), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Chairperson:Hidenori Genda(Earth-Life Science Institute, Tokyo Institute of Technology), Yasuhito Sekine(Earth-Life Science Insitute, Tokyo Institute of Technology), Tomohiro Usui(Japan Aerospace Exploration Agency), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Takazo Shibuya(Japan Agency for Marine-Earth Science and Technology)

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

[MIS14-13] Degassing history and the structural evolution of Martian mantle

★Invited Papers

*Masaki Ogawa[1] (1.Division of General Systems Studies, Graduate School of Arts and Sciences, University of Tokyo)

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

[MIS14-14] Effect of photo-oxidation reactions of ferrous iron on geochemical conditions required for redox stratification on early Gale lake

*Haruhisa Tabata[1,2], Yasuhito Sekine[2], Kazumi Ozaki[3] (1.Department of Earth and Planetary Science, University of Tokyo, 2.Earth-Life Science Institute, Tokyo Institute of Technology, 3.Department of Environmental Science, Toho University)

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

[MIS14-15] Water vapor vertical distributions on Mars: Results from three years of TGO/NOMAD science operations

*Shohei Aoki[1,2], Ann Carine Vandaele[2], Frank Daerden [2], Geronimo L. Villanueva [3], Giuliano Liuzzi [3], Ian R, Thomas [2], Justin T. Erwin [2], Loic Trompet [2], Lori Neary [2], Severine Robert [2,9], Sebastien Viscardy [2], Arianna Piccialli [2], R. Todd Clancy [4], Michael Smith[3], Matteo Crismani [5], Bojan Ristic [2], Miguel A. Lopez-Valverde[6], Adrian Brines [6], Manish R. Patel [7], James A. Holmes [7], Giancarlo Bellucci[8], Jose J. Lopez-Moreno[6] (1.Université de Liège, 2.Royal Belgian Institute for Space Aeronomy, 3.NASA Goddard Space Flight Center, 4.Space Science Institute, 5.California State University, 6.Instituto de Astrofísica de Andalucía, 7.Open University, 8.Istituto di Astrofisica e Planetologia, 9.Université catholique de Louvain)

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

[MIS14-16] Theoretic study of atmosphere and hydrological cycle with groundwater transportation on land planets

*Taniguchi Keigo[1,2], Yasuhito Sekine[1], Takanori Kodama[3], Natsumi Noda[4], Hidenori Genda[1], Ayako Abe-Ouchi[5] (1.Earth-Life Science Institute, Tokyo Institute of Technology, 2.Department of Earth & Planetary Sciences, Tokyo Institute of Technology, 3.The university of Tokyo, 4.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 5.Atmosphere and Ocean Research Institute, The University of Tokyo)

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

[MIS14-17] Possibility of formation of local reductive environment by cometary impact on the early Earth

*Ryo Miyazaki[1], Hidenori Genda[1] (1.Earth Life Science Institute, Tokyo Institute of Technology)

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

[MIS14-18] Oceanic retention of ammonia and thermal stability of the atmosphere-ocean system on the primitive earth

*Kirara Arima[1], Kiyoshi Kuramoto[1] (1.Hokkaido university)

[J] Oral | M (Multidisciplinary and Interdisciplinary) : M-IS Intersection

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Ch.26 Zoom Room 26

[M-IS16] Paleoclimatology and paleoceanography

convener:Yusuke Okazaki(Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University), Hitoshi Hasegawa(Faculty of Science and Technology, Kochi University), Atsuko Yamazaki(Faculty of Science, Kyushu University), Akitomo Yamamoto(Japan Agency for Marine-Earth Science and TechnologyAtmosphere and Ocean Research Institute), Chairperson:Akitomo Yamamoto(Japan Agency for Marine-Earth Science and TechnologyAtmosphere and Ocean Research Institute)

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

[MIS16-11] **Reconstruction of the ice sheet history since the Last Glacial Maximum based on field-based geomorphological observations and surface exposure ages along the southern Soya Coast, Lützow-Holm Bay, East Antarctica**

*Moto Kawamata[1], Yusuke Suganuma[2,1], Koichiro Doi[2,1], Keiji Misawa[2,1], Motohiro Hirabayashi[2], Akihisa Hattori[1], Takanobu Sawagaki[3] (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)

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

[MIS16-12] Characteristic of radiocarbon dates in response to sea-level changes in the Bonaparte Gulf, Northwestern Australia

*Takeshige Ishiwa[1,2,3], Yusuke Yokoyama[2,3,4], Stephen Obrochta[5], Katsuto Uehara[6], Jun'ichi Okuno[1,7], Minoru Ikehara[8], Yosuke Miyairi[2] (1.National Institute of Polar Research, 2.Atmosphere and Ocean Research Institute, The University of Tokyo, 3.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 4.Japan Agency for Marine-Earth Science and Technology, 5.Graduate School of International Resource Science, Akita University, 6.Research Institute for Applied Mechanics, Kyushu University, 7.Department of Polar Research Science, School of Multidisciplinary Science, The Graduate University for Advanced Studies (SOKENDAI), 8.Center for Advanced Marine Core Research, Kochi University)

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

[MIS16-13] Wind-wave changes in Tokyo Bay during the Holocene: impact of sea-level change and land configuration

*Katsuto Uehara[1] (1.Kyushu University)

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

[MIS16-14] Reconstruction of organic matter inflow fluctuations from the Bolling-Allerod interstadial to Late Holocene using Lake Baikal sediments

*Keiko Takehara[1], Masatoshi Nakakuni[2], Shuichi Yamamoto[3] (1.Kochi university Graduate School of Integrated Arts and Sciences, 2.Faculty of Agriculture, Kagawa University, 3.Department of Environmental Engineering for Symbiosis, Graduate School of Engineering, Soka University)

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

[MIS16-15] Reconstruction of Early Pleistocene sea-surface temperature in the Northwestern Pacific Ocean based on calcareous microfossils

*Daisuke Kuwano[1], Yuki Tsuchiya[2], Yuma Oura[1], Hiroki Hayashi[3], Yoshimi Kubota[4], Kanako Mantoku[5], Koji Kameo[1] (1.Chiba University, 2.Nagoya University, 3.Shimane University, 4.National Museum of Nature and Science, 5.National Institute for Environmental Studies)

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

[MIS16-16] Variation of the North Pacific Ocean circulation during the Late Pleistocene glacial-interglacial cycles

*Furukawa Keisuke[1], Osamu Seki[1], Masanobu Yamamoto[1], Tomohisa Irino[1] (1.Hokkaido University)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Ch.26 Zoom Room 26

[M-IS16] Paleoclimatology and paleoceanography

convener:Yusuke Okazaki(Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University), Hitoshi Hasegawa(Faculty of Science and Technology, Kochi University), Atsuko Yamazaki(Faculty of Science, Kyushu University), Akitomo Yamamoto(Japan Agency for Marine-Earth Science and TechnologyAtmosphere and Ocean Research Institute), Chairperson:Hitoshi Hasegawa(Faculty of Science and Technology, Kochi University)

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

[MIS16-17] Reconstruction of the Mediterranean sulfur cycle during the Messinian salinity crisis using evaporites

*Takeru Kochi[1], Junichiro Kuroda[1], Nanako O. Ogawa[2], Toshihiro Yoshimura[2], Takashi Miyazaki[2], Bogdan Stefanov Vaglarov[2], Naohiko Ohkouchi[2] (1.the University of Tokyo, 2.Japan Agency for Marine–Earth Science and Technology)

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

[MIS16-18] Increased eolian dust in the Pacific since around the Eocene-Oligocene boundary estimated from a rock-magnetic study of red clay

*Toshitsugu Yamazaki[1], Wei Fu[1], Takaya Shimono[2], Yoichi Usui[3] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Geological Survey of Japan, AIST, 3.Japan Agency for Marine-Earth Science and Technology)

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

[MIS16-19] **Authigenic and detrital Mg and Li isotopes as a tracer of Antarctic chemical silicate weathering across the EOT**

*Adam David Sproson[1,2,3], Toshihiro Yoshimura[1], Yusuke Yokoyama[1,3], Takahiro AZE[3], Tsuyoshi Ishikawa[4], Shigeyuki Wakaki[4], Naohiko Ohkouchi[1] (1.Department of Biogeochemistry, Japan Agency for Marine-Earth Science and Technology, 2-15 Natsushima, Yokosuka, Kanagawa 237-0061, Japan, 2.Submarine Resources Research Center, Japan Agency for Marine-Earth Science and Technology, 2-15 Natsushima, Yokosuka, Kanagawa 237-0061, Japan, 3.Atmosphere and Ocean Research Institute, University of Tokyo, 5-1-5 Kashiwanoha, Kashiwa, Chiba 277-8564, Japan, 4.Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology 200 Monobe Otsu, Nankoku City, Kochi 783-8502, Japan)

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

[MIS16-20] Terrestrial environmental response to the global climate change during the early to middle Eocene (52.7-43.8 Ma): evidence from lacustrine deposits of the Green River Formation, Utah, USA

*Ryusei Kuma[1], Hitoshi Hasegawa[2], Koshi Yamamoto[1], Jessica H. Whiteside[3], Amy L. Elson[3], Hidekazu Yoshida[1], Koichi Mimura[1] (1.Nagoya University, 2.Kochi University, 3.University of Southampton)

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

[MIS16-21] C40-alkenone unsaturation index from the Cretaceous and paleothermometry in southern high latitude of Proto-Indian Ocean

*Takashi Hasegawa[1], Akiko S. Goto[2,1], Hiromichi Komiya[3], Shota Morikawa[3] (1.Faculty of Geoscience and Engineering, Institute of Science and Engineering, Kanazawa University, 2.Center of Ecological Research, Kyoto University, 3.Graduate School of Natural Science and Engineering, Kanazawa University)

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

[MIS16-22] Opposing responses in the hydrological cycle of the East Asia to climate warming related with the Tibetan Plateau

*Taro Higuchi[1], Ayako Abe-Ouchi[1], Wing-Le Chan[1] (1.Atmospheric 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 | Ch.03 Zoom Room 03

[M-IS17] Interface- and nano-phenomena on crystal growth and dissolution

convener:Yuki Kimura(Institute of Low Temperature Science, Hokkaido University), Hitoshi Miura(Graduate School of Science, Department of Information and Basic Science, Nagoya City University), Hisao Satoh(Low-Level Radioactive Waste Disposal Center, Japan Nuclear Fuel Limited), Chairperson:Yuki Kimura(Institute of Low Temperature Science, Hokkaido University)

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

[MIS17-01] Nucleation of water particles in the mesosphere

*Kyoko Kitakami Tanaka[1,2], Yuki Kimura[3], Ingrid Mann[4] (1.Tohoku University, 2.Nihon University, 3.ILTS, Hokkaido University, 4.UiT the Arctic University of Norway)

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

[MIS17-02] Possible new water on an ice III crystal in water

*Hiromasa Niinomi[1], Tomoya Yamazaki[2], Hiroki Nada[3], Tetsuya Hama[4], Akira Kouchi[2], Junpei Okada[1], Nozawa Jun[1], Satoshi Uda[1], Yuki Kimura[2] (1.Institute for Materials Research, Tohoku University, 2.Institute of Low Temperature Science, Hokkaido University, 3.National Institute of Advanced Industrial Science and Technology, 4.Komaba Institute for Science, The University of Tokyo)

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

[MIS17-03] HCl droplets induced bunched steps on ice crystal surfaces under atmospheric-concentration HCl gas

*Ken Nagashima[1], Ken-ichiro Murata[1], Gen Sazaki[1] (1.The Institute of Low Temperature Science, Hokkaido University)

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

[MIS17-04] Adsorption of nucleotides on clay induced by change in hydration structure by magnesium ion

*Yuki Araki[1], Yoshihiro Furukawa[2] (1.Ritsumeikan University, 2.Tohoku University)

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

[MIS17-05] Surface-Selective Vibrational Micro-Spectroscopy Unveils Physicochemical States and the History of Crystals

★Invited Papers

*Hiroharu Yui[1] (1.Tokyo University of Science)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Ch.03 Zoom Room 03

[M-IS17] Interface- and nano-phenomena on crystal growth and dissolution

convener:Yuki Kimura(Institute of Low Temperature Science, Hokkaido University), Hitoshi Miura(Graduate School of Science, Department of Information and Basic Science, Nagoya City University), Hisao Satoh(Low-Level Radioactive Waste Disposal Center, Japan Nuclear Fuel Limited), Chairperson:Hitoshi Miura(Graduate School of Science, Department of Information and Basic Science, Nagoya City University)

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

[MIS17-06] Control of particles by electric field and its applicability in LC-TEM for observing crystallization and dissolution processes

*Tomoya Yamazaki[1], Hiromasa Niinomi[2], Yuki Kimura[1] (1.Institute of Low Temperature Science Hokkkaido University, 2.Institute for Materials Research, Tohoku University)

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

[MIS17-07] Time lapse imaging of pH/ionic concentration distribution for understanding the dissolution/formation process of minerals in aqueous solution

*Jun Kawano[1], Makoto Yazaki[2], Shinji Matsumoto[2], Takashi Toyofuku[3,4], Yukiko Nagai[3,5], Kazuya Ohno[2], Takaya Nagai[1] (1.Faculty of Science, Hokkaido Univ., 2.Graduate School of Science, Hokkaido Univ., 3.JAMSTEC, 4.TUMSAT, 5.NMNS)

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

[MIS17-08] Pore space property of clayey materials in the forms of gelled to compacted: a strategy for designing buffer materials

*Hisao Satoh[1], Yuki Araki[2] (1.Japan Nuclear Fuel Limited, 2.Ritsumeikan University)

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

[MIS17-09] Hidden stability of norsethite revealed by phase diagram

*Harutoshi Asakawa[1], Kaoru Isobe[1], Hiroshi Uneda[1], Itaru Echigo[1], Ryuichi Komatsu[1] (1.Graduate School of Sciences and Technology for Innovation Yamaguchi University)

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

[MIS17-10] Control of defect structure in functional bulk crystals

★Invited Papers

*Harada Shunta[1,2] (1.Nagoya University, 2.PRESTO JST)

[J] Oral | M (Multidisciplinary and Interdisciplinary) : M-IS Intersection

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Ch.10 Zoom Room 10

[M-IS20] Ocean Plastics, an earth science perspective

convener:Atsuhiko Isobe(Research Institute for Applied Mechanics, Kyushu University), Kiichiro Kawamura(Yamaguchi University), Yusuke Okazaki(Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University), Masashi Tsuchiya(Research Institute for Global Change, Japan Agency for Marine-Earth Science and Technology), Chairperson:Atsuhiko Isobe(Research Institute for Applied Mechanics, Kyushu University)

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

[MIS20-01] Numerical model approach on the fate of pelagic plastics in the world's ocean

*Atsuhiko Isobe[1] (1.Research Institute for Applied Mechanics, Kyushu University)

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

[MIS20-02] Estimating vertical distribution of microplastic particles under wind-driven and Langmuir turbulence by Large Eddy Simulation

*Yoshimasa Matsumura[1], Shin-ichi Ito[1], Chiharu Sasaki[1] (1.Atmosphere and Ocean Research Institute, University of Tokyo)

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

[MIS20-03] Numerical experiment on vertical motion of microplastics with biological processes

*Miho Yoshitake[1], Atsuhiko Isobe[1] (1.Kyushu university)

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

[MIS20-04] Numerical model approach of macroplastic transport to find microplastic sources around the Indonesian archipelago

*Ryohei Kono[1], Atsuhiko Isobe[1] (1.Research Institute for Applied Mechanics, Kyushu University)

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

[MIS20-05] Quantifying the degree of pollution of beaches using an AI technique

*Mitsuko Hidaka[1], Daisuke Sugiyama[1], Daisuke Matsuoka[1], Fumiaki Araki[1], Masafumi Kamachi[1], Yoichi Ishikawa[1] (1.Japan Agency for Marine-Earth Science and Technology)

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

[MIS20-06] Estimation of plastic litter abundance in cities using big data associated with citizen science and deep learning

*Shinichiro Kako[1], Shintaro Kanno[2], Atsuhiko Isobe[3], Masato Kuki[4], Kotaro Yamamoto[4], Fujio Kojima[4] (1.Graduate School of Science and Engineering, Kagoshima University, 2.Faculty of engineering, Kagoshima University, 3.Research Institute for Applied Mechanics, Kyushu University, 4.Pirika, Inc. / Prika association)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Ch.10 Zoom Room 10

[M-IS20] Ocean Plastics, an earth science perspective

convener:Atsuhiko Isobe(Research Institute for Applied Mechanics, Kyushu University), Kiichiro Kawamura(Yamaguchi University), Yusuke Okazaki(Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University), Masashi Tsuchiya(Research Institute for Global Change, Japan Agency for Marine-Earth Science and Technology), Chairperson:Kiichiro Kawamura(Yamaguchi University)

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

[MIS20-07] Large-scale distribution and composition of floating plastic debris in the transition region of the North Pacific

*Kentaro Miyazono[1], Rei Yamashita[2], Hiroomi Miyamoto[3], Kazuaki Tadokoro[4], Yugo Shimizu[5], Kazutaka Takahashi[1] (1.Graduate school of agricultural and life science, The University of Tokyo , 2.Atmosphere and Ocean Research Institute, The University of Tokyo , 3.Fisheries Research Agency, Hachinohe, 4.Fisheries Research Agency, Shiogama, 5.Fisheries Agency)

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

[MIS20-08] TARA-JAMBIO Microplastic Mission : Distributions of microplastics in water surface and sediment of Japanese coastal waters

*Kugako Sugimoto[1], JAMBIO Consortium[3], Tara Japan[2], Sylvain Agostini[1] (1.Shimoda Marine Research Center, University of Tsukuba, 2.Tara Océan Fondation, 3.Japanese Association for Marine Biology)

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

[MIS20-09] Distribution of Microplastics in the Deep-sea Sediments

*Tomo Kitahashi[1], Masashi Tsuchiya[1], Ryota Nakajima[1], Rie Matsui[1], Kazumasa Oguri[1,2], Kiichiro Kawamura[3], Yosaku Maeda[1], Sanae Chiba[1], Katsunori FUJIKURA[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.University of Southern Denmark, 3.Yamaguchi University)

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

[MIS20-10] Chemical properties of film coatings developed on microplastics distributed on the urban river shore in Mongolia

*Masayuki Kawahigashi[1], Batdulam Battulga[1] (1.Tokyo Metropolitan University)

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

[MIS20-11] A trial of small microplastics collection by Neuston net

*Haodong XU[1], Haruka NAKANO[1], Tadashi TOKAI[1], Hisayuki ARAKAWA[1] (1.Tokyo University of Marine Science and Technology)

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

[MIS20-12] Non-contact real-time identification of microplastics in flow by combining holography and Raman spectroscopy

*Tomoko Takahashi[1,2,3], Zonghua Liu[2], Thangavel Thevar[4], Nicholas Burns[4], Dhugal Lindsay[1], John Watson[4], Sumeet Mahajan[3], Blair Thornton[2,3] (1.Japan Agency for Marine-Earth Science and Technology, 2.Institute of Industrial Science, The University of Tokyo, 3.University of Southampton, 4.University of Aberdeen)

[J] Oral | M (Multidisciplinary and Interdisciplinary) : M-IS Intersection

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Ch.26 Zoom Room 26

[M-IS28] Evolution of Pelagic Realm

convener:Atsushi Matsuoka(Department of Geology, Faculty of Science, Niigata University), Toshiyuki Kurihara(Graduate School of Science and Technology, Niigata University), Junichiro Kuroda(Department of Ocean Floor Geoscience, Atmosphere and Ocean Research Institute, the University of Tokyo), XIN LI(State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences), Chairperson:Atsushi Matsuoka(Department of Geology, Faculty of Science, Niigata University), Junichiro Kuroda(Department of Ocean Floor Geoscience, Atmosphere and Ocean Research Institute, the University of Tokyo)

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

[MIS28-01] Toward a global correlation of the Jurassic–Cretaceous boundary among pelagic, neritic and terrestrial sequences in the Pacific and Asia

*Atsushi Matsuoka[1] (1.Department of Geology, Faculty of Science, Niigata University)

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

[MIS28-02] **Early Cretaceous anti-tropical radiolarians of from Tibet at the breakup timing of Gondwana**

*XIN LI[1], Noritoshi Suzuki[2], Peter Baumgartner[4], Atsushi Matsuoka[3] (1.State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, 2.Institute of Geology and Paleontology, Gradute School of Science, Tohoku University, 3.Department of Geology, Faculty of Science, Niigata University, 4.Institut des sciences de la Terre, Université de Lausanne)

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

[MIS28-03] Repeated organic-rich deposition in Early Triassic pelagic deep Panthalassa and its relationship with global seafloor anoxia

*Shun Muto[1] (1.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology)

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

[MIS28-04] Marine Os isotope record from the uppermost Barremian to the lowest Turonian

*Hironao Matsumoto[1], Rodolfo Coccioni[2], Fabrizio Frontalini[2], Kotaro Shirai[1], Junichiro Kuroda[1] (1.Atmosphere and Ocean Research Institute, the University of Tokyo, 2.University of Urbino)

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

[MIS28-05] Depositional ages of multiple REY peaks in deep-sea sediments around Minamitorishima Island based on osmium isotope stratigraphy

*Yuta Oda[1], Junichiro Ohta[1,2], Erika Tanaka[1], Kazutaka Yasukawa[1,2], Yusuke Kuwahara[1], Moei Yano[2,1], Koichiro Fujinaga[2,1], Kentaro Nakamura[1], Yasuhiro Kato[1,2] (1.School of Engineering, The University of Tokyo, 2.ORCeNG, Chiba Institute of Technology)

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

[MIS28-06] Depositional environments of the Late Cretaceous REY-rich mud in the western North Pacific Ocean inferred from deep-water agglutinated foraminifers

*Kondo Yuta[1], Junichiro Ohta[1,2], Kazutaka Yasukawa[1,2], Kentaro Nakamura[1], Koichiro Fujinaga[2,1], Yasuhiro Kato[1,2] (1.School of Engineering, The University of Tokyo, 2.ORCeNG, Chiba Institute of Technology)

[J] Oral | EVENT : EVENT

12:20 PM - 1:00 PM JST | 3:20 AM - 4:00 AM UTC | Ch.01 Zoom Room 01

[EV-22] Lunchtime Special Lecture

12:20 PM - 1:00 PM JST | 3:20 AM - 4:00 AM UTC

[E-11-24] Uncover the cryptic nitrogen flows in the terrestrial ecosystems

[J] Oral | EVENT：EVENT

1:45 PM - 2:30 PM JST | 4:45 AM - 5:30 AM UTC | Ch.12 Zoom Room 12

[EV-24] Exhibitors' Seminar

1:45 PM - 2:30 PM JST | 4:45 AM - 5:30 AM UTC

[E-11-25] An introduction to Research Institute for Humanity Nature (RIHN)'s interdisciplinary researches on global environmental issues. Earth Scientists, join our Research Projects!

[J] Oral | U (Union)：Union

Sat. Jun 5, 2021 3:30 PM - 5:00 PM JST | Sat. Jun 5, 2021 6:30 AM - 8:00 AM UTC | Ch.01 Zoom Room 01

[U-14] Current status and issues of the earth education necessary for living on the changing earth

convener:Hiroshi Ichikawa, Saori Nakai(kyoto koka womens university department of child education), Hidenori Kumagai(Japan Agency for Marine-Earth Science and Technology), Hiroshi Nishi(The Center for Academic Resources and Archives, The Tohoku Museum Tohoku University), Chairperson:Hiroshi Ichikawa(None)

A proposal entitled by "Importance of Earth Education in Elementary and Secondary School Education and Lifelong Education: for learning essential knowledge to live on a changing earth" was published by the Science Council of Japan on June 23, 2020. This proposal points out that, for all people living in the Japanese archipelago frequently attacked by severe natural disasters, it is important to increase the chances to acquire "the essential knowledge to live on a changing earth" in school learning of the nature, and learn it lifelong. Responding to this proposal, this session is held by WG for Studying on Teacher Training System, established for studying complex and diverse issues related to teacher training and others in May 2019 in the Education Committee, JpGU. This session aims to deepen discussions on the current situation and issues of elementary and secondary school teachers responsible for earth education in the fields of Geosciences and Geography regarding the teacher training and recruitment system and self-improvement of knowledge and skills.

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

[U14-01] The Essentials of Living on a Changing Planet

★Invited Papers

*Hiroshi Nishi[1] (1.Fukui Prefectural University, Institute of Dinosaur Research)

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

[U14-02] **Variations in the promotions of high schools offering Basic and Advanced Earth Science classes in Prefectures throughout Japan**

★Invited Papers

*Hideo Takagi[1], Kohei Yoshida[2] (1.Department of Earth Science, Faculty of Education and Integrated Arts and Sciences, Waseda University, 2.Higashi Fukuoka High School)

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

[U14-03] Global-Earth education in geography of high school

★Invited Papers

*Yoshiyasu Ida[1] (1.Faculty of Human Sciences,University of Tsukuba)

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

[U14-04] How to support elementary, junior high and high school teachers who are not familiar with Earth Science

★Invited Papers

*Hiroyuki Hoshi[1] (1.Department of Earth Sciences, Aichi University of Education)

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

[U14-05] Issues raised at the meeting for exchanging Information on the Earth Science Education in High Schools

★Invited Papers

*Iwata Makoto[1], Iida Kazuya[2], Satoshi Miyajima[3] (1.Hiroshima Prefectural Ogaki High School, 2.Komaba-Toho Junior and Senior High School, 3.Saitama Prefectural Kumagaya High School)

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

[U14-06] Discussion on the current status and issues of the earth education
★Invited Papers

*Hiroshi Ichikawa[1], Saori Nakai[2], Hidenori Kumagai[3], Hiroshi Nishi[4] (1.Education Committee, JpGU, 2.Kyoto Koka Women's University, 3.Japan Agency for Marine-Earth Science and Technology, 4.Fukui Prefectural University)

The Essentials of Living on a Changing Planet

*Hiroshi Nishi[1]

1. Fukui Prefectural University, Institute of Dinosaur Research

Japan faces many problems between the natural environment and human society, such as climate change, natural disasters and environmental pollution. We must be prepared to face the violence and prepare sufficient disaster prevention and mitigation measures. For that purpose, it is necessary to acquire the "discipline for living on a changing earth" that people living in this disaster-prone country should share through education in fields closely related to nature such as earth science and geography. As a result, each individual will have the ability to prepare for "saving lives" against the threat of nature, and will be able to live in harmony with nature.

There are two important points to acquire this background. One is to strengthen "learning the nature system" in school education. In particular, the perspective of "integration of literature and science" is important for this education. The other is to provide a place for learning during the lifetime. Examples of places to learn include museums and Geopark activities. Through learning in these school and lifelong educations, society will increase knowledge related to natural disasters and the global environment, and increase opportunities to learn countermeasures. In order to achieve this, it is need to establish human resources and organizations to support the activities. For that objectives, research institutes such as universities, academic societies, and local public organizations cooperate and collaborate, and citizens routinely work together. There should be many places where society can learn about the Earth.

Keywords: natural disaster, changing Earth, literacy for living

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Variations in the promotions of high schools offering Basic and Advanced Earth Science classes in Prefectures throughout Japan

*Hideo Takagi[1], Kohei Yoshida[2]

1. Department of Earth Science, Faculty of Education and Integrated Arts and Sciences, Waseda University, 2. Higashi Fukuoka High School

The subject of science in Japanese high school is divided into physics, chemistry, biology and Earth science, and the number of credit is set to 2 for basic subjects and 4 for advanced subjects. With the change of courses based on the new course of study guidelines enforced by MEXT in 2012, the Earth science field has classes in Basic Earth Science (BES) and Advanced Earth Science (AES). However, the percentages of high schools that offer Earth science classes in each prefecture have not been reported. Therefore, we have estimated the proportion of high schools that offer BES and AES classes in a survey of more than 5,000 high schools in Japan. Data for the survey were collected from the curriculum listed in each high-school homepage and from a questionnaire distributed using the Google mail system. Survey results indicate that 43.7% of high schools offer BES, and only 8.8% of high schools offer AES nationwide. In addition, the proportion of high schools offering Earth science classes varies depending on the prefecture. The top prefectural percentage for AES is 48% (Okinawa) and then 38% (Chiba), but nine prefectures have no high schools that offer AES.The percentage of high school students who take Earth science classes is also estimated from the number of textbooks adopted by MEXT (26% for BES and 1.2-0.9% for AES). The proportion of high schools offering Earth science correlates with the number of teachers over the past 40 years employed in Earth science in each prefecture. However, some prefectures have records only of the total number of science teachers, therefore the numbers of teachers hired specifically for Earth science are unknown in these cases. The percentage of high schools offering Earth science classes is higher in prefectures for which only the total number of science teachers is known. Based on our results, for the promotion of high school geoscience education, supports should be provided through workshops in Earth science education, so that science teachers other than full-time Earth science can recognize the importance of Earth science and teach BES whose establishment rate has increased since 2012.
Reference: Yoshida, K. and Takagi, H., 2020, Journal of Geography (Chigaku Zasshi), 129, 337-354.

Keywords: high-school curriculum, establishment rate, Earth science subject

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Global-Earth education in geography of high school

*Yoshiyasu Ida[1]

1. Faculty of Human Sciences,University of Tsukuba

The purpose of this presentation is to clarify the overview and issue of global-earth education in the compulsory subject "geography" in high school."Geography" can be said to be a subject that provides earth education that includes global citizenship education. While aiming for earth education from global perspective, it is also a subject that should foster awareness as citizen under nation of Japan. Teachers who teach "Geography" will be required the balance with global-earth citizenship education based on global natural phenomena, and global education based on tha country or identity of nation will be required. Training teachers who teach "Geography" is an one of urgent issues.

Keywords: Global-earth education, Geography in high school, citizenship education

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How to support elementary, junior high and high school teachers who are not familiar with Earth Science

*Hiroyuki Hoshi[1]

1. Department of Earth Sciences, Aichi University of Education

School teachers who teach Earth Science and related subjects at elementary, junior high and high schools in Japan are not limited to those who majored in Earth Science at college or university. In fact, there are more teachers who do not know much about Earth Science than those who know well. Earth Science experts should strongly support such school teachers so that they raise the level of their knowledge, while making the teachers feel the fun and depth of Earth Science. This will greatly contribute to the improvement of the quality of Earth Science education in schools, which in turn will lead to the improvement of the Earth Science literacy of the people.

Keywords: Earth Science Education, Science Education, School Teacher

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Issues raised at the meeting for exchanging Information on the Earth Science Education in High Schools

*Iwata Makoto[1], Iida Kazuya[2], Satoshi Miyajima[3]

1. Hiroshima Prefectural Ogaki High School, 2. Komaba-Toho Junior and Senior High School, 3. Saitama Prefectural Kumagaya High School

At the "the meeting for exchanging Information on the Earth Science Education in High Schools" held on November 23 and 24, 2019, the issues of geoscience education in high schools were the isolation and aging of earth science teachers, and teachers other than full-time earth science teachers. In order to solve these problems, "formation of a network that transcends schools and regions", "creation of a system that inherits know-how across generations", "dedicated to earth science" The need for "support for teachers other than" was proposed. In response to the proposal, the "the Online meeting for exchanging Information on the Earth Science Education in High Schools" was established as a place for online information exchange. The online information exchange meeting is a voluntary activity by junior high school, high school, university faculty members, research institutes, publishers, etc., and is mainly operated using apps called Slack and Zoom, and participants report on class practice. We have carried out various activities such as introduction of teaching materials, lectures on each specialized field by university faculty members and people from research institutes. Here, I would like to report on some of the issues that have emerged during the exchange of information.

The first is support for young earth science teachers. Many earth science teachers are often alone in school, and they are originally in an environment that tends to be isolated. In each prefecture, there are geoscience subcommittees and geoscience study groups that are active by high school teachers, and information exchange and exchanges have been carried out across schools. However, the number of young earth science faculty members who participate in these meetings is decreasing year by year, and in some prefectures, efforts are declining due to a shortage of people. In addition to supporting the activities of the earth science subcommittees and geoscience study groups in each prefecture, we also support students in the teacher training stage to continue learning earth science education even after becoming teachers, such as by introducing the efforts of these study groups.

The second is support for earth science education from outside the school. During the exchange of information, many high school teachers wanted to give students an opportunity to come into contact with earth science through lectures on the latest research by experts. There were also researchers and university officials looking for opportunities to outreach high school students. Despite the needs of both of these, there are still few practical examples that have been implemented. While online exchanges are seeing new forms of support for earth science education, it is necessary to consider how to increase opportunities for students to come into contact with earth science in the future.

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Discussion on the current status and issues of the earth education

*Hiroshi Ichikawa[1], Saori Nakai[2], Hidenori Kumagai[3], Hiroshi Nishi[4]

1. Education Committee, JpGU, 2. Kyoto Koka Women's University, 3. Japan Agency for Marine-Earth Science and Technology, 4. Fukui Prefectural University

On June 23, 2020, the Earth and Planetary Science Committee, Earth and Planetary Science Human Resources Development Subcommittee, the Science Council of Japan, published a proposal "Importance of Earth Education in Elementary and Secondary Education and Lifelong Education: for learning essential knowledge to live on a changing earth". As a follow-up to this proposal, this session is convened by the WG for Studying on Teacher Training System, the Education Committee, JpGU, for the purpose of deepening discussions on the current status and issues regarding the training and recruitment system for primary and secondary school teachers in the fields of Geoscience and Geography, and self-improvement of knowledge and skills. We will discuss on what activities JpGU should carry out in the future in response to the proposal, what items should be intensively considered at the Science Council of Japan in the future, what proposal should be urgently published by the Science Council of Japan, and others. We look forward to the participation of many members who are interested in promoting and enhancing the earth education.

Keywords: Earth Education, Science Council of Japan, proposal, action plan

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[J] Oral | U (Union)：Union

Sat. Jun 5, 2021 1:45 PM - 3:15 PM JST | Sat. Jun 5, 2021 4:45 AM - 6:15 AM UTC | Ch.01 Zoom Room 01

[U-15] JpGU's mission against giant earthquake and tsunami disasters: last 10 years and the future

convener:Koji Okumura(Graduate School of Letters, Hiroshima University), Yoshinori MIYACHI(Geological Survey of Japan, AIST), Hitoshi SAITO(College of Economics, Kanto Gakuin University), Chairperson:Koji Okumura(Graduate School of Letters, Hiroshima University), Yoshinori MIYACHI(Geological Survey of Japan, AIST), Hitoshi SAITO(College of Economics, Kanto Gakuin University)

10 years have passed since the M9.0 2011 Tohoku Taiheiyo-Oki earthquake. Devastating disasters by strong and wide-spread ground motion, many fatalities and destruction of coastal area by huge tsunamis, and the accidents of the Fukushima Dai-ichi Nuclear Power Plant greatly impacted Japanese society and scientific community. Recovery from the damages is still under way. Meantime, the next giant earthquake from Nansai Trough is approaching. Researchers in earth and planetary sciences have been working hard on large earthquakes and tsunamis. In addition, researchers are obliged to contribute to the safe society from these disasters. 2011 great Tohoku disasters introduced collaboration of all disciplines in earth and planetary sciences together with related scientific communities. This session aims at first to summarize our scientific achievement with emphasis on the output to and the interaction with the society for disaster mitigation in these 10 years. Then we discuss about our missions against giant earthquakes and tsunamis in coming 10 years or before the next big one. The discussion will cover our contributions to national and local government efforts for disaster mitigation, risk management and hazard responses of individuals and organizations, and education on hazards and disasters.

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

[U15-01] JpGU's activities on gigantic earthquakes and tsunamis, 10 years since Great East Japan disasters

★Invited Papers

*Koji Okumura[1] (1.Graduate School of Humanities and Social Sciences, Hiroshima University)

2:05 PM - 2:25 PM JST | 5:05 AM - 5:25 AM UTC

[U15-02] The Decade of Progress of the Tohoku Geographical Association following the 2011 Great East Japan Earthquake

★Invited Papers

*ODA TAKASHI[1] (1.Miyagi University of Education)

2:25 PM - 2:45 PM JST | 5:25 AM - 5:45 AM UTC

[U15-03] Correspondence and the BCP (business continuity plan) maintenance situation of the commerce and industry establishment after the East Japan great earthquake disaster

★Invited Papers

*Toshio HATSUZAWA[1] (1.Fukushima University)

2:45 PM - 3:05 PM JST | 5:45 AM - 6:05 AM UTC

[U15-04] Ground motion characteristics during The 2011 off the Pacific coast of Tohoku Earthquake and The 2016 Kumamoto Earthquake

★Invited Papers

*Shinichi Matsushima[1] (1.Disaster Prevention Research Institute, Kyoto University)

3:05 PM - 3:15 PM JST | 6:05 AM - 6:15 AM UTC

[U15-05] Discussion

JpGU's activities on gigantic earthquakes and tsunamis, 10 years since Great East Japan disasters

*Koji Okumura[1]

1. Graduate School of Humanities and Social Sciences, Hiroshima University

The 2011 off the Pacific coast of Tohoku Earthquake and tsunamis, subsequent devastating damages, and the accidents of the Fukushima Daiichi Nuclear Power Plant were the most shocking severest natural hazards for the Japan Geoscience Union that was established in 2005. Before the great Tohoku disasters, the damages from natural hazards were not so severe and extensive as in 2011, so individual scientific organizations conducted researches by itself. However, the severity and the magnitude of the damages from the hazards and accidents in 2011 urged organized cooperative efforts of scientific organizations to study the hazards and disasters. The Japan Geoscience Union, as a unique organization consisted of most earth and planetary science societies in Japan, started to support these cooperative efforts immediately after the disasters. In the earliest days after the disasters, dissemination of information on the post earthquake investigation for better coordination of many groups through the internet was an important task of the Union. Information gathering and distribution have been carried out through the Union web pages, news letters, and scientific journals continuously. However, the most important activity of the Union is the annual meeting. For the advancement and promotion of the research on gigantic earthquakes and tsunamis, environmental effects of nuclear accidents, and disaster mitigation as well the sessions of the JpGU annual meetings have been the most important arena for scientists. Reviewing the activities in the past 10 years since the Great East Japan disasters, we will understand our missions to prepare for the future gigantic earthquakes and tsunamis.

Keywords: Great East Japan disaster, gigantic earthquake, tsunamis

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The Decade of Progress of the Tohoku Geographical Association following the 2011 Great East Japan Earthquake

*ODA TAKASHI[1]

1. Miyagi University of Education

As an academic society located in a disaster-hit area, the Tohoku Geographical Association played an important role following the Great East Japan Earthquake of 2011. The member geographers conducted field studies to assess the damage, examine the recovery of lives of the affected people and discuss rebuilding of Tohoku. Wide range of related studies were conducted with a variety of topics including geomorphology, housing, migration and displacement, the impact of the Fukushima Daiichi Nuclear Power Plant accident, and welfares of affected people. It functioned as a hub of frontline researchers who were eager to draw lessons from the catastrophes that occurred in areas close to their fields of study.

Shortly after the earthquake, a special website was established to share geographic studies on this mega disaster and its lessons with the wider public in English and Japanese by the members. Based on the experience of the 2011 earthquake, the Association went on to build a framework to support members who conduct field research immediately after a disaster occurs. In February 2018, the "Internal Rules on Support for Emergency Disaster Investigations by Members of the Tohoku Geographical Society" was ratified to financially support the members. The rules applied recent disasters including the Hokkaido Eastern Iburi Earthquake of 2018, Western Japan Storms of 2018, and the Typhoon disasters of 2019.

There are great expectations for the role that studies of geography could play in disaster risk reduction and its education and enlightenment. One of such contributions include educating the school teachers and the students for topographic map and hazard map reading to raise awareness of the use of geographic information for disaster risk reduction. Hence, the Association in recent years began to hold a series of workshops for in-service high school teachers in collaboration with the Geospatial Information Authority of Japan to better understand geographic understanding of natural and social environments.

As described above, the academic society has developed various efforts in the wake of the catastrophe. By looking back on the trajectory of the decade of progress as local academic society, we discuss its contributions and interdisciplinary collaborations among the academic societies in earth and planetary science.

Keywords: Great East Japan Earthquake, disaster recovery, disaster risk reduction, education, academic society, geography

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Correspondence and the BCP (business continuity plan) maintenance situation of the commerce and industry establishment after the East Japan great earthquake disaster

*Toshio HATSUZAWA[1]

1. Fukushima University

The Minamisoma-city Haramachi area is located in the Fukushima Beach street district central part and is located within the range of 20-30km from the first Fukushima nuclear power plant. At first I grasp the suffering situation of a commerce and industry establishment located in the Haramachi area and clarify it from the maintenance situation of BCP of each company after the earthquake disaster for disaster prevention. The reporter performed commerce and industry fact-finding after an earthquake disaster every year in cooperation with the Haramachi chamber of commerce. This report is based on the result.

The material damage was left to a small thing when I watched the damage situation at the time of the earthquake disaster. However, the influence of the nuclear plant accident was big, and the sales of 2011 decreased to 60% of manufacturing industry, 76% of construction industry, 45% of wholesale trade, 73% of retail trade, 63% of service industry compared with the previous year. The stop of the business by the suffering was big by the manufacturing industry. In the order of the manufacturing industry, the business partner of 39% in the city, 53% of Soma-Futaba area, 20% of prefecture except these areas, 29% of Tohoku districts except Fukushima were lost. The regional economy received an extremely big blow.

It is important that not only I merely strengthen the disaster prevention measures of the hard aspect, but also the software aspect including the security of a business partner and the circulation route takes measures to cope with a disaster. The development of BCP (business continuity plan) is the one.

The reporter investigated it over three times in the investigation that I performed in Minamisoma-city about BCP. From three investigations, the maintenance rate of BCP understands that it remain in the level for 10% of establishments which I maintain although it is in an upward trend. In the suffering company analysis of the East Japan typhoon of 2019, indirect damage exceeds direct damage greatly. This shows the importance of the measures of the software side, however, there is the disaster prevention correspondence of the establishment mainly on a hardware aspect. It is necessary to expand the disaster prevention of the software side including BCP.

Keywords: East Japan great earthquake disaster, BCP, Minami-Soma city Fukushima Prefecture

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Ground motion characteristics during The 2011 off the Pacific coast of Tohoku Earthquake and The 2016 Kumamoto Earthquake

*Shinichi Matsushima[1]

1. Disaster Prevention Research Institute, Kyoto University

The 2011 off the Pacific coast of Tohoku Earthquake which caused the Great East Japan Earthquake Disaster, initiated on 14:46 of March 11th 2011. The epicenter was 130 km east of Sendai in the off Miyagi region and the focal depth was 24 km. As a result, the rupture spread to a length of 400 to 500 km and width of 150 to 200 km along the boundary between the Pacific plate and Eurasian plate and became moment magnitude (Mw) of 9.0. The relative slip close to the trench east of the epicenter was about 60 m and made a huge tsunami. On the other hand, it recorded the JMA seismic intensity of 7 in Tsukidate of City of Kurihara in Miyagi Prefecture. This earthquake counted 19,729 causalities, 2,559 missing and 6,233 injured, as of March 1st, 2020. There were 121,996 totally collapsed, 282,941 half destroyed and 748,416 partially damaged houses, and 14,527 public buildings and 92,059 of other structures suffered damage during the earthquake. This catastrophe was caused mainly by the huge tsunami along the shoreline. On the other hand, K-NET Tsukidate (MYG004) station of the Kyoshin Network (K-NET) operated by the National Research Institute for Earth Science and Disaster Resilience recorded JMA seismic intensity 7. Although it recorded a maximum acceleration of 2,700 cm/s/s for the north-south component (about 2.7 times of gravitational acceleration), there were hardly no building damage near the station. This was because the frequency content of the recorded ground motion was about 4 Hz. On the contrary, the K-NET Furukawa (MYG006) station recorded JMA seismic intensity of 6+, but there were collapsed houses because the dominant frequency of the ground motion was about 1 Hz (period of 1 sec). Despite the fact that the earthquake was the largest among the recorded earthquakes around Japan and the highest peak ground acceleration ever recorded, it was found by many researches that damage will not be caused depending on the characteristics of ground motions.

Furthermore, during the mainshock of the 2016 Kumamoto Earthquake, which was the largest JMA magnitude (Mjma) earthquake in this 10 years, JMA seismic intensity (JMA-SI) of 7 was recorded at two stations. Mjma 7.3 is the largest inland active fault earthquake that was recorded. Houses were damaged heavily in Mashiki town of Kumamoto Prefecture, one of the sites where JMA-SI 7 were recorded and the dominant frequency of the ground motion was about 1 Hz. The other site, Nishihara village had not suffered great damage in the central part of the village, but there where damage near the surface rupture of the fault. In Nishihara, the dominant period was about 3 seconds. It was re-recognized that the ground motion with dominant frequency of 1 Hz has the potential of causing great damage to houses. In addition, ground motion with dominant period of 3 seconds which may cause severe damage to base-isolated structures and high-rise buildings has been observed and it has raised a question concerning safety of these types of buildings.

Keywords: The 2011 off the Pacific coast of Tohoku Earthquake, The 2016 Kumamoto Earthquake, Ground motion, Period of 1 second, Building damage

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[J] Oral | U (Union) | Union

[U-15] JpGU's mission against giant earthquake and tsunami disasters: last 10 years and the future

convener:Koji Okumura(Graduate School of Letters, Hiroshima University), Yoshinori MIYACHI(Geological Survey of Japan, AIST), Hitoshi SAITO(College of Economics, Kanto Gakuin University), Chairperson:Koji Okumura(Graduate School of Letters, Hiroshima University), Yoshinori MIYACHI(Geological Survey of Japan, AIST), Hitoshi SAITO(College of Economics, Kanto Gakuin University)

Sat. Jun 5, 2021 1:45 PM - 3:15 PM Ch.01 (Zoom Room 01)

10 years have passed since the M9.0 2011 Tohoku Taiheiyo-Oki earthquake. Devastating disasters by strong and wide-spread ground motion, many fatalities and destruction of coastal area by huge tsunamis, and the accidents of the Fukushima Dai-ichi Nuclear Power Plant greatly impacted Japanese society and scientific community. Recovery from the damages is still under way. Meantime, the next giant earthquake from Nansai Trough is approaching. Researchers in earth and planetary sciences have been working hard on large earthquakes and tsunamis. In addition, researchers are obliged to contribute to the safe society from these disasters. 2011 great Tohoku disasters introduced collaboration of all disciplines in earth and planetary sciences together with related scientific communities. This session aims at first to summarize our scientific achievement with emphasis on the output to and the interaction with the society for disaster mitigation in these 10 years. Then we discuss about our missions against giant earthquakes and tsunamis in coming 10 years or before the next big one. The discussion will cover our contributions to national and local government efforts for disaster mitigation, risk management and hazard responses of individuals and organizations, and education on hazards and disasters.

3:05 PM - 3:15 PM

[U15-05]Discussion

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

Sat. Jun 5, 2021 9:00 AM - 10:30 AM JST | Sat. Jun 5, 2021 12:00 AM - 1:30 AM UTC | Ch.04 Zoom Room 04

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

convener:Megumi Matsumoto(Graduate School of Science, Tohoku University), Shin Ozawa(Department of Earth Science, Graduate School of Science, Tohoku University), Yuki Hibiya(Submarine Resources Research Center, Japan Agency for Marine-Earth Science and Technology), Noriyuki Kawasaki(Department of Earth and Planetary Sciences, Graduate School of Science, Hokkaido University), Chairperson:Yuki Hibiya(Submarine Resources Research Center, Japan Agency for Marine-Earth Science and Technology), Noriyuki Kawasaki(Department of Earth and Planetary Sciences, Graduate School of Science, Hokkaido University)

In this session, we will discuss the material evolution in the Solar System based on extraterrestrial sample analyses and experimental works. We will overlook recent knowledge from primitive materials such as chondrites, interplanetary dust particles, and returned samples by space missions. Research works on meteorite parent body processes such as aqueous alteration, thermal metamorphism, shock metamorphism, volcanic activity, and core-mantle-crust differentiation will also be discussed. The topics of this session include experimental studies which, together with meteorite studies, help us to understand the material formation/evolution in the Solar System as well as processes on meteorite parent bodies. Presentations on new innovative analytical and theoretical techniques in various research fields (chemistry, theoretical calculation, physical property) are highly welcome to improve future studies of the Solar System evolution. This session is J (Japanese) session but English talks are also welcomed.

9:00 AM - 9:30 AM JST | 12:00 AM - 12:30 AM UTC

[PPS07-06] Novel approaches based on correlated short-lived and stable isotope variations for dating nucleosyntheses and early solar system events

★Invited Papers

*Tsuyoshi Iizuka[1], Yuki Hibiya[2], Mitsuru SUZUKI[1], Takehito Hayakawa[3] (1.University of Tokyo, 2.JAMSTEC, 3.National Institutes for Quantum and Radiological Science and Technology)

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

[PPS07-07] Oxygen and Al–Mg isotopic constraints on the cooling rate, age, and precursor of partial melting of an Allende Type B CAI, Golfball

*Noriyuki Kawasaki[1], Shoichi Itoh[2], Naoya Sakamoto[1], Steven B. Simon[3], Daiki Yamamoto[4], Hisayoshi Yurimoto[1] (1.Hokkaido University, 2.Kyoto University, 3.University of New Mexico, 4.JAXA)

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

[PPS07-08] Chemical and isotopic fractionation of Type B CAI caused by evaporation: An experimental study

*Michiru Kamibayashi[1], Shogo Tachibana[1,3], Noriyuki Kawasaki[2], Daiki Yamamoto[3], Hisayoshi Yurimoto[2] (1.The University of Tokyo, 2.Hokkaido University, 3.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

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

[PPS07-09] I-Xe ages of chondrites and its relevance for solar-wind derived noble gas concentrations

*Koharu Arai[1], Hirochika Sumino[1], Atsushi Takenouchi[2], Shogo Tachibana[1,3] (1.The University of Tokyo, 2.National Institute of Polar Research, 3.Institute of Space and Astronautical Science)

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

[PPS07-10] Requirement of turbulent nebula and dust grains for grain size coarsening in chondrule rims

*Hiroaki Kaneko[1], Sota ARAKAWA[2], Taishi Nakamoto[1] (1.Tokyo Institude of Technology, 2.National Astronomical Observatory of Japan)

Novel approaches based on correlated short-lived and stable isotope variations for dating nucleosyntheses and early solar system events

*Tsuyoshi Iizuka[1], Yuki Hibiya[2], Mitsuru SUZUKI[1], Takehito Hayakawa[3]

1. University of Tokyo, 2. JAMSTEC, 3. National Institutes for Quantum and Radiological Science and Technology

Short-lived radionuclides (SLRs) present in the early solar system can be used to constrain the birth environment of our sun and serve as chronometers for nucleosyntheses and early solar system events. Their use as chronometers commonly rests on the assumption that they were uniformly distributed in the early solar system. However, this assumption has been challenged by the report of the heterogeneous distribution of the SLR ^{26}Al (e.g., Bollard et al., 2019 GCA). Such SLR heterogeneity is compatible to the results of high-precision isotope analyses of meteorites, showing that carbonaceous chondrites (CC) and non-carbonaceous (NC) meteorites exhibit fundamentally different nucleosynthetic anomalies with respect to stable isotopes, such as Ti isotopes (e.g., Kruijer et al., 2019 Nature Astronomy). In addition, we have recently found that the SLR ^{92}Nb was ~80% more abundant in CC than in NC reservoirs (Hibiya et al., 2019 LPSC). Because ^{92}Nb exclusively originates from supernovae, ^{92}Nb enrichment requires a biased distribution of ejecta from a supernova in the protoplanetary disk. These results call for establishment of new methodology for chronology of nucleosyntheses and early solar system events without assuming the homogeneous distribution of supernova-derived SLRs.
Here, we present novel chronological approaches coupling the SLR and nucleosynthetic stable isotope heterogeneities. In the chronology of early solar system events, the SLR heterogeneity leads to erroneous relative ages, which can be calibrated if the initial SLR abundance difference is known. We show that the ^{26}Al and ^{92}Nb clocks can be calibrated using the correlation with the nucleosynthetic Ti isotope heterogeneity, considering that these isotope variations are attributed to biased distribution of ejecta from a core-collapse supernova (CCSN) across the protoplanetary disk. Coupling the SLR and Ti isotope variations further allows us to estimate the timing of the CCSN. In the context of the heterogeneous distribution of CCSN ejecta, a difference in the initial abundance of a CCSN-derived SLR between two disk reservoirs is a function of two parameters: (i) the time interval from the CCSN to solar system formation and (ii) the difference in dilution factors of the ejecta in the disk reservoirs. Importantly, the latter can be independently estimated from the variation in the nucleosynthetic stable isotope heterogeneity, which in turn allows to date the CCSN. We combine the ^{26}Al and Ti isotope heterogeneities and estimate the timing of the CCSN explosion to be 0.4–1.5 Myr before the CAI formation. In addition, assuming that CAIs record the isotope composition of the molecular cloud core in which the CCSN ejecta were most efficiently trapped, we estimate the distance between the CCSN and cloud core to be ~1 parsec. These results imply that our sun was born in a stellar cluster containing massive stars and a nearby CCSN triggered the formation of the solar system. We will extend the cosmochronological approach proposed here to other nuclides, in particular proton-rich SLR ^{98}Tc and long-lived radionuclide ^{138}La. Because ^{98}Tc and ^{138}La as well as ^{92}Nb are produced by the same processes in CCSNe, combining these p-nuclides would potentially allows us to determine the timing of the last CCSN event more accurately than the combined ^{26}Al–Ti chronometer.

Keywords: supernova, short-lived radionuclide, nucleosynthesis, isotope dichotomy

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Oxygen and Al–Mg isotopic constraints on the cooling rate, age, and precursor of partial melting of an Allende Type B CAI, Golfball

*Noriyuki Kawasaki[1], Shoichi Itoh[2], Naoya Sakamoto[1], Steven B. Simon[3], Daiki Yamamoto[4], Hisayoshi Yurimoto[1]

1. Hokkaido University, 2. Kyoto University, 3. University of New Mexico, 4. JAXA

Coarse-grained, igneous Ca-Al-rich inclusions (CAIs) in CV chondrites formed through multiple melting events (e.g., MacPherson and Davis, 1993; Yurimoto et al., 1998; Simon et al., 2005; Kawasaki et al., 2018). We conducted *in situ* O-isotope analysis and Al–Mg systematics by secondary ion mass spectrometry of relict and later-crystallized minerals from multiple melting events in an Allende Type B CAI, Golfball. Golfball has a type B CAI bulk composition (Simon and Grossman, 2004) and a unique structure (Simon et al., 2005): a fassaite-rich mantle enclosing a melilite-rich core. Blocky melilite crystals in the core often contain irregularly shaped Al-rich ($Åk_{5–12}$) grains enclosed in strongly zoned ($Åk_{15–70}$) overgrowths. Since the Al-rich melilite grains could not have formed from a melt of Golfball (Beckett et al., 1999), they are relict survived later melting events (Simon et al., 2005). The O-isotopic compositions of the blocky melilite crystals plot along the carbonaceous chondrite anhydrous mineral line, ranging between $\Delta^{17}O \sim -14‰$ and $-5‰$. The Al-rich relict melilite grains and their overgrowths exhibit the same O-isotopic compositions, while the O-isotopic variations for the melilite are spatially distributed. We found O-isotopic variations across several melilite crystals that gradually change within few tens of micrometers. The O-isotopic compositions of the melt could not have been homogenized during the partial melting in that scale and thus O-isotope exchange with the nebular gas was insufficient. Considering a timescale of O self-diffusion in the melt (Yamamoto et al., 2018), a cooling rate of partial melting would be $> \sim 10^4$ K/h. Al–Mg isotope data of relict and later-crystallized minerals perfectly plot on a straight line on an Al–Mg evolutionary diagram. A mineral isochron for Golfball gives initial $^{26}Al/^{27}Al$ of $(4.42 \pm 0.14) \times 10^{-5}$ and initial $^{26}Mg/^{24}Mg$ of $-0.020 \pm 0.047‰$. The O-isotopic compositions and initial values for Golfball are consistent with those for fluffy Type A (Kawasaki et al., 2019) and fine-grained CAIs (Kawasaki et al., 2020), implying its precursor contains fluffy Type A and/or fine-grained CAIs. The multiple melting events for Golfball occurred in very short order after the formation of the precursor.

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Chemical and isotopic fractionation of Type B CAI caused by evaporation: An experimental study

*Michiru Kamibayashi[1], Shogo Tachibana[1,3], Noriyuki Kawasaki[2], Daiki Yamamoto[3], Hisayoshi Yurimoto[2]

1. The University of Tokyo, 2. Hokkaido University, 3. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency

CAIs are the oldest objects formed in the early Solar System, and some subsets of these inclusions show chemical and isotopic features that indicate their formation through high temperature events that resulted in partial melting and evaporation of relatively volatile elements such as Mg and Si. Many laboratory and theoretical studies have discussed evaporation and crystallization of CAI melts (e.g., Stolper and Paque, 1986; Grossman et al., 2002), but the circumstances that made their chemical and isotopic features have not yet been fully understood. These characteristics can be used as a cosmobarometry in the early solar system when appropriate interpretation is given. In this study, crystallization experiments of CAI-like composition melts in nebula-like low pressure hydrogen gas were conducted to investigate the effect of evaporation during crystallization of Type B CAIs and to constrain the nebular pressure during the CAI formation.

The starting material was prepared by mixing SiO_2, TiO_2, Al_2O_3, MgO, and $CaCO_3$ powders at a composition aiming at a precursor composition given on the condensation trajectory of Grossman et al. (2002). Premelted glassy spherical samples on Ir wire loop (2.5 mm in diameter) were used as starting materials. Cooling experiments were conducted using a vacuum furnace equipped with a hydrogen gas flow system. The experiments were conducted from 1420˚C to 1100-1277˚C at controlled cooling rates of 5-50˚C/hr and under three different pressures (P_{H2}=10, 1, 0.1 Pa) to examine the pressure dependence of compositional and textural change. Textural observation and quantitative analysis were conducted by FE-SEM-EDS. Magnesium isotopic analysis of melilite and pyroxene was conducted by SIMS (Cameca ims-1280HR at Hokkaido University).

All of the run products presented significant weight losses which can be attributed to the evaporation of volatile components, Mg and Si. Some of the experimental residues from experiments at P_{H2} = 1 and 10 Pa show their outer regions are enriched in melilite, which resembles the melilite mantle observed in natural Type B1 CAIs. The chemical composition of melilite is Mg-poor at the sample rim and becomes Mg-rich toward the inside, suggesting that these melilites crystallized inward from the melt droplet surface, as inferred from petrological studies of Type B1 (Wark and Lovering, 1982). Melilite composition at the rim is Mg-poor and as low as ~Åk10, which is more depleted in Mg than that expected for the melt of starting composition to crystallize (~Åk20). Such Mg-poor melilite can only crystallize from a melt which has lower Mg and Si concentrations.

For samples which exhibit a well-developed melilite mantle, elevated $d^{25}Mg$ values at the sample rim compared to the interior are observed. This can also be attributed to diffusion-limited evaporation of Mg and Si from the melt surface. Isotope fractionation in a vaporizing melt is controlled by the relative rates of evaporation and diffusion. At higher P_{H2} (e.g., 10 Pa), evaporation could occur faster than diffusive homogenization of the melt, because evaporation is enhanced by the presence of hydrogen (Mendybaev et al., 2021), while diffusion is not. The resulting consequence is preferential crystallization of melilite from the melt droplet surface enriched in Ca and Al. Despite many of the CAIs show lighter isotopic

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composition at the margin or show homogeneous isotopic composition throughout the inclusion (e.g., Bullock et al., 2013), such increase in isotope fractionation at the margin of the inclusion is consistent with some of the natural existing CAIs (Goswami, 1994). Although one or more steps needs to be taken into account to explain the isotopic fractionation of the majority of natural CAIs, Type B1-like melilite mantle can indeed crystallize as a result of evaporation in relatively high P_{H2} condition.

Keywords: CAI, evaporation, protosolar disk

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I-Xe ages of chondrites and its relevance for solar-wind derived noble gas concentrations

*Koharu Arai[1], Hirochika Sumino[1], Atsushi Takenouchi[2], Shogo Tachibana[1,3]

1. The University of Tokyo, 2. National Institute of Polar Research, 3. Institute of Space and Astronautical Science

The lifetime of protoplanetary disk gas ranges 1-10 million years, which depends on viscous dissipation and photo-evaporation of the disk gas. It is not clear how long the Sun’ s protoplanetary disk held its gas component, during which gas giants formed. Ca-, Al-rich inclusions and chondrules are considered to have formed in the presence of disk gas, but the timing of clearing of disk gas has not yet been tightly constrained [1]. Bajo [2] found a correlation between Solar-wind derived noble gas concentrations and I-Xe ages of brecciated chondrites. Bajo [2] hypothesized that the I-Xe ages, which could represent impact ages [3], of solar-wind-rich meteorites indicated the timing of disk-gas clearing because the solar wind reaches to the surface of small bodies only after the complete dissipation of disk gas. In this study, to test this hypothesis, I-Xe ages and solar-wind noble gas concentrations of Zag (H36), Northwest Africa 801 (CR2) (NWA 801), Ochansk (H4), Nuevo Mercurio (H5) meteorites were determined.

About 30 mg fragments of these meteorites, irradiated with neutrons at the Kyoto University research reactor, were heated in vacuum stepwisely in the temperatures range of 400-1800˚C to extract xenon. After purifying the noble gases extracted at each heating step, xenon isotope ratios were measured using a magnetic-sector-type mass spectrometer VG3600. The obtained $^{129}Xe/^{128}Xe$ ratios of the samples after corrections for low temperature alteration and trapped component were converted to relative I-Xe ages by comparing with $^{129}Xe/^{128}Xe$ ratio of the Shallowater meteorite with the absolute age of 4.5633±0.0004 billion years [4]. About 5 mg fragments of these meteorites were heated in vacuum at 800 and 1700℃ for noble gas analysis. We found that the solar-wind-poor portion of Zag was systematically older (4.551±0.008 and 4.558±0.013 billion years) than the solar-wind-rich portion (4.541±0.010 and 4.551±0.006 billion years) as shown in [2]. NWA 801 is also a solar wind rich meteorite Its I-Xe age is obtained as 4.529±0.016 billion years. The present dataset is broadly consistent with the hypothesis [2], but further data with lesser analytical uncertainties is surely required.

References: [1] I. Pascucci and S. Tachibana (2010) In Protoplanetary Dust (eds. D. Apai and D. S. Lauretta). [2] K. Bajo (2010) Ph.D thesis, Univ. Tokyo. [3] J. D. Gilmour and M. J. Filtness (2019) Nature Astronomy 3, 326. [4] J. D. Gilmour et al. (2006) Meteorit. Planet. Sci. 41, 19.

Keywords: I-Xe ages, solar-wind derived noble gases, chondrite

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Requirement of turbulent nebula and dust grains for grain size coarsening in chondrule rims

*Hiroaki Kaneko[1], Sota ARAKAWA[2], Taishi Nakamoto[1]

1. Tokyo Institude of Technology, 2. National Astronomical Observatory of Japan

Chondrules are mm size objects in primitive chondrites. They are coated with fine-grained dust rim (FGRs). The origin of FGRs is still controversial. In a turbulent nebula, free floating chondrules can acquire FGRs through sweeping up dust grains. (nebula origin scenario)

Xiang et al. (2019) examined the internal structures of FGRs formed in such a turbulent nebula. They prepared two different dust populations; monomer grains or dust aggregates. When monomer grains accreted on chondrules, FGRs showed grain size coarsening from the bottom to the top. On the other hand, when aggregates accreted on chondrules, FGRs showed uniform structures. However, Xiang et al. (2019) did not consider dust aggregation and, in what kinds of nebular conditions monomer grains or dust aggregates accrete to form FGRs.

We simulate both aggregation of polydisperse monomer grains and their accretion on chondrules. Aggregate growth can be divided into two stages, monomer-aggregation stage and BCCA-like stage. In the monomer-aggregation stage, smaller monomer grains are incorporated into aggregates faster than larger ones. Most of the monomer grains larger than the average size of aggregates are isolated. In the BCCA-like stage, the evolution of aggregates is similar to the fractal evolution of single size monomer grains. We obtain the requirement for monomer grains to accrete on chondrules. When monomer grains population follows the same power-law size distribution as the Inter Stellar Medium (ISM), the maximum grain size of >1 μm is widely required in a moderately turbulent nebula ($\alpha < 10^{-3}$), while if turbulent intensity is very weak ($\alpha = 10^{-5}$), ~ 10 μm is required. Moreover, size distributions which weigh larger grains more than ISM may be preferable for effective grain size coarsening.

Keywords: chondrule, protoplanetary disk, fine-grained rims

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

Sat. Jun 5, 2021 10:45 AM - 12:15 PM JST | Sat. Jun 5, 2021 1:45 AM - 3:15 AM UTC | Ch.04 Zoom Room 04

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

convener:Megumi Matsumoto(Graduate School of Science, Tohoku University), Shin Ozawa(Department of Earth Science, Graduate School of Science, Tohoku University), Yuki Hibiya(Submarine Resources Research Center, Japan Agency for Marine-Earth Science and Technology), Noriyuki Kawasaki(Department of Earth and Planetary Sciences, Graduate School of Science, Hokkaido University), Chairperson:Shin Ozawa(Department of Earth Science, Graduate School of Science, Tohoku University), Megumi Matsumoto(Graduate School of Science, Tohoku University)

In this session, we will discuss the material evolution in the Solar System based on extraterrestrial sample analyses and experimental works. We will overlook recent knowledge from primitive materials such as chondrites, interplanetary dust particles, and returned samples by space missions. Research works on meteorite parent body processes such as aqueous alteration, thermal metamorphism, shock metamorphism, volcanic activity, and core-mantle-crust differentiation will also be discussed. The topics of this session include experimental studies which, together with meteorite studies, help us to understand the material formation/evolution in the Solar System as well as processes on meteorite parent bodies. Presentations on new innovative analytical and theoretical techniques in various research fields (chemistry, theoretical calculation, physical property) are highly welcome to improve future studies of the Solar System evolution. This session is J (Japanese) session but English talks are also welcomed.

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

[PPS07-11] Nanostructures of iron sulfides in lunar soils and implications for the behavior of sulfur on airless bodies.

*Toru Matsumoto[1], Takaaki Noguchi[1], Yu Tobimatsu[1], Dennis Harries[2], Falko Langenhorst[2], Akira Miyake[3], Hiroshi Hidaka[4] (1.Kyushu University, 2.Friedrich Schiller University Jena, 3.Kyoto University, 4.Nagoya University)

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

[PPS07-12] **Multiple sulfur isotope evidence for the formation of mesosiderite meteorites**

*Shun Mihira[1], Madhusoodhan Satish-Kumar[1], Akira Yamaguchi[2], Tomohiro Usui[3] (1.Department of Geology, Faculty of Science, Niigata University, 2.National Institute of Polar Research, 3.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

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

[PPS07-13] The shock pressure threshold for producing shock melt veins in basaltic rocks

*Haruka Oono[1], Kosuke Kurosawa[1], Takafumi Niihara[2], Takashi Mikouchi[3], Hidenori Genda[4], Naotaka Tomioka[7], Masahiro KAYAMA[5], Mizuho Koike[6], Yuji Sano[8], Wataru Satake[1], Takafumi Matsui[1] (1.Planetary Exploration Research Center, Chiba Institute of Technology, 2.Shool of Engineering, The University of Tokyo, 3.The University of Museum, The University of Tokyo, 4.Earth-Life Science Institute, Tokyo Institute of Technology, 5.Graduate School of Arts and Sciences, The University of Tokyo, 6.Graduate School of Advanced Science and Engineering, Hiroshima University, 7.Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology , 8.Atmosphere and Ocean Research Institute, The University of Tokyo)

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

[PPS07-14] **Shock effects in silica minerals in eucrites**

*Rei Kanemaru[1], Akira Yamaguchi[2,1], Naoya Imae[2,1], Atsushi Takenouchi[2], Hirotsugu Nishido[3] (1.The Graduate University for Advanced Studyies (SOKENDAI), 2.National Institute of Polar Research (NIPR), 3.Okayama University of Science (OUS))

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

[PPS07-15] Effect of ultraviolet C irradiation on surface alteration of basalt due to evaporation of sulfuric acid

*Nobuo Komori[1] (1.The United Graduate School of Education Tokyo Gakugei University)

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

[PPS07-16] Discussion

Nanostructures of iron sulfides in lunar soils and implications for the behavior of sulfur on airless bodies.

*Toru Matsumoto[1], Takaaki Noguchi[1], Yu Tobimatsu[1], Dennis Harries[2], Falko Langenhorst[2], Akira Miyake[3], Hiroshi Hidaka[4]

1. Kyushu University, 2. Friedrich Schiller University Jena, 3. Kyoto University, 4. Nagoya University

Alteration of materials on airless bodies with time is referred to as space weathering. Extensive studies for space weathering have focused on silicate minerals, whereas the behavior of other minerals in space-exposed environments remains poorly investigated. Recent analysis of Itokawa samples revealed unique features of space weathered rims on iron sulfides, such as selective sulfur loss and the formation of metallic iron whiskers [1]. In this study [2], we investigated surface features of iron sulfides in lunar mature soil grains for the general understanding of sulfide space weathering. We used scanning electron microscopy (SEM) and transmission electron microscopy (TEM) for the observation of sulfides. SEM observations show that iron sulfides have vesicular textures and iron whiskers on their surfaces. Iron sulfides observed using TEM are composed of 2C troilite and NC-pyrrhotite. The space-weathered rim on the iron sulfides is characterized by crystallographic misorientations and the disappearance of superstructure reflections of 2C troilite in electron diffraction patterns. These crystallographic modifications are probably formed by solar wind irradiation. The rim contains opened vesicles that are aligned along the *c*-plane of the iron sulfides, as well as numerous tiny vesicles. The Fe/S ratio at the surface of the rim is higher than in non-altered regions, indicating that sulfur escaped from the sulfide surface. Iron whiskers protrude from the space weathered rim and consist of polycrystalline metallic iron. The sulfide rims and the iron whiskers are both coated with vapor-deposited materials rich in O and Si. The combined processes including the solar wind irradiation, heating during impact events, solar UV radiation, and the thermal cycling may cause vesicular textures, selective sulfur escape from the iron sulfides, and the formation of the iron whiskers. The structures of the space weathered rim support the notion that the enrichment of heavy sulfur isotopes in mature lunar soils is due to space weathering of iron sulfides [3]. The space weathered rims on lunar iron sulfides are similar to those observed in regolith particles from asteroid Itokawa. Therefore, alterations of iron sulfide might be common among airless bodies in the solar system.

[1]Matsumoto et al. 2020, *Nature Communications* 11, 1-8. [2] Matsumoto et al. 2021, *Geochimica Cosmochimica Acta*, accepted. [3] Kaplan and Smith 1970 *Science* 167, 541-543.

Keywords: Moon, iron sulfides, space weathering

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Multiple sulfur isotope evidence for the formation of mesosiderite meteorites

*Shun Mihira[1], Madhusoodhan Satish-Kumar[1], Akira Yamaguchi[2], Tomohiro Usui[3]

1. Department of Geology, Faculty of Science, Niigata University, 2. National Institute of Polar Research, 3. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency

Mesosiderites and HED (howaldite, eucrite, diogenite) meteorites are considered to have a common origin, from the asteroid Vesta. However, the processes that led to the origin of mesosiderites and their relation with HED's are not clear yet. In this respect, multiple sulfur isotopic composition may track their petrological relationships and suggest genetic links of mesosiderites with other meteorites. In this study, multiple sulfur isotopic composition of selected mesosiderites were measured and a comparison with othermeteorites is attempt to constrain the formation process of mesosiderites.

Although Clayton et al. (1996) suggested genetic links between pallasites, IIIAB iron meteorites, and HED meteorites based on the $D^{17}O$ values, the $d^{34}S$ and $D^{33}S$ relationships of the pallasites and IIIAB iron meteorites indicate that they do not match with those of HED meteorites (Rai et al., 2005; Dottin et al., 2018). The sulfur isotopic composition of mesosiderites in this study indicates similarities with IIIAB iron meteorites and pallasites but not with HED. This suggests that the sulfur isotopic composition may not preserve their true parent body information, but probably represent information on some reactions or mixing during their formation.

A recent study suggests that the formation process of mesosiderites can be explained by a hit-and-run model (Haba et al., 2019). Rai et al. (2005) has reported Mass-Independent Fractionation (MIF) for HED meteorites, however in our study the mesosiderites are devoid of MIF. This indicates two possibilities, either mixing of Vesta with the impactor or there is no genetic links between HED and mesosiderites. In our presentation we will discuss about these two possibilities on the formation process of mesosiderites using sulfur isotopic composition in comparison with the existing data of HED meteorites.

References

1. Antonelli M. A., Kim S-T., Pters M., Labidi J., Cartigny P., Walker R. J., Lyons J. R., Hoek J., and Farquhar J., Early inner solar system origin for anomalous sulfur isotopes in differentiated protoplanets, PNAS, 111, 17749-17754, (2014).
2. Clayton R. N. and Mayeda T.K., Oxygen isotope studies of achondrites. Geochim. Cosmochim. Acta, 60, 1999-2017, (1996).
3. Dottin J. W., Farquhar J., and Labidi J., Multiple sulfur isotopic composition of main group pallasites support genetic links to IIIAB iron meteorites, Geochim. et Cosmochim. Acta, 224, 276-281, (2018).
4. Haba M. K., Wotzlaw J-F., Lai J-Y., Yamaguchi A., and Schonbachler M., Mesosiderite formation on asteroid 4 Vesta by a hit-and-run collision, Nature Geoscience, 12, 510-515, (2019).
5. Rai V. K., Jackson T. L., and Thiemens M. H., Photochemical mass-independent sulfur isotopes in achondritic meteorites, Science, 309, 1026-1065, (2005).

Keywords: Mesosiderite, Sulfur isotope

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The shock pressure threshold for producing shock melt veins in basaltic rocks

*Haruka Oono[1], Kosuke Kurosawa[1], Takafumi Niihara[2], Takashi Mikouchi[3], Hidenori Genda[4], Naotaka Tomioka[7], Masahiro KAYAMA[5], Mizuho Koike[6], Yuji Sano[8], Wataru Satake[1], Takafumi Matsui[1]

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Introduction

Shock metamorphic textures record the impact history of meteorite parent bodies. Shock features in meteorites have been classified into progressive stages (shock stages) based on petrological and mineralogical textures (e.g., Stöffler et al., 2018), and the classification has been used to decode the impact conditions, including projectile diameter and impact velocity. Stöffler et al., 2018 summarized the classifications for a variety of minerals and rocks as the table, which is known as “the Stöffler table”, by using a number of previous results of uniaxial-shock recovery experiments. Recently, Kanemaru et al. 2020 independently constructed a detailed shock metamorphic classification pertaining to basaltic eucrites. They showed that the shock stages of the Stöffler table for mafic rocks (Table M) could be further divided into a few shock degrees. In this study, we performed a shock recovery experiment with terrestrial basalt samples using decaying shock waves. We recovered the shocked sample which has experienced a wide range of shock pressures and temperatures. The shock textures in the recovered sample were compared with the previous study (Kanemaru et al., 2020). The peak pressures and temperatures depending on the initial locations in the target were estimated using numerical simulations under the same impact conditions.

Sample and Methods

We used terrestrial basalt samples (Inner Mongolia), which are composed mainly of plagioclase, pyroxene, and olivine, as a target. The sample was shaped to a cylinder (30 mm in diameter, 24 mm in height), and it was set in titanium (Ti) container. A polycarbonate sphere was used as a projectile. The impact velocity was 7.3 km s^{-1}. A thin section of the recovered sample was observed by optical microscopy and a Scanning Electron Microprobe (SEM). We estimated pressures and temperature in the sample based on petrological and mineralogical textures. In addition, peak pressures and temperatures in the target were also numerical estimated with the iSALE shock physics code (Amsden et al., 1980, Ivanov et al., 1997, Wünnemann et al., 2006). The results from the above two different estimations were compared with each other.

Results and Discussion

Plagioclase, pyroxene, and olivine in the shocked sample around the epicenter in the recovered sample showed a shock feature called undulatory extinction. Several shock melt veins (up to 4 μm in width) were identified around the epicenter. The presence of vesicles (~2 μm in diameter) in the melt veins would be evidence of volatile degassing due to melting. The plagioclase grains adjoining the shock melt veins exhibit undulatory extinction, but they do not exhibit planar deformation features (PDFs), mosaicism, and vitrification. According to the Stöffler table M, the recovered sample is classified into the shock stage S2 in terms of the shock features in plagioclase. The sample also belongs to the shock stage S3 based on the fact that shock melt veins are produced due to some local effects. In contrast, the textures observed in

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our shocked sample uniquely correspond to the shock degree C proposed by Kanemaru et al. (2020). The iSALE simulations showed that the pressures and temperatures around shock melt veins were estimated to be up to 10 GPa and 600 K, respectively. Therefore, we recognized that the shock degree C (Kanemaru et al., 2020) was formed due to a shock compression to ~10 GPa, the local temperature could be about 800 K higher than the calculated temperature (the temperature is estimated from the solidus of dry basalt), and the Stöffler table does not predict such the temperature excess.

Conclusion

We performed a shock recovery experiment and determined the required pressure for producing shock melt veins in basaltic rocks to be ~10 GPa. The shock features in the collected sample are similar to the textures in basaltic eucrites at the shock degree C. The peak temperatures in the sample around the shock melt veins were estimated to be ~600 K, which is much lower than the solidus at the reference pressure. Thus, the local temperature could be much higher than the expected one from the conventional shock stage (Stöffler table).

Keywords: shock metamorphism, mafic rocks, basalt, shock experiment

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Shock effects in silica minerals in eucrites

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Eucrite is a group of differentiated meteorites probably originated from the Vestan crust [1]. Recently, we defined the progressive shock degrees (A-E) of eucrites on the basis of petrographic and X-ray diffraction methods [2]. Here, we studied shock effects in eucrites of shock degrees C-E focusing on shock textures of silica minerals.

We studied polished thin sections of five eucrites, Y 980433 (shock degree: D), Y-792510 (C), A-881747 (C), Cachari (D), and A-87272 (E) using a micro-Raman spectrometer (Renishaw inVia), a Chroma CL (Gatan), and an energy dispersive spectrometer (Oxford Aztek Energy) attached to the JEOL JSM-7100 field emission scanning electron microscope at NIPR.

Eucrites studied here contain significant amounts (~10 vol%) of silica minerals. We identified tridymite, quartz, and silica glass in the host basaltic rocks, and quartz, coesite, stishovite in shock melt veins (Table 1). In eucrites with shock degree C, characterized by the absence of maskelynite, silica minerals do not show clear shock textures.

Eucrites with shock degree D, are characterized by the presence of maskelynite near shock veins, but these eucrites do not contain maskelynite in the basaltic host (unmelted portions). Maskelynite near shock veins was produced by shock under the heat from shock melt veins [e.g., 3]. Tridymite in the basaltic host in Cachari and Y 980433 is converted to glass (~50 vol%). Patches of remnant tridymite are heterogeneously distributed in silica glass. The tridymite (partly converted to glass) preserves original lath shape. In contrast, Y-790266 (D) contains quartz and cristobalite, and is not converted into glass. The facts indicate that the amorphization pressure of tridymite is lower than those of quartz, cristobalite, and calcic plagioclase. A-87272 (shock with shock degree: E) is characterized by the abundant maskelynite (>50 vol%). Most of the silica minerals (~90 vol%) in the host are converted to glass. We found traces of quartz and tridymite.

Shock veins are commonly observed in eucrites with shock degrees C or higher[2]. We found coesite and stishovite in Y-790266, quartz, stishovite, and coesite in Cachari, and silica glass in Y 980433. The occurrences of these silica minerals are controlled by local pressure-temperature paths in or near the shock melt veins [e.g., 4].

References

[1] Binzel R.P. and Xu S. (1993) *Science* 260, 186-191.
[2] Kanemaru R. et al. (2020) *Polar Science* 26, 100605.
[3] Yamaguchi A. et al. (2002) *High-Pressure Shock Compression of Solids V*. Springer, 29–44 chap. 2.
[4] Miyahara M. et al. (2014) *PNAS* 111, 30, 10939-10942.

Keywords: Eucrite, silica minerals, Shock metamorphism

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Table 1. Silica minerals in studied eucrites.

Sample	Classification	Shock degree [2]	Silica minerals Lithology	
			Host	Shock vein
Y-792510	Basaltic	C	Trd, Qtz	-
A-881747	Basaltic	C	Trd, Qtz	Qtz
Y-790266	Basaltic	D	Qtz, Cri	Coe, Sti
Cachari	Basaltic	D	Trd, Qtz Glass (~50 vol%)	Qtz, Sti, Coe
Y 980433	Cumulate	D	Trd, Qtz,Glass (~50 vol%)	-
A-87272	Basaltic	E	Trd, Qtz, Glass (~90 vol%)	Qtz, Sti

Qtz: Quartz, Trd: Tridymite, Cri: Cristobalite, Sti: Stishovite, Coe: Coesite.

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Effect of ultraviolet C irradiation on surface alteration of basalt due to evaporation of sulfuric acid

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1. The United Graduate School of Education Tokyo Gakugei University

A large amount of iron oxide, sulfate, chloride, etc. have been detected on the surface of Mars, which is the cause of the reddish-brown color of the surface of Mars. Also, much evidence has led to the belief that liquid water once existed widely.
As an research activity of the science club in the junior high school, the author has irradiated basalt and iron olivine soaked in water or an acidic aqueous solution with ultraviolet rays and investigated their changes (Komori, 2020). Studies related to weathering of the surface of Mars include Golden et al. (2005) and Cole (2015). No experimental research has been conducted to investigate changes in basalt in sulfuric acid while irradiating with ultraviolet rays.

Ⅰ Research purpose

In the process of drying basalt soaked in sulfuric acid aqueous solution, the effect of ultraviolet rays C on the alteration of basalt is investigated and compared with related studies.

Ⅱ Method

1 Immerse two shaped basalt samples in sulfuric acid for 24 hours. Sulfuric acid is a mixture of boiled purified water and a stock solution of sulfuric acid.
2 Take out the two basalt samples from sulfuric acid and put them in separate test tubes with the surface wet. Replace the air with nitrogen.
3 Set the two test tubes in the ultraviolet irradiator. The ultraviolet irradiator is a bundle of four 20W germicidal lamps, and irradiates the sample with ultraviolet C of about 20W / m2. One of the two test tubes was directly irradiated (UVC) and the other was covered with aluminum foil so that it was not irradiated (N).
4 Every few days after the ultraviolet irradiation, the test tube was taken out from the ultraviolet irradiator, and the basalt sample was visually observed and photographed. After that, the air in the test tube was replaced with nitrogen and returned to the ultraviolet irradiator.
5 After the experiment, the analysis of the brown powder generated on the sample surface was analyzed by XRD. The surface of the sample was photographed with a digital microscope.

Ⅲ Result

UVC produced a powdery substance on the surface of the basalt. XRD revealed that the brown powder formed on the sample UVC surface was ferric sulfate, mainly metahomanite, and the white powder was gypsum. In the sample N, it seems that a slight amount of gypsum was formed on the entire surface.

Ⅳ Discussions

On Mars in the past, it is possible that irradiation of ultraviolet C produced minerals containing Fe3+, such as metahomanite, in the process of drying basalt soaked in the sea of sulfuric acid due to regression.

Keywords: Mars, ultraviolet rays C, sulfuric acid, trivalent iron, evaporation

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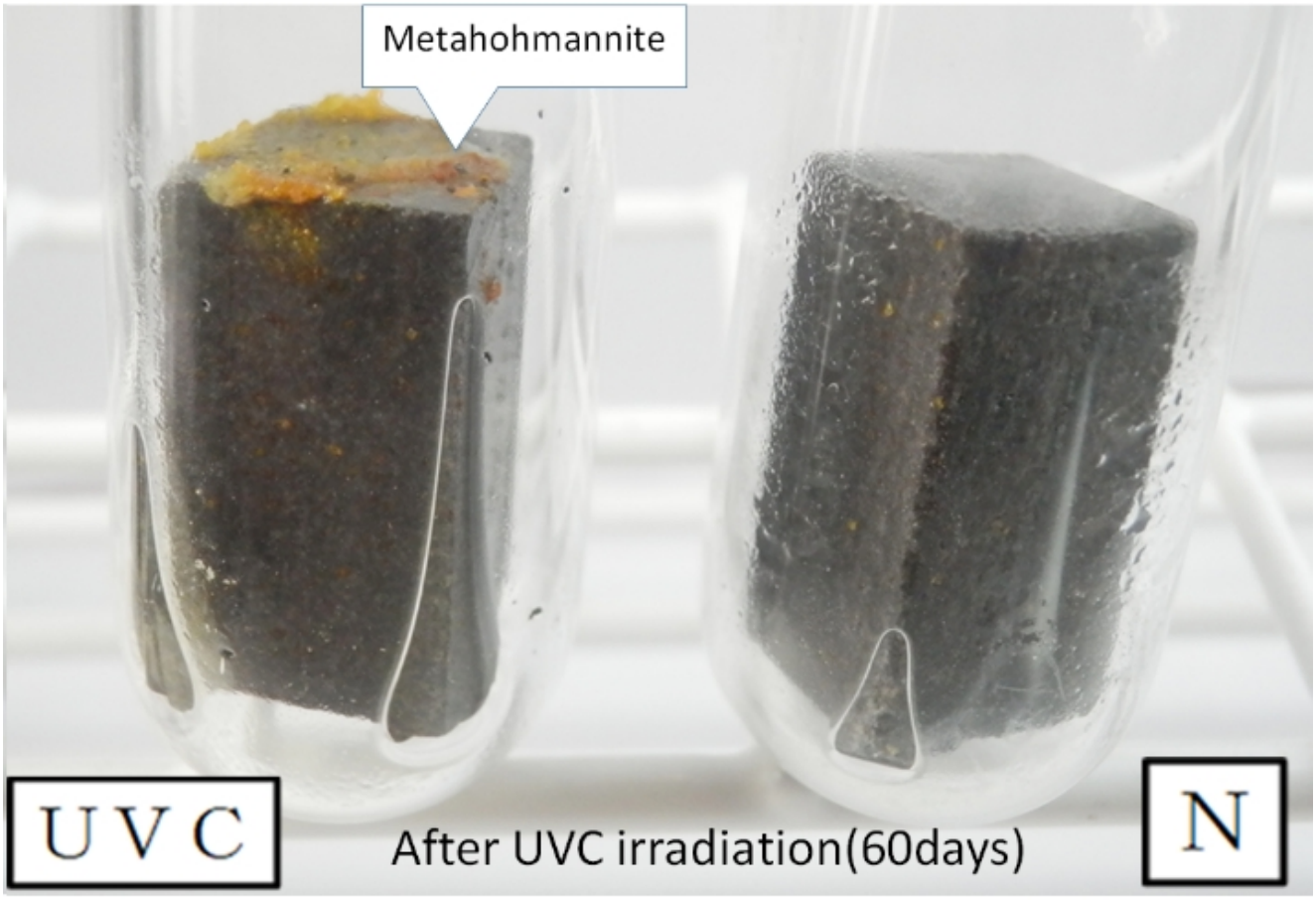

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[J] Oral | P (Space and Planetary Sciences) | P-PS Planetary Sciences

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

convener:Megumi Matsumoto(Graduate School of Science, Tohoku University), Shin Ozawa(Department of Earth Science, Graduate School of Science, Tohoku University), Yuki Hibiya(Submarine Resources Research Center, Japan Agency for Marine-Earth Science and Technology), Noriyuki Kawasaki(Department of Earth and Planetary Sciences, Graduate School of Science, Hokkaido University), Chairperson:Shin Ozawa(Department of Earth Science, Graduate School of Science, Tohoku University), Megumi Matsumoto(Graduate School of Science, Tohoku University)

Sat. Jun 5, 2021 10:45 AM - 12:15 PM Ch.04 (Zoom Room 04)

In this session, we will discuss the material evolution in the Solar System based on extraterrestrial sample analyses and experimental works. We will overlook recent knowledge from primitive materials such as chondrites, interplanetary dust particles, and returned samples by space missions. Research works on meteorite parent body processes such as aqueous alteration, thermal metamorphism, shock metamorphism, volcanic activity, and core-mantle-crust differentiation will also be discussed. The topics of this session include experimental studies which, together with meteorite studies, help us to understand the material formation/evolution in the Solar System as well as processes on meteorite parent bodies. Presentations on new innovative analytical and theoretical techniques in various research fields (chemistry, theoretical calculation, physical property) are highly welcome to improve future studies of the Solar System evolution. This session is J (Japanese) session but English talks are also welcomed.

12:00 PM - 12:15 PM

[PPS07-16]Discussion

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

Sat. Jun 5, 2021 10:45 AM - 12:15 PM JST | Sat. Jun 5, 2021 1:45 AM - 3:15 AM UTC | Ch.06 Zoom Room 06

[P-EM14] Heliosphere and Interplanetary Space

convener:Kazumasa Iwai(Institute for Space–Earth Environmental Research (ISEE), Nagoya University), Yasuhiro Nariyuki(Faculty of Education, University of Toyama), Ken Tsubouchi(University of Electro-Communications), N Masaki Nishino(Japan Aerospace Exploration Agency, Institute of Space and Astronautical Science), Chairperson:Kazumasa Iwai(Institute for Space–Earth Environmental Research (ISEE), Nagoya University)

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 observation/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.

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

[PEM14-01] Yearly variation of the Sun’s polar regions during Solar Cycle 24 observed with Hinode

*Daikou Shiota[1], Masumi Shimojo[2] (1.National Institute of Information and Communications Technology (NICT), 2.National Astronomical Observatory of Japan (NAOJ))

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

[PEM14-02] Improvement of the computer assisted tomography of interplanetary scintillation observations

*Munetoshi Tokumaru[1], Ken'ichi Fujiki[1], Masayoshi Kojima[1], Kazumasa Iwai[1] (1.Institute for Space-Earth Environmental Research, Nagoya University)

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

[PEM14-03] Physical properties of fast and slow solar wind studied by spacecraft radio scintillation

*Shota Chiba[1], Takeshi Imamura[1], Munetoshi Tokumaru[2], Daikou Shiota[3], Hiroki Ando[4] (1.Graduate School of Frontier Sciences, The University of Tokyo, 2.Institute for Space-Earth Environment Research, Nagoya University, 3.National Institute of Information and Communications Technology, 4.Kyoto Sangyo University)

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

[PEM14-04] Solar wind density distribution derived from DM measurements of Crab pulsar

*Maeda Ryuya[1], Munetoshi Tokumaru[1], Kaito Tawara[1], Toshio Terasawa[2] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Institute for Cosmis Ray Research,The University of Tokyo)

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

[PEM14-05] Next generation solar wind observation system: science requirements and pathfinders.

*Kazumasa Iwai[1], Munetoshi Tokumaru[1], Ken'ichi Fujiki[1] (1.Institute for Space–Earth Environmental Research (ISEE), Nagoya University)

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

[PEM14-06] Discussion

Yearly variation of the Sun’s polar regions during Solar Cycle 24 observed with Hinode

*Daikou Shiota[1], Masumi Shimojo[2]

1. National Institute of Information and Communications Technology (NICT), 2. National Astronomical Observatory of Japan (NAOJ)

Observations of the magnetic fields in the Sun’s polar regions are of crucial importance to understand the long-term variation of solar magnetism. As a consequence of the magnetic variation the three-dimensional structure of global solar corona and solar wind also show a drastic long-term variation and, as a result, fast solar wind emanates from the polar regions around solar minima. The first Hinode observation of the polar region reveals the fine structure of photospheric vector magnetic fields of the polar areas: the existence of many patchy magnetic concentrations with intrinsic field strengths of over 1kG distributed across the entire polar region (Tsuneta et al. 2008) around the solar minimum. Following the first polar observation, the monitoring of the polar regions has been continued for 12 years. Since 2012, which was before the solar maximum of this cycle, the time variations in the distribution of the whole polar regions during the polarity reversal period have been monitored with periodic SP observations during a month at the proper timing (March for the south pole and September for the north pole). At September 2020, Solar Cycle 25 Prediction Panel, an international group of experts co-sponsored by NASA and NOAA, announced that solar minimum occurred in December 2019. This means that Hinode succeeded to observe the Sun’s polar regions during whole of Solar Cycle 24.
In this study, we investigated the yearly variation in magneitc field distribution of both Sun’s polar regions obtained in the monitoring during Solar Cycle 24. We also combined the polar magnetic field data with HMI/SDO synoptic map. Using the maps, we calculated the three-dimensional coronal magnetic field with potential field source surface model. We will report yearly variation in the coronal magnetic field structure associated with the variation in the polar magnetic field.

Keywords: solar cycles, photospheric magnetic field, coronal magnetic field

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Improvement of the computer assisted tomography of interplanetary scintillation observations

*Munetoshi Tokumaru[1], Ken'ichi Fujiki[1], Masayoshi Kojima[1], Kazumasa Iwai[1]

1. Institute for Space-Earth Environmental Research, Nagoya University

The computer assisted tomography (CAT) of interplanetary scintillation (IPS) observations allows reconstruction of global distribution of the solar wind speed. Earlier studies demonstrated that the solar wind data derived from the CAT analysis are comparable to those from in situ measurements. However, comparison between the CAT analysis and in situ measurements at the Earth orbit for the period after 2009 showed that the solar wind speeds derived from IPS observations are systematically higher than those from in situ observations. In this study, we examined two effects as a cause for this discrepancy; one is the effect of the number of IPS data used for the CAT analysis, and the other is the effect of the empirical relation between solar wind speed V and density fluctuations ΔN_e; $V \propto \Delta N_e^{\alpha}$, which is assumed in the CAT analysis. As the result, we found that the latter can explain the observed discrepancy if α varies with time, whereas the former is unlikely. Instead, the effect of the number of IPS data can account for variations of rms deviations and correlations between IPS and in situ observations. The index of α=-0.5 is optimal to analyze IPS observations between 1985 and 2008, and a positive and larger value of alpha (i.e. α=+1.0) yields better agreement between IPS and in situ observations. By using these optimal values for α, the CAT analysis of IPS observations is improved, and this leads to better understanding of global heliosphere. The result obtained here also suggests that physical properties of solar wind micro-turbulence may evolve over long timescale. If the momentum flux is invariant among different solar wind flows, the result obtained here implies that fractional density fluctuations of the solar wind for the recent period depend on the speed more strongly than those for the past period.

Keywords: solar wind, interplanetary scintillation, turbulence, tomography

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Physical properties of fast and slow solar wind studied by spacecraft radio scintillation

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1. Graduate School of Frontier Sciences, The University of Tokyo, 2. Institute for Space-Earth Environment Research, Nagoya University, 3. National Institute of Information and Communications Technology, 4. Kyoto Sangyo University

The solar wind is a supersonic plasma flow streamed from the solar corona. The solar wind is classified into the fast wind (typically ~750 km/s) and the slow wind (~300 km/s). The acceleration of the solar wind mainly occurs in the outer corona at heliocentric distances of about 5–10 R_S (= solar radii), where the coronal heating by magnetohydrodynamic waves and the wave-induced magnetic pressure are thought to play major roles in the acceleration. The mechanisms have not been fully confirmed by observations because the acceleration region is too close to the Sun to be observed by in-situ probes.
Key physical processes in the acceleration region can be observed with radio occultation. Coronal plasma traversing the ray path disturbs radio wave's amplitudes and frequency, from which we can derive physical parameters such as the flow speed and wave's amplitudes. In this research, we analyze data taken by radio occultation observations carried out using JAXA's Venus orbiter Akatuki's during the superior conjunction periods from May 30 to June 15, 2016 and June 6 to July 8, 2011. Solar offset distances of about 1.4–9.0 R_S were probed intermittently by 11 observations in the former period and about 1.5–20.6 R_S were probed by 16 observations in the latter.
The radial velocity and the turbulence characteristics (power-law exponent, axial ratio, and inner scale) were retrieved from the intensity scintillation time series taken in 2016 by fitting a theoretical spectrum to the observed power spectra. In the radial distribution of the derived solar wind velocity, fast winds originating from regions near a coronal hole and slow winds from other regions were identified. We also found that the inner scale increases with the heliocentric distance and that the fast solar wind has larger inner scales than the slow solar wind. These tendencies are consistent with the inertial length model proposed by Coles and Harmon (1989).
We also applied wavelet analysis to the frequency time series taken in 2011 to detect quasi-periodic fluctuations (QPC), which are thought to represent acoustic waves, and quantify the amplitude, the period, and the coherence time of each wave event. The density amplitude and the wave energy flux were estimated following the method of Miyamoto et al. (2014). We confirmed that the fractional density amplitude increases with distance up to ~6 R_S. The amplitude reaches tens of percent, suggesting a possibility of wave breaking. The energy fluxes increase with distance up to ~6 R_S, suggesting local generation of waves. It is probable that these radial distributions indicate that the Alfven waves propagating from the photosphere generate acoustic waves in the outer corona, and the generated acoustic waves dissipate to heat the corona, as suggested by numerical models. The wave energy fluxes in the fast solar wind were larger than those in the slow wind. The results suggest that the fast solar wind originating from the coronal hole is powered by a larger injection of wave energy than the slow wind originating from other regions. In this presentation, we will also report results from the data taken in 2016.

Keywords: solar wind, Remote sensing, Fast and slow solar wind

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Solar wind density distribution derived from DM measurements of Crab pulsar

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1. Institute for Space-Earth Environmental Research, Nagoya University, 2. Institute for Cosmis Ray Research,The University of Tokyo

The pulsed radio wave emitted by a pulsar undergoes a delay by intervening plasma through propagation in the interstellar medium and the solar wind (SW). This delay depends on frequency, and the pulsar emission observed at the Earth exhibits the frequency dispersion. The magnitude of frequency dispersion is called dispersion measures (DM), and provides information of the plasma density integrated along the LOS from the pulsar to the observer. We have made observation of Crab pulsar since 2018 using 327MHz radio telescope (SWIFT) at Toyokawa. The LOS of Crab pulsar approaches the sun by ~5R_s (R_s: solar radius) in every mid-June. This enables to investigate the plasma density near the sun by using the DM of Crab pulsar. We derived the DM from Crab pulsar observations at Toyokawa by optimizing intensity height of the giant radio pulses (GRP), and determined the SW density distribution near the sun from derived DM data. In our previous study, we used the GRPs with a signal-to-noise ratio (S/R)>15. However, the number of GRP with S/N>15 observed in both 2018 and 2019 decreased as Crab pulsar's LOS approached to the sun, and this decrease significantly worsened the accuracy of DM measurements. In order to improve decrease in accuracy, we used GRPs with S/N>10 to derive DM in this study. A lower threshold for GRP intensity results in an increase of the number of GRP, and leading to better statistics even for the period when the number of GRPs greatly reduces. We found that errors and outliers of DM measurements were significantly reduced in the analysis with S/N>10. We determined the increase in DM (ΔDM) due to the solar wind by subtracting the effect of the interstellar medium. The effects of the interstellar medium were estimated from observations made for the period of a large solar elongation. The solar wind density model was fit to observed ΔDM. While the density model obtained here was almost the same as the one from the previous study, the estimation error was reduced by about one-third, and the accuracy of model determination was greatly improved.

Keywords: Solar Wind, Pulsar

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Next generation solar wind observation system: science requirements and pathfinders.

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1. Institute for Space–Earth Environmental Research (ISEE), Nagoya University

Interplanetary scintillation (IPS) is a radio scattering phenomenon caused by the disturbances in the solar wind. The IPS observation using ground-based radio telescopes has been an important technique to investigate the global structure of the heliosphere. Nagoya University have observed the solar wind velocity and density irregularities for several decades using large radio telescopes at 327 MHz. In this study, we investigated the science requirements and design of next generation IPS observation instruments, and developed their pathfinders.
The main scope of this research is to elucidate the acceleration mechanisms of the solar wind. To do that, the relationship between the accelerated solar wind velocity and the magnetic field structure of its source region should be derived. We can derive the global structure of the solar wind from the IPS data using the tomography method. However, the spatial resolution of the solar wind distribution projected on the solar surface is not enough to distinguish its source structures. Therefore, we consider a new solar wind observation system that can observe multiple directions simultaneously by constructing a 2D flat phased-array antenna system consisting of multiple dipole antennas, and installing digital phased-array devices. The multidirectional simultaneous radio scintillation observation using this system enables the solar wind observation 10 times as much as the conventional radio instruments have been done, which will give enough spatial resolution of the solar wind distribution.
We also developed a proto type of the digital phased array instrument. This instrument has 8 analog-digital converters (ADCs), field-programmable gate array (FPGA), and 10-Gbit Ethernet output. This system enables us to measure four beams simultaneously by processing four types of different beamforming in parallel. We also added an automated calibration sequence to the FPGA. This sequence makes a calibration table that compensates an amplitude and phase differences of the 8 signals. By Appling this table, we can quickly calibrate the amplitude and phase differences of antennas and receivers. In the laboratory experiments, we confirmed that the calibration system works as expected.

Keywords: solar wind, CME, radio observation

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

[P-EM14] Heliosphere and Interplanetary Space

convener:Kazumasa Iwai(Institute for Space–Earth Environmental Research (ISEE), Nagoya University), Yasuhiro Nariyuki(Faculty of Education, University of Toyama), Ken Tsubouchi(University of Electro-Communications), N Masaki Nishino(Japan Aerospace Exploration Agency, Institute of Space and Astronautical Science), Chairperson:Kazumasa Iwai(Institute for Space–Earth Environmental Research (ISEE), Nagoya University)

Sat. Jun 5, 2021 10:45 AM - 12:15 PM Ch.06 (Zoom Room 06)

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 observation/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.

12:00 PM - 12:15 PM

[PEM14-06]Discussion

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

Sat. Jun 5, 2021 1:45 PM - 3:15 PM JST | Sat. Jun 5, 2021 4:45 AM - 6:15 AM UTC | Ch.06 Zoom Room 06

[P-EM14] Heliosphere and Interplanetary Space

convener:Kazumasa Iwai(Institute for Space–Earth Environmental Research (ISEE), Nagoya University), Yasuhiro Nariyuki(Faculty of Education, University of Toyama), Ken Tsubouchi(University of Electro-Communications), N Masaki Nishino(Japan Aerospace Exploration Agency, Institute of Space and Astronautical Science), Chairperson:Yasuhiro Nariyuki(Faculty of Education, University of Toyama), Masaki N Nishino(Japan Aerospace Exploration Agency, Institute of Space and Astronautical Science)

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 observation/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

[PEM14-07] Identification of solar wind regimes using the non-hierarchical cluster analysis

*Shinichi Watari[1] (1.National Institute of Information and Communications Technology)

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

[PEM14-08] Numerical simulation on invasion process of galactic cosmic rays into the heliosphere: Particle orbits and statistics

*Kotaro Yoshida[1], Shuichi Matsukiyo[2,3], Haruichi Washimi[3], Tohru Hada[2,3] (1.Department of Earth System Science and Technology, Interdisciplinary Graduate School of Engineering Sciences, Kyushu University, 2.Faculty of Engineering Sciences, Kyushu University, 3.International Center for Space Weather Science and Education, Kyushu University)

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

[PEM14-09] Kaguya Observations of Solar Wind Electron Modification by Electrostatic Waves Above the Lunar Day Side: Preliminary Results

*Yuki Harada[1], Yoshiya Kasahara[2], Masaki N Nishino[3], Satoshi Kurita[4], Yoshifumi Saito[3], Shoichiro Yokota[5], Futoshi Takahashi[6], Hisayoshi Shimizu[7] (1.Graduate School of Science, Kyoto University, 2.Information Media Center, Kanazawa University, 3.ISAS, JAXA, 4.Research Institute for Sustainable Humanosphere, Kyoto University, 5.Graduate School of Science, Osaka University, 6.Faculty of Sciences, Kyushu University, 7.Earthquake Research Institute, University of Tokyo)

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

[PEM14-10] Elliptically polarized 0.01-0.3 Hz magnetic field variation in the lunar wake

*Tomoko Nakagawa[1], Futoshi Takahashi[2], Hisayoshi Shimizu[3], Yoshifumi Saito[4] (1.Information and Communication Engineering, Tohoku Institute of Technology, 2.Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University, 3.Earthquake Research Institute, University of Tokyo, 4.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

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

[PEM14-11] On the relationship between the cross-helicty and the residual energy in the solar wind MHD turbulence: A phenomenological approach

*Yasuhiro Nariyuki[1] (1.Faculty of Education, University of Toyama)

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

[PEM14-12] Discussion

Identification of solar wind regimes using the non-hierarchical cluster analysis

*Shinichi Watari[1]

1. National Institute of Information and Communications Technology

By identifying solar wind regimes, we can get information on their solar sources and situations. Experience is necessary for us to identify the solar wind regimes. We need an objective identification method for this. Richardson and Cane (2004) identified solar wind regimes using heavy ion charge states. However, heavy ion charge states are not always observed by satellites. A method using basic solar wind data (speed, density, temperature, density, and magnitude of magnetic field) is suitable as proposed by Xu and Borovsky (2015).

Here we report identification of the solar wind regimes using one of the non-hierarchical cluster analysis, the k-means method. Data are classified into given number of clusters optimizing the distances of data from the cluster centers by the k-means method. We used speed, temperature, density, and magnitude of magnetic field in the one-hour solar wind data from the OMNI data of the NASA/NSSDC. The data between 1998 and 2019 were applied for our analysis because almost continuous data are available during this period. We also used three parameters, entropy, Alfven speed, and ratio of expected temperature from speed to observed temperature, which were used by Xu and Borovsky (2015).

Keywords: non-hierarchical cluster analysis, k-means method, solar wind, identification of solar wind regimes

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Numerical simulation on invasion process of galactic cosmic rays into the heliosphere: Particle orbits and statistics

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1. Department of Earth System Science and Technology, Interdisciplinary Graduate School of Engineering Sciences, Kyushu University, 2. Faculty of Engineering Sciences, Kyushu University, 3. International Center for Space Weather Science and Education, Kyushu University

Galactic cosmic rays (GCRs) are produced in our galaxy. Some of them invade the heliosphere and reach the earth. The motion of GCRs in the heliosphere is very complicated because of the influence of solar wind flow and magnetic field. The transport processes of GCRs have been discussed by using convection-diffusion models. But the model does not tell us the information of GCRs trajectories. Our goal in this study is to understand the invading process of GCRs into the heliosphere in the level of particle trajectory.
We performed three-dimensional relativistic test particle simulations using electromagnetic fields reproduced by the global MHD simulation of the heliosphere ([1] Washimi et al. 2015). In the MHD simulation, the solar wind velocity, density, magnetic field strength and temperature at 1 AU are set to be 400 km/s, 5.0 /cc, 35 μG and 10^5 K, respectively. These quantities are assumed to be time stationary and simply extrapolated to the inner boundary of the simulation domain at 50 AU from the sun. For the outer boundary at 900AU, the corresponding parameters of the stationary interstellar plasma are 23 km/s, 0.1 /cc, 6,300 K, and 3 μG, respectively. In the test particle simulation, the motions of protons initially distributed outside the heliopause with Lorentz factor γ are solved. Their velocity distribution function is given by a mono-energetic shell distribution. We found various patterns of particle trajectories. They exhibit different characteristics depending on their initial energy. Some concrete trajectories will be discussed in detail. Furthermore, we will estimate some statistics of the particles reached at the inner boundary, such as distribution of arrival position, energy, momentum, etc.

Keywords: galactic cosmic rays, heliosphere

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Kaguya Observations of Solar Wind Electron Modification by Electrostatic Waves Above the Lunar Day Side: Preliminary Results

*Yuki Harada[1], Yoshiya Kasahara[2], Masaki N Nishino[3], Satoshi Kurita[4], Yoshifumi Saito[3], Shoichiro Yokota[5], Futoshi Takahashi[6], Hisayoshi Shimizu[7]

1. Graduate School of Science, Kyoto University, 2. Information Media Center, Kanazawa University, 3. ISAS, JAXA, 4. Research Institute for Sustainable Humanosphere, Kyoto University, 5. Graduate School of Science, Osaka University, 6. Faculty of Sciences, Kyushu University, 7. Earthquake Research Institute, University of Tokyo

Despite the lack of a global intrinsic magnetic field and a dense atmosphere, the Moon drives many observable effects on the upstream solar wind plasma through absorption, scattering, reflection, and emission of charged particles by the surface and crustal magnetic fields. As a result, a variety of plasma waves are excited in the upstream solar wind in a similar manner to planetary foreshocks, though a global bow shock is absent at the Moon. Recently, Chu et al. (2020) reported two case studies of THEMIS-ARTEMIS observations above lunar crustal magnetic anomalies, thereby proposing two sources of electrostatic waves around the Moon: (i) counter-streaming electron beams consisting of incoming solar wind electrons and reflected electrons, and (ii) relative drift across the magnetic field between reflected ions and solar wind electrons. The former drives electron two stream instability generating electric field structures parallel to the background magnetic field, while the latter drives electron cyclotron drift instability leading to perpendicular electric field waves. They also proposed that these electrostatic instabilities cause substantial heating of solar wind electrons. However, the global nature of these electrostatic waves and resulting solar wind electron modification remains largely unexplored, partly because of the nearly equatorial orbits of the THEMIS-ARTEMIS probes.

In this study, we generate global selenographic maps of electric field waves and solar wind electron modification from Kaguya data obtained on the lunar dayside at ~100 km altitude polar orbits. The global maps clearly demonstrate the lunar crustal field control of electrostatic wave generation and incoming solar wind electron modification. Additionally, we identify IMF cone angle dependence of the waves and electron modification above strong magnetic anomalies. We discuss these preliminary results in the context of the proposed electrostatic instabilities.

Keywords: Moon, Solar Wind Electron, Electrostatic Waves

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Elliptically polarized 0.01-0.3 Hz magnetic field variation in the lunar wake

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1. Information and Communication Engineering, Tohoku Institute of Technology, 2. Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University, 3. Earthquake Research Institute, University of Tokyo, 4. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency

Elliptically polarized magnetic field variation in the frequency range of 0.01-0.3 Hz was detected by Kaguya MAP-LMAG in the lunar wake. The polarization was highly elliptic and the direction of rotation was consistent with the vortex behind an obstacle in a fast flow, but no clear vortex motion was found in ion velocity observed by MAP-PACE onboard Kaguya. The magnetic variation was compressional, and the wave number vector was nearly parallel or oblique to the background magnetic field. The waves persisted in the deepest wake, suggesting that they were not surface waves. High frequency components above the local ion cyclotron frequency exhibited circular polarization of right-handed or left-handed rotation with respect to the background magnetic field.

Keywords: moon, lunar wake, polarization, magnetic field variation, ion cyclotron frequency, Kaguya

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On the relationship between the cross-helicty and the residual energy in the solar wind MHD turbulence: A phenomenological approach

*Yasuhiro Nariyuki[1]

1. Faculty of Education, University of Toyama

It is known that solar wind turbulence is well characterized by the cross-helicty and the residual energy[Tu+Marsch, Space Sci. Rev., 1995; Bruno+Carbone, Living Rev. Solar Phys., 2013]. A simple linear relation derived by a MHD turbulence model[Tu+Marsch, JGR, 1993] has been compared with the observational studies, while the observational data is usually scattered around the line [e.g., Bruno et al, Ann. Geophys., 2007; Perri+Balogh, GRL, 2010]. Recently, the Langevein equation is applied to model the Alfvenic fluctuations with non-equilibrium cross-helicty and residual energy. Although circularly polarized waves are used, the Langevin model can reproduce the linear relation mentioned above. In this talk, the extension of the previous Langevin model is discussed. Non-circularly polarized, multi-dimensional Alfven wave solution [Primavera et al, ApJ, 2019] is applied to consider deviation from the linear relation.

Keywords: solar wind turbulence, Langevin model

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

[P-EM14] Heliosphere and Interplanetary Space

convener:Kazumasa Iwai(Institute for Space–Earth Environmental Research (ISEE), Nagoya University), Yasuhiro Nariyuki(Faculty of Education, University of Toyama), Ken Tsubouchi(University of Electro-Communications), N Masaki Nishino(Japan Aerospace Exploration Agency, Institute of Space and Astronautical Science), Chairperson:Yasuhiro Nariyuki(Faculty of Education, University of Toyama), Masaki N Nishino(Japan Aerospace Exploration Agency, Institute of Space and Astronautical Science)
Sat. Jun 5, 2021 1:45 PM - 3:15 PM Ch.06 (Zoom Room 06)

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 observation/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.

3:00 PM - 3:15 PM

[PEM14-12]Discussion

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

Sat. Jun 5, 2021 3:30 PM - 5:00 PM JST | Sat. Jun 5, 2021 6:30 AM - 8:00 AM UTC | Ch.09 Zoom Room 09

[A-OS14] Coastal physical processes associated with mixing, eddies, internal waves

convener:Eisuke Tsutsumi(Atmosphere and Ocean Research Institute, The University of Tokyo), Eiji Masunaga(Ibaraki University), Taira Nagai(Graduate School of Science, The University of Tokyo), Chairperson:Eisuke Tsutsumi(Atmosphere and Ocean Research Institute, The University of Tokyo), Eiji Masunaga(Ibaraki University), Taira Nagai(Graduate School of Science, The University of Tokyo)

Recently developed observational and numerical approaches have revealed details of physical processes in coastal regions, which are keys 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

[AOS14-01] Enhancement of turbulent mixing over tidal sandwaves and formation of front: an observational study in Seto Inland Sea

*Eisuke Tsutsumi[1], Xinyu Guo[2], Naoki Yoshie[2], Takahiro Endoh[3], Takeshi Matsuno[3], Sachihiko Itoh[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Center for Marine Environmental Studies, Ehime University, 3.Research Institute for Applied Mechanics, Kyushu University)

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

[AOS14-02] Dynamics of the upwelling at the upstream of the East Sakhalin Current (ESC)

*Nan Yuan[1] (1.Hokkaido University, the Institute of Low Temperature Science)

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

[AOS14-03] Numerical study of tide-induced deep-ocean mixing near the head of Suruga Trough

*Taira Nagai[1], Toshiyuki Hibiya[1] (1.Graduate School of Science, The University of Tokyo)

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

[AOS14-04] **Amplitude modulation of currents at tidal and inertial bands at the Otsuchi Bay mouth**

*Tongjun Sun[3,1], Sachihiko Itoh[3], Eisuke Tsutsumi[3], Miho Ishizu[2], Kiyoshi Tanaka[3] (1.Graduate School of Agricultural and Life Sciences/Faculty of Agriculture,The University of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology, 3.Atmosphere and Ocean Research Institute, The University of Tokyo)

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

[AOS14-05] Water mass classification off the east coast of Japan mainland using Regional Ocean Modeling System (ROMS)

*Masashi Ikeda[1], Eiji Masunaga[1], Yusuke Uchiyama[2], Yota Suzue[4], Sachihiko Itoh[3] (1.Ibaraki University , 2.Kobe University, 3.The University of Tokyo, 4.CTI Engineering)

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

[AOS14-06] Vertical mixing and mass transport in a shallow lake, Lake Kasumingaura, Japan

*Eiji Masunaga[1], Tatsumi Kitamura[2], Sachihiko Itoh[3] (1.Ibaraki University, 2.Ibaraki Kasumigaura Environmental Science Center, 3.The University of Tokyo)

Enhancement of turbulent mixing over tidal sandwaves and formation of front: an observational study in Seto Inland Sea

*Eisuke Tsutsumi[1], Xinyu Guo[2], Naoki Yoshie[2], Takahiro Endoh[3], Takeshi Matsuno[3], Sachihiko Itoh[1]

1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. Center for Marine Environmental Studies, Ehime University, 3. Research Institute for Applied Mechanics, Kyushu University

It is known that in Iyo-nada, Seto Inland Sea, Japan large sandwaves are formed in the southwest. The generation mechanism of large sandy bedforms has been intensively studied in rivers, estuaries, coastal and shelf seas. However, there has been less attention to how sandwaves affects ocean circulations and environments. In this study, we report on the significant enhancement of vertical mixing by sandwaves from a total of 24 field campaigns consisting of microstructure turbulence and current measurements in Iyo-nada conducted during 2012–2019. We document elevation of turbulence energy dissipation rate to $O(1\ \mathrm{W\ m^{-2}})$ over large sandwaves, flow separation at the sandwave crest, and the associated downstream turbulent wakes due to the form drag. This strong turbulence suggests that the turbulent buoyancy flux in the large sandwave region exceeds the surface buoyancy flux, creating a contrast in the vertical mixing regime to the region without sandwaves and promoting the formation of a front between the two regions.

Keywords: Flow-seabed interaction, Microstructure turbulence measurement, Tidal mixing front, Seto Inland Sea

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Dynamics of the upwelling at the upstream of the East Sakhalin Current (ESC)

*Nan Yuan[1]

1. Hokkaido University, the Institute of Low Temperature Science

The resuspension of the sediments at the upstream of ESC was confirmed by ADCP high backscatter events *[Ito et al.,2017]*. Further observation discovered that the sediments resuspended was frozen into the frazil ice at the surface of the upstream of ESC and might be conveyed to the south to support the next spring broom when the ice melts *[Ito et al.,2017; Mustapha et al.,2008]*, which indicates the vertical mixing, whole depth upwelling typically, was at the upstream of ESC and corresponded with the strong wind event *[Ito et al.,2017]*. According to the dissolved oxygen distribution *[Ohshima et al.,2001 Figure 3(a)]*, there should be an upwelling at the southwest of the Sea of Okhotsk as well.

Downwelling-favorable wind from Siberia High in winter, buoyancy flux from Amur River carried by ATW, and the bottom friction are the main dynamic sources of the western coastal current of the Sea of Okhotsk, which might contribute to the coastal upwelling. There are many researches investigated the coast responses to different initial conditions. For a stratified coast with an alongshelf current, idealized simulation depicted an upwelling at the shelf break *[Benthuysen et al.,2015].* Benthuysen et al 2015 explained it with the well-known buoyancy shutdown process. The geostrophic current is modified by the tilted isopycnal via the thermal wind relation which induces the bottom Ekman transport convergence and the upwelling consequently. The shelf break is one of the main reasons for the isopycnal tilt in their research. A similar process might happen at the coast of the ESC, and the buoyancy instability is contributed to the downwelling favorable wind. In the idealized simulations by Allen and Newberger 1996, and Austin and Lentz 2002, the downwelling favorable wind remains a well-mixed water mass at the coast and a downwelling front shoulder by shoulder. With the freshwater discharge, the well-mixed water mass at the coast might be replaced by a stratified one, which could be the situation of the ESC.

We accomplished a simulation with the COCO, an Ocean General Circulation Model. The initial conditions are the same as the Matsuda et al [2015]. The grid size at the coast is finer to 3 km at the coast of the ESC. The reanalysis datasets ERA-Interim from 1980.01.01 to 2018.12.31 were adopted as the meteorological forces. The freshwater discharge is from Dai and Trenberth [2002]. Analyzing the output of the January mean, the upwelling is simulated at the upstream of the ESC. The buoyancy shutdown takes part in the formation of the upwelling according to the isopycnal distribution. Adjacent to the upwelling it is an anti-clockwise overturning, means the water is stratified with the surface onshore current and bottom offshore current. The eddy generated by the baroclinic instability attempts to maintain the coastal stratification, while the diffusion demolishes the stratification. We are figuring out how the mean current takes its responsibility in the coastal overturning. The reasonable hypothesis is the mean current just works inversely compared to the eddy.

Keywords: upwelling, baroclinic instability, eddy

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Numerical study of tide-induced deep-ocean mixing near the head of Suruga Trough

*Taira Nagai[1], Toshiyuki Hibiya[1]

1. Graduate School of Science, The University of Tokyo

Coastal submarine canyons are widely expected to be sites of enhanced mixing which may offer a potential solution to the ‘missing mixing’ problem. In Suruga Bay, mooring observations along the steep submarine canyon (Suruga Trough) show the existence of strong semi-diurnal and diurnal internal tides near the ocean bottom. In this trough, therefore, enhanced turbulent mixing induced by breaking of these internal tides is expected, although details of physical processes that produce strong internal tides have not been discussed yet.

In order to investigate the excitation processes of internal tides in Suruga Trough, we carry out a couple of high-resolution ($\Delta x,\ \Delta y = 1/240^{o}$) non-hydrostatic three-dimensional numerical experiments incorporating realistic semi-diurnal (M_2) and diurnal (K_1) tidal forcing, respectively. We first investigate the energetics of M_2 internal-tide to show that (1) internal tides generated over Izu Ridge propagate towards Suruga Trough, (2) in which the incident waves interact with the reflected waves from the trough head, and finally (3) the internal tide energy together with its dissipation is intensified. The K_1 tidal frequency, on the other hand, is subinertial in this area, so that K_1 tidal flow mainly generates coastal trapped waves which propagate cyclonically along the coast of Suruga Bay. It is suggested that these coastal trapped waves induce strong velocity shear near the bottom of the trough causing bottom confined intense mixing.

Keywords: Suruga Trough, Internal tides, Coastal trapped waves

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Amplitude modulation of currents at tidal and inertial bands at the Otsuchi Bay mouth

*Tongjun Sun[3,1], Sachihiko Itoh[3], Eisuke Tsutsumi[3], Miho Ishizu[2], Kiyoshi Tanaka[3]

1. Graduate School of Agricultural and Life Sciences/Faculty of Agriculture,The University of Tokyo, 2. Japan Agency for Marine-Earth Science and Technology, 3. Atmosphere and Ocean Research Institute, The University of Tokyo

In the Sanriku coastal areas, various current and waves vigorously interact on the narrow shelf and likely have major influences on the water exchanges between inshore and offshore areas. The inertial period dividing internal waves and coastal trapped waves is approximately 18.9 h at Otsuchi Bay in the middle of the Sanriku coast, and semidiurnal and diurnal frequencies become superinertial and subinertial, respectively. Consequently, both of these waves and their interactions are thought to have impacts on the inflow to and outflow from the bay. In this study, based on the mooring observations at the two stations at the north and south of the bay mouth during 2012–2016, we aim at showing the variability of internal waves forced by tidal flows and coastal trapped waves, and clarifying water exchange processes between the inshore and offshore areas. The mooring observation revealed that flow velocities were excited in summer at semidiurnal and diurnal bands, where the former was markedly strong. By contrast, the velocities of the semidiurnal and diurnal flows were comparable during winter, whereas their amplitude decreased down to ~1/5 of that during summer. Velocity data during July–October 2013 where both of the two stations are available showed that low-frequency background flow (period > 40 h) entered from the north and exited from the south of the bay mouth, respectively. Although the spring tide should appear approximately 2 times in one month due to its inherent fortnight period, semidiurnal and diurnal tidal flows had a shorter period and their amplitude showed irregular fluctuations. To investigate the cause of this fluctuation, harmonic analysis was applied to tide gauge records at the Kamaishi tide station, extracting semidiurnal and diurnal components, and were compared with the velocity fluctuations recorded at the mooring stations. The sea level fluctuations were dominated by the semidiurnal component during this period. The peaks of semidiurnal and diurnal tide almost coincided in the early July, but gradually separated after August, and then approached in the late October and finally coincided again. On the other hand, during February–May 2013, the sea level records showed spring/neap cycle and the fluctuation in the peak timing, but the velocity amplitude was very weak and the difference in the peak timing was hardly detected. As these phenomena cannot be explained solely by the local tides, interactions between semidiurnal and diurnal tides, wave propagations from remote areas, influences of low-frequency flows and changes in the stratification are thought to play some roles.

Keywords: Otsuchi Bay, tide, internal wave, coastal trapped wave, spring tide

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Water mass classification off the east coast of Japan mainland using Regional Ocean Modeling System (ROMS)

*Masashi Ikeda[1], Eiji Masunaga[1], Yusuke Uchiyama[2], Yota Suzue[4], Sachihiko Itoh[3]

1. Ibaraki University , 2. Kobe University, 3. The University of Tokyo, 4. CTI Engineering

Marine environments off the Sanriku Coast are important for oceanic ecosystems and influence fishing grounds in the North Pacific Ocean. The T-S (Temperature - Salinity) combination has been frequently used for understanding water masses off the Sanriku Coast (e.g., Hanawa and Mitsudera., 1987). However, the water mass classification based on T-S diagram proposed by Hanawa and Mitsudera cannot explain seasonal variations of water masses in the surface layer. This study investigated the seasonal variation of water masses off the Sanriku coast using the Regional Ocean Modeling System (ROMS). The quality of the ROMS model was validated by comparing with the observed data obtained by the Iwate Prefectural Fisheries Laboratory. Model results well matches to the observed data. We have developed a method for the water mass classification for the three water masses of the Tsugaru Warm Current, Oyashio and Kuroshio using the normalized T-S combination. The normalized T-S diagram is computed from normalized temperature and salinity data with the standard deviation of unity. Three water masses (Tsugaru Warm Current, Oyashio, Kuroshio) were classified based on the distance between each T-S data and the three water masses on a normalized T-S diagram. Original T-S combinations of the Tsugaru Warm current, Oyashio, and Kuroshio were taken from averaged T-S values in Tsugaru Strait, Kuroshio Current Axis, and off Cape Erimo of Hokkaido, respectively. The three water masses were reasonably separated in the surface layer by this method and were not appropriately separated by a previously used conventional method. The water mass classification using this method is consistent with the velocity field of the surface layer. The area of the Oyashio water in the study area is majorly influenced by seasonal variations of the Tsugaru Warm Current.

Keywords: Water mass classification, Oyashio, Kuroshio

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Vertical mixing and mass transport in a shallow lake, Lake Kasumingaura, Japan

*Eiji Masunaga[1], Tatsumi Kitamura[2], Sachihiko Itoh[3]

1. Ibaraki University, 2. Ibaraki Kasumigaura Environmental Science Center, 3. The University of Tokyo

This study presents vertical mixing and associated mass transport processes in a shallow lake, Kasumigaura, Japan. Field campaigns were carried out using a mooring system, microstructure profiler (VMP250) and high-resolution tow-yo instrument (YODA Profiler) in summer, 2020. The mooring system consisted of high and low frequency sampling thermistors (SBE56s and TidbiT v2s), and Aquadopp current profiler. Strong stratification and vertical mixing occurred with periods of several hours to several days. The Richardson number was less than 1/4 when complete vertical mixing occurred (temperature difference in the water column is less than 0.5 degrees). The rate of turbulent kinetic energy dissipation rate (e) and vertical eddy diffusivity (K_r) were 10^{-10}–10^{-9} W/kg and 10^{-7}–10^{-6} m^2/s, respectively, near the bottom boundary layer under weak wind stratified conditions.On the other hand, when vertical mixing occurred due to wind stress, e and K_r were 10^{-8}–10^{-5}W/kg and 10^{-5}–10^{-3} m^2/s, respectively. In addition to microstructure surveys, the eddy diffusivity was also estimated by two independent methods using high-frequency sampled temperature data: (1) $K_{rI18} = 0.09 L_E^2 S$, where L_E is the Ellison scale and S is the vertical velocity shear (Ivey et al., 2018); (2) a method with an assumption of $L_O \sim L_E$, where L_O is the Ozmidov length scale, *viz.*, $e = L_O^2 N^3 \sim L_E^2 N^3$, $K_{rLE} = G L_O^2 N \sim G L_E^2 N$, where G is the mixing efficiency 0.2. The relationship between L_O and L_E were estimated from the microstructure surveys and K_{rLE} was computed from high frequency sampled temperature. K_{rLE} showed reasonable agreements with K_r and K_{rI18}. We analyzed time series of the vertical mixing using K_{rLE}. Stratification and mixing were repeatedly generated by daily cycle shortwave radiation and sea-breeze, respectively. Surface stratification was increased by shortwave radiation from the sunrise to noon. The wind stress was enhanced by see breeze in the afternoon, which results in strong vertical mixing. Convective mixing due to night-time cooling was supposed to be weaker than wind-induced mixing. Vertical oxygen transport from the surface layer toward the bottom layer was generated by the wind-induced mixing in the afternoon. In addition, vertical mixing also contribute to nutrient supplies from sediments leading to eutrophication.

Keywords: Mixing, Heat flux, Coastal areas, Dissolved oxygen

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

Sat. Jun 5, 2021 3:30 PM - 5:00 PM JST | Sat. Jun 5, 2021 6:30 AM - 8:00 AM UTC | Ch.07 Zoom Room 07

[A-OS16] Global ocean observing systems, their status, research results and future perspective

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: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), Shigeki Hosoda(Japan Marine-Earth Science and Technology)

The global ocean is complementary covered by variable kinds of observing networks such as Argo, GO-SHIP, OceanSITES, earth observing satellite, then its observing network is crucial for research, monitoring and future predictions of climate changes and ocean environment. Besides, the ocean observing networks are also recognized as infrastructures for research, human societies, and industries in the SDGs and the UN Decade, which is suggested to achieve their goals and to develop the network within 10 years. In the session held previously, we discussed the status and future perspective on the ocean observing network, following themes in OceanObs19, etc., exchanging current information. After the previous session, the roadmap2020 for progress of the global ocean observation had been suggested, the GO BGC Argo project was accepted by the National Science Foundation in 2020, and the UN Decade starts from 2021. Under these circumstances, the target of this session is to host a meeting exchanging information on the recent status of the observing networks, and discussing for future perspectives regarding pilot studies of large-scale ocean observations, OSE and OSSE for the ocean observing networks, development of sensor and platform technologies. At the same time, we would like to share information of current research results regarding large-scale heat, freshwater, material transports, physical and biogeochemical mechanisms of water mass formation and modification, air-sea interaction, and developing measurement sensors and data quality controls contributing to those researches, overarching variable research fields.

3:30 PM - 3:35 PM JST | 6:30 AM - 6:35 AM UTC

[AOS16-01] Introduction

3:35 PM - 3:55 PM JST | 6:35 AM - 6:55 AM UTC

[AOS16-02] Biogeochemical Argo: Significances and Challenges

★Invited Papers

*Masao Ishii[1] (1.Meteorological Research Institute, Japan Meteorological Agency)

3:55 PM - 4:15 PM JST | 6:55 AM - 7:15 AM UTC

[AOS16-03] 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, University of Tokyo)

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

[AOS16-04] Two-year seismic observation by hydrophone floats

*Masayuki Obayashi[1], Hiroko Sugioka[2], Junko Yoshimitsu[1] (1.Japan Agency for Marine-Earth Science and Technology, 2. Department of Planetology, Kobe University)

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

[AOS16-05] Discussion toward a New Global Ocean Observing System

*Shuhei Masuda[1] (1.Japan Agency for Marine-Earth Science and Technology)

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

[A-OS16] Global ocean observing systems, their status, research results and future perspective

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: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), Shigeki Hosoda(Japan Marine-Earth Science and Technology)

Sat. Jun 5, 2021 3:30 PM - 5:00 PM Ch.07 (Zoom Room 07)

The global ocean is complementary covered by variable kinds of observing networks such as Argo, GO-SHIP, OceanSITES, earth observing satellite, then its observing network is crucial for research, monitoring and future predictions of climate changes and ocean environment. Besides, the ocean observing networks are also recognized as infrastructures for research, human societies, and industries in the SDGs and the UN Decade, which is suggested to achieve their goals and to develop the network within 10 years. In the session held previously, we discussed the status and future perspective on the ocean observing network, following themes in OceanObs19, etc., exchanging current information. After the previous session, the roadmap2020 for progress of the global ocean observation had been suggested, the GO BGC Argo project was accepted by the National Science Foundation in 2020, and the UN Decade starts from 2021. Under these circumstances, the target of this session is to host a meeting exchanging information on the recent status of the observing networks, and discussing for future perspectives regarding pilot studies of large-scale ocean observations, OSE and OSSE for the ocean observing networks, development of sensor and platform technologies. At the same time, we would like to share information of current research results regarding large-scale heat, freshwater, material transports, physical and biogeochemical mechanisms of water mass formation and modification, air-sea interaction, and developing measurement sensors and data quality controls contributing to those researches, overarching variable research fields.

3:30 PM - 3:35 PM

[AOS16-01]Introduction

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Biogeochemical Argo: Significances and Challenges

*Masao Ishii[1]

1. Meteorological Research Institute, Japan Meteorological Agency

Since 1980s, high-quality data of ocean carbon and biogeochemistry (BGC) have been acquired globally from the ocean interior in ship-based hydrographic programs such as WOCE/JGOFS and GO-SHIP and at time-series sites such as those at 137°E, station ALOHA near Hawaii and BATS near Bermuda. These datasets have been quality-controlled and are freely available from the database GLODAPv2, helping constrain the global budget of anthropogenic carbon and documenting the progress of ocean acidification and oxygen decline that are endangering the marine ecosystems worldwide and thus our societies. However, we still have large data gaps particularly in time for most of the ocean regions. The measurements with low time frequency in global oceans, typically once in several years to a decade in GO-SHIP, prevent from resolving seasonality in upper layers as well as distinguishing between the impact of human-induced forcing and that of ocean internal variability on ocean carbon and BGC.

On October 29, 2020, NSF announced a $53 million grant to build a global network of BGC-Argo (GO-BGC) (~500 floats). In Japan, several Argo floats installed with O_2 and pH sensors are to be deployed in the region of North Pacific Subtropical Mode Water in February 2021 as a part of Kakenhi project “Hybrid ocean observations” in “Hotspot 2”. A sustained observing network of BGC-Argo is expected to help fill in the large data gaps in the ocean carbon and BGC and greatly improve our understanding of their change and variability, thus understand and project impacts of climate change and variability as well as the changes in anthropogenic CO_2 emission on BGC and carbon-climate feedback. Massive data from BGC-Argo are also potentially to be critical in measuring the effectiveness of our policy and efforts to reduce CO_2 emission on the changes in ocean and its health on which our society depends.

However, collecting climate-quality data of BGC from sustained BGC-Argo network well enough to quantify the trends of, e.g., acidification and oxygen decline is still a challenge. It is required to establish a network of in-situ ocean observing networks which enables to provide high-quality reference data for calibration and validation of data from sensors, in addition to further improving the performance of sensors for BGC in terms of precision, stability, cost and so on.

Keywords: BGC Argo, GO-SHIP, ocean acidification, oxygen decline, ocean observing network

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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, 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.

In association with the 17 academic societies in the Fisheries/Oceanography Research Liaison Council and the Paleontological Society of Japan, the Oceanographic Society of Japan submitted a research proposal to the "Master Plan 2020" designed by the Science Council of Japan. After document screening and hearing, this proposal was selected as one of the "High-Priority Large Research Projects 2020". The proposal aims to unveil the deep oceanic circulation, which is currently acting as the bottleneck in reproducing past 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 oceanic circulation, Prediction of future climate changes, Prediction of future ecosystem changes

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Two-year seismic observation by hydrophone floats

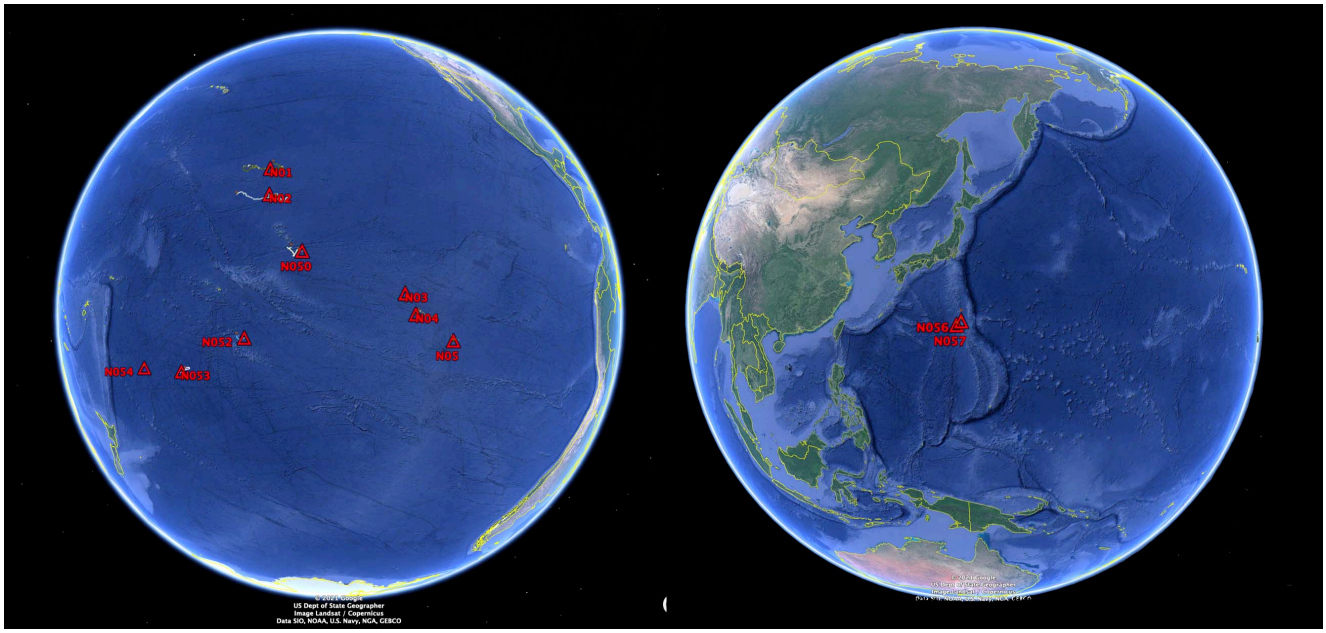
*Masayuki Obayashi[1], Hiroko Sugioka[2], Junko Yoshimitsu[1]

1. Japan Agency for Marine-Earth Science and Technology, 2. Department of Planetology, Kobe University

A new international joint seismic observation project using autonomous float instrument (MERMAID) started from 2018. More than 50 MERMAID instruments were deployed in the south Pacific to study the mantle beneath the South Pacific Superswell, broad seafloor anomalously elevated and concatenated by several volcanic island (hot spot) chain. 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. 9 Japanese MERMAIDs out of them were deployed in the winter and summer of 2019. So far, we obtained approximately 1700 P-wave records from about 480 earthquakes. One of the MEMRAID is recoding continuous pressure to search for a possibility to detect pressure changes due to tsunamis. Additionally, we launched two MERMAIDs to monitor the seismic activities of Nishinoshima volcano island that became active since 2013. We will introduce how we operate the Mermaid floats and what kind of data we obtained in the presentation.

Figure 1: Present locations of 11 Japanese MERMAIDs (9 in south Pacific and 2 near Nishinoshima volcano island)

Keywords: float, hydrophone, Pacific Plume, Nishinoshima, seismic observation



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Discussion toward a New Global Ocean Observing System

*Shuhei Masuda[1]

1. Japan Agency for Marine-Earth Science and Technology

We will discuss a future vision of global ocean observation system based on presentations in this session.

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

Sat. Jun 5, 2021 10:45 AM - 12:15 PM JST | Sat. Jun 5, 2021 1:45 AM - 3:15 AM UTC | Ch.10 Zoom Room 10

[A-OS19] Physical Oceanography (General)

convener:Yoshimi Kawai(Research Institute for Global Change, Japan Agency for Marine-Earth Science and Technology), Kitade Yujiro(Tokyo University of Marine Science and Technology), Chairperson:Yoshimi Kawai(Research Institute for Global Change, Japan Agency for Marine-Earth Science and Technology)

This session invites presentations on a wide variety of topics related to physical oceanography, including observation, theory, technology, and numerical modeling.

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

[AOS19-01] Frontal waves in the east of the Tsugaru Strait revealed by the high-frequency radar observation

*Hitoshi Kaneko[1], Takahiro Tanaka[2], Hiroto Abe[1,3], Masahide Wakita[1], Ken'ichi Sasaki[1], Daisuke Hasegawa[2], Takeshi Okunishi[2], Shuichi Watanabe[1], Shoko Tatamisashi[1], Yoshiaki Sato[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Japan Fisheries Research and Education Agency, 3.Graduate School/Faculty of Fisheries Sciences, Hokkaido University)

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

[AOS19-02] 17 year observation of bottom water current on deep seafloor offshore of Tokachi in Hokkaido: Recovery of acoustic Doppler current profiler (ADCP) data of cabled observatory

*Ryoichi Iwase[1] (1.National Research and Development Agency, Japan Agency for Marine-Earth Science and Technology)

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

[AOS19-03] Winter large-scale atmospheric circulation during La Niña events: A comparison between the first year and second year of events

*Gaku Nishihira[1], Shusaku Sugimoto[1] (1.Graduate School of Science, Tohoku University)

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

[AOS19-04] Decadal variation of the asymmetry of SSTA in the tropical Atlantic and its relations with midlatitude atmosphere circulation

*Yoshinobu Furukawa[1], Shusaku Sugimoto[1] (1.Graduate School of Science, Tohoku University)

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

[AOS19-05] Nearshore wave–current interaction effects on wave power density near Japan

*Adrean Webb[1], Takuji Waseda[2] (1.Kyoto University, Disaster Prevention Research Institute, Coastal Disaster Research, 2.The University of Tokyo, Graduate School of Frontier Sciences, Department of Ocean Technology Policy and Environment)

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

[AOS19-06] Medium-term oceanic transport of microplastics in and around the South China Sea analyzed with climatological and synoptic models

*Kosei Matsushita[1], Yusuke Uchiyama[1], Naru Takaura[1], Taichi Kosako[2] (1.Kobe University, 2.Port and Airport Research Institute)

Frontal waves in the east of the Tsugaru Strait revealed by the high-frequency radar observation

*Hitoshi Kaneko[1], Takahiro Tanaka[2], Hiroto Abe[1,3], Masahide Wakita[1], Ken'ichi Sasaki[1], Daisuke Hasegawa[2], Takeshi Okunishi[2], Shuichi Watanabe[1], Shoko Tatamisashi[1], Yoshiaki Sato[1]

1. Japan Agency for Marine-Earth Science and Technology, 2. Japan Fisheries Research and Education Agency, 3. Graduate School/Faculty of Fisheries Sciences, Hokkaido University

Surface velocity observations of the eastern part of the Tsugaru Strait made by the high-frequency radar revealed frequent occurrence of frontal waves along the axis of the Tsugaru Warm Current in 2017–2019. The current axis (zonal flow maximum in the meridional direction) disturbed in the north-south direction with period of about 14 days that is dominant timescale of tide modulation in the strait. In addition, another peak of the timescale of the modulation was also recognized around ~27 days. The amplitude of the axis fluctuation increased in the downstream direction, from the eastern neck of the channel (~141˚E) to the wider mouth adjacent to the Pacific Ocean (~141˚30’ E). The disturbance propagated downstream with far later speed than that of surface advection especially in the seasons when the stratification was developed. It took from a week to 10 days for propagation of about 100 km. The density and vertical velocity distribution obtained from repeated shipboard observations across the channel in each season were used for investigation for phase speed of the baroclinic instability waves. The propagation speed of the disturbance agreed well with that estimated from the theory based on the two-layer baroclinic instability model except for winter when the stratification was weak. The north–south modulation of the axis at the outlet of the strait (~141˚30˚E) could cause short-term (from 20 days to one month) clockwise rotation of the Tsugaru gyre that is developed in the east of the outlet during summer, as suggested by the previous studies. In addition, such frontal disturbance may contribute to the water mass exchange and modification between the water of the Tsugaru Warm Current and the Oyashio water across the front, and subsequent faster acidification in the strait than in the open ocean.

Keywords: Tsugaru Strait, Tsugaru Warm Current, High Frequency Radar, Frontal Wave

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17 year observation of bottom water current on deep seafloor offshore of Tokachi in Hokkaido: Recovery of acoustic Doppler current profiler (ADCP) data of cabled observatory

*Ryoichi Iwase[1]

1. National Research and Development Agency, Japan Agency for Marine-Earth Science and Technology

In order to observe earthquakes and tsunamis in Kuril Trench region, the cabled observatory attached with three ocean bottom seismometers (OBSs) and two pressure gauges (PGs) along a 240km long submarine was deployed offshore of Kushiro-Tokachi in Hokkaido in 1999. The observatory is equipped not only with the OBSs and the PGs but also with various types of sensors, such as hydrophones, an acoustic Doppler current profiler (ADCP), an electro-magnetic current meter, a CTD (conductivity, temperature and depth) sensor, and a video camera. The ADCP is mounted on the cable-end station which is located at a depth of 2540 m offshore of Tokachi. The observation with the ADCP was continued until 2016 after the deployment. However, much of the data are left unanalyzed and moreover some might be dissipated. This time, the recovery of the ADCP data is carried out.

The raw data of the ADCP are usually converted to the ASCII data by using the software “WinADCP” which is supplied by Teledyne RDI Instruments. There are some problems with the raw ADCP data. Some of the data contain bit errors due to the communication error during data transmission. The raw data contain check sum bytes at each record obtained at one ping. The WinADCP converts each raw record to ASCII only when the corresponding check sum bytes are normal. In other words, if there is a single bit error in a record, the corresponding whole record including the other part without error cannot be converted. This time, we refer to the documentations produced by Teledyne RDI Instruments and decode the raw binary data directly. As a result, we can convert some raw data that cannot be done with the WinADCP.

The ADCP measures the vertical profile of the current velocities in 48 layers. The thickness of each layer is 8 meters and the height of the bottom layer is 12 meters from the seafloor. The sampling rate is usually 30 minutes. The ADCP measures not only current velocities but also acoustic backscatter (echo) intensity from each layer and the bottom water temperature. The echo intensity indicates the concentration of the suspended materials in each layer. The echo intensity tends to have a peak in late spring or early summer. Meanwhile visual observation of the seafloor was carried out with the video camera of the cable-end station from June 2006 to June 2008. JPEG format still images were acquired approximately every 10 seconds. Although significant turbidity has not been observed, moderate increase in benthic organisms tends to be observed in May or June. Those phenomena may relate to the spring bloom in sea surface.

Including the above phenomena preliminary results obtained through the data recovery will be reported in the presentation.

Keywords: acoustic Doppler current profiler (ADCP), long term observation on deep seafloor offshore of Tokachi in Hokkaido, benthic organisms

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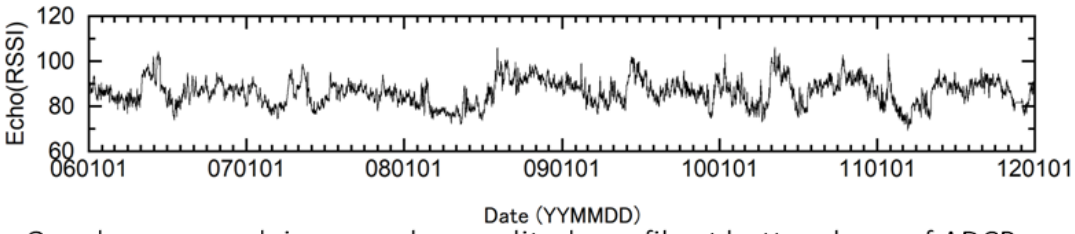
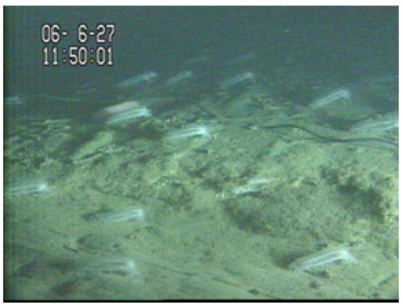


One day averaged six year echo amplitude profile at bottom layer of ADCP from 2006 to 2011.



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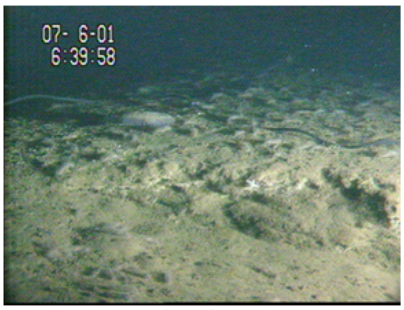

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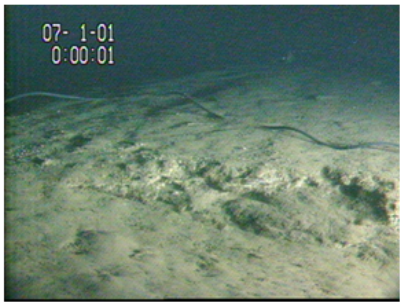

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Seafloor images observed with the video camera

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Winter large-scale atmospheric circulation during La Niña events: A comparison between the first year and second year of events

*Gaku Nishihira[1], Shusaku Sugimoto[1]

1. Graduate School of Science, Tohoku University

The sea surface temperature (SST) distribution associated with ENSO generates large-scale atmospheric teleconnection patterns, such as the PNA pattern characterized by a wave-train from the central North Pacific to North America, and results in affecting the global climate. Recent studies have reported that there is a temporal asymmetry between El Niño and La Niña, with La Niña tending to last for multiple years compared to El Niño. It is suggested that atmospheric response would differ between the first year and the following year of the La Niña. However, the understanding has not been obtained yet. In this study, we conducted statistical analysis using observational and reanalysis datasets since 1950 and numerical experiments using the linear baroclinic model (LBM) to investigate characteristics of winter large-scale atmospheric circulation associated with La Niña.

First, we conducted a composite analysis using observational and reanalysis datasets. As a result, in the first year of La Niña, we detected enhanced convective activity over the western equatorial Pacific and the South China Sea, and low-pressure anomalies were distributed over Japan. A wave-train in geopotential height fields was observed from Japan to North America. This atmospheric pattern was not consistent with existing teleconnection patterns. Surface air temperature showed significant cooling around Japan, as previously pointed out in past works. We investigated the cold air mass distribution and indicated that a large amount of cold air flowing into Japan from the continent was a cause of the cold winter in Japan. We conducted the same analysis for the second year of La Niña. Results represented that convection in the western equatorial Pacific was not as active as in the first year. The large-scale pressure pattern indicated the wave-train from the central North Pacific to North America, consistent with the negative PNA pattern. Negative surface air temperature anomalies around Japan were obtained, but its amplitude was smaller than that of the first year, and it was not significant.

This study revealed the atmospheric responses attributable to La Niña events differ between the first and second years. Also, the heating sensitivity experiments by the LBM showed almost identical atmospheric responses.

Keywords: multiyear La Niña, teleconnection, cold air mass

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Decadal variation of the asymmetry of SSTA in the tropical Atlantic and its relations with midlatitude atmosphere circulation

*Yoshinobu Furukawa[1], Shusaku Sugimoto[1]

1. Graduate School of Science, Tohoku University

A north-south asymmetric pattern of SSTA, whose boundary lies along the equator in the Atlantic exists, and this has a decadal (about 10 years) timescale as pointed out by past work (Tanimoto and Xie, 2002). Past works denoted that this asymmetric pattern develops due to the Wind-Evaporation-SST (WES) feedback mechanism. On the other hand, it has been implied that the asymmetric pattern could be influenced by the mid-latitude large-scale atmospheric pattern such as NAO. In this study, we examine the dominant timescale of the asymmetric pattern by using the long-term SST dataset, and then investigate a relationship between the asymmetric pattern and the large-scale atmospheric pattern such as NAO and EA using atmospheric reanalysis data. Two data were used for the indicator of north-south asymmetric pattern of the Atlantic Equator region: ERA5 SST (January 1978 to August 2019) and HadISST (January 1870 to September 2019). The indicator was calculated as follows; (1) we calculate SSTA regional-mean values over the northern equator (5 ˚-15 ˚N, 20 ˚-60 ˚W) and the southern equator (5 ˚-15 ˚S, 0 ˚-40 ˚W), (2) we obtain the 37-month running mean values of the difference between northern equation and southern equation, and then (3) we regard the smoothed time series as the asymmetry index. In addition, the meridional wind speed and SLP of ERA5 were used. We calculate monthly climatology for 30 years from 1978 to 2007. The NAO and EA index produced by NOAA. The asymmetric index by ERA5 SST showed a marked decadal-scale variations as a result of a wavelet analysis,. Identical timescale features were obtained from HadISST; the decadal timescale can be traced back to 1870. To investigated whether the WES feedback worked on this asymmetric pattern, we performed correlation analyses of the asymmetric index versus the north-south wind speed and SLP of ERA5. Results indicated a strong positive correlation with the north-south wind over the equator, and negative SLP correlation coefficients in the North Atlantic Ocean and positive SLP coefficients in the South Atlantic Ocean. It can be concluded that the WES feedback works for this asymmetric pattern. We focused on the winter (December-February) and investigated the relationship between the asymmetric index and the NAO index / EA index. Resultantly, significant correlation coefficients were not obtained, and it is pointed out that the asymmetric pattern is almost independent of NAO / EA. In the presentation, we will also discuss results of CMIP6 under future climate.

Keywords: tropical Atlantic, atmospheric-ocean interaction, long period variability

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Nearshore wave–current interaction effects on wave power density near Japan

*Adrean Webb[1], Takuji Waseda[2]

1. Kyoto University, Disaster Prevention Research Institute, Coastal Disaster Research, 2. The University of Tokyo, Graduate School of Frontier Sciences, Department of Ocean Technology Policy and Environment

For countries with extensive coastlines such as Japan, energy harvested from surface ocean waves has the potential to be a notable source of green energy. Along many southern parts of Japan however, a strong Kuroshio current flows near the coastline, with surface velocities routinely exceeding 1 m/s. Wave-current interactions (WCI) in such regions can significantly modify the wave resource both locally and remotely and is a source of epistemic uncertainty in many assessments.

In order to quantify these nearshore effects, comparisons are conducted here between long-term (21 years) and high-resolution (1 km) wave resource assessments of Japan with and without WCIs included (Webb et al., 2020). The wave resource assessment (named TodaiWW3) is based on NOAA WAVEWATCH III (version 4.18) simulations using NCEP and JAMSTEC forcings, and includes a new Doppler-shifted wave power density formulation.

In general, short-term differences in wave power due to changes in the wave field alone can be exceptional (over 80%), while longer-term differences are often offset by the Doppler-shift in the group velocity. In this study, the largest long-term differences occur in the nearshore Kuroshio region, with overall differences (and relative differences) between 21-year climatologies of wave power density reach 3 kW/m (and approximately 20%). Further details of the comparison will be discussed, including the underlying mechanisms of change and the role of the Doppler-shift in the wave power density equation.

References:
A. Webb, T. Waseda, and K. Kiyomatsu, 2020. A high-resolution, long-term wave resource assessment of Japan with wave–current effects. Renewable Energy, 161:1341–1358. doi:10.1016/j.renene.2020.05.030.

Keywords: Wave resource assessment, Wave–current interactions, Wave power density, Doppler-shift, NOAA WAVEWATCH III

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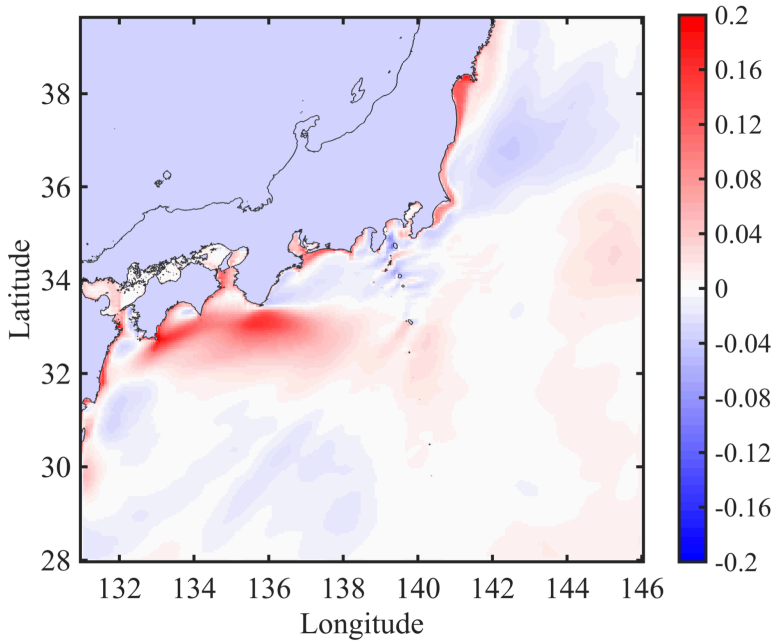

Figure 1. Relative difference between 21-year climatologies of wave power density with and without inclusion of WCI effects (using latter as reference).

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Medium-term oceanic transport of microplastics in and around the South China Sea analyzed with climatological and synoptic models

*Kosei Matsushita[1], Yusuke Uchiyama[1], Naru Takaura[1], Taichi Kosako[2]

1. Kobe University, 2. Port and Airport Research Institute

Lagrangian particle tracking experiments were conducted to evaluate the transport of microplastics (MPs) derived from the four major rivers, i.e., Pearl , Han (China), Mekong (Vietnam), Pasig (Philippines) rivers, that have been known to discharge a huge amount of plastic wastes into the South China Sea (SCS). We carried out two types of the experiments: 1) 2D tracking of MP particles placed at surface to represent positively buoyant (light) MPs, and 2) 3D tracking of neutrally buoyant MP particles that are passively transported by ambient flow, using the pre-computed 3D current velocity field by the HYCOM-ROMS downscaling model at a lateral resolution of 5 km for the SCS. We released more than 1×10^5 particles continuously for the four-year period from 2012 to 2015 into the synoptic model and for one year into the climatological model. The MP particles are discharged at the mouths of the four major MP-source rivers located in the SCS. The comparative synoptic and climatological experiment enables us to analyze the seasonal and inter-annual variability of the river-derived MP transport. The seasonally varying monsoons in the SCS are found to provoke strong seasonal variability in the river-derived MP transport. We found that mesoscale eddies generated along the east coast of the Philippines promote westward transport and accumulation of the MPs from Pasig river. The comparative experiments also allow extracting medium-term climatological variability in the MP transport in the El Niño years (2014-2015).

Keywords: Microplastics, the South China Sea, Particle tracking model, monsoons, mesoscale eddies, El Niño

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

Sat. Jun 5, 2021 1:45 PM - 3:15 PM JST | Sat. Jun 5, 2021 4:45 AM - 6:15 AM UTC | Ch.08 Zoom Room 08

[A-CG37] 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(Arid Land Research Center, Tottori 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-CG54.

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

[ACG37-01] Temporal and spatial variation of soil CO_2/CH_4 fluxes in two cool-temperate forests in Japan

*Lifei Sun[1], Naishen Liang[1], Takashi Hirano[2], Yoshiyuki Takahashi [1], Munemasa Teramoto[3], Kentaro Takagi[2], Toshiaki Kondo[4], Jun Koarashi[5], Mariko Atarashi-Andoh[5], Reiko Ide[1], Xin Zhao[1], Sachinobu Ishida[6], Masahiro Takagi[7], Tomotsugu Yazaki[8] (1.National Institute for Environmental Studies Japan, 2.Hokkaido University, 3.Tottori University, 4.Japan International Research Center for Agricultural Sciences , 5.Japan Atomic Energy Agency , 6.Hirosaki University, 7.University of Miyazaki, 8.Meji University)

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

[ACG37-02] Decomposition of coarse woody debris produced through land conversion from a forest to an oil palm plantation

*Takashi Hirano[1], Shoko Murata[2], Guan Xhuan Wong[3], Joseph Wenceslaus Waili[3], Kim San Lo[3], Frankie Kiew[3], Edward Baran Aeries[3], Ryuichi Hirata[4], Tomohiro Shiraishi[4], Masato Hayashi[6], Masayuki Itoh[5], Lulie Melling[3] (1.Research Faculty of Agriculture, Hokkaido University, 2.Japan Science and Technology Agency, 3.Sarawak Tropical Peat Research Institute, 4.National Institute for Environmental Studies, 5.University of Hyogo, 6.Japan Aerospace Exploration Agency)

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

[ACG37-03] Anticipation of research development on the atmosphere-land interactions of the terrestrial nitrogen cycle

*Kentaro Hayashi[1] (1.Institute for Agro-Environmental Sciences, NARO)

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

[ACG37-04] Simulation of snow algal blooming in the global scale using a land surface model

*Yukihiko Onuma[1], Kei Yoshimura[1], Nozomu Takeuchi[2] (1.Institute of Industrial Science, The University of Tokyo, 2.Graduate School of Science, Chiba University)

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

[ACG37-05] Intercomparison of Data-Driven Estimation of Soil Respiration in Japan

*Hina Yamanuki[1], Kazuhito Ichii[1,2], Naishen Liang[2], Munemasa Teramoto[3], Yoshiyuki Takahashi[2], Jiye Zeng[2], Kentaro Takagi[4], Takashi Hirano[4], Sachinobu Ishida[5], Masahiro Takagi[6], Masaaki Naramoto[7], Kaneyuki Nakane[8], Toshiaki Kondo[9], Jun Koarashi[10], Mariko Atarashi-Andoh[10] (1.Center for Environmental Remote Sensing, Chiba University, 1-33 Yayoi-cho, Inage-ku, Chiba-shi, Chiba 263-8522, Japan, 2.Center for Global Environmental Research, National Institute for Environmental Studies, Tsukuba, Ibaraki 305- 8506, Japan, 3.Arid Land Research Center, Tottori University, 1390 Hamasaka, Tottori, Tottori 680-0001, Japan, 4.Hokkaido University, Kita 8, Nishi 5, Kita-ku, Sapporo, Hokkaido 060-0808, Japan, 5.Hirosaki University, 3 Bunkyo-cho, Hirosaki-shi, Aomori 036-8561, Japan, 6.University of Miyazaki, Gakuen-kibanadai-nishi-1-1, Miyazaki, Miyazaki 889-2192, Japan, 7.Shizuoka University, 836, Ohya, Suruga-ku, Shizuoka-Shi, Shizuoka 422-8529, Japan, 8.Hiroshima University, 1-3-2 Kagamiyama, Higashi-Hiroshima-Shi, Hiroshima 739-8511, Japan, 9.Japan International Research Center for Agricultural Sciences, 1-1 Ohwashi, Tsukuba, Ibaraki 305-8686, Japan, 10.Japan Atomic Energy Agency, 2-4 Shirakata, Tokai-mura, Naka-gun, Ibaraki 319-1195, Japan)

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

[ACG37-06] Overview of the Regional Carbon Budget Assessment and Processes (RECCAP2), and activities on Southeast Asia

*Masayuki Kondo[1] (1.Center for Global Environmental Research, National Institute for Environmental Studies)

Temporal and spatial variation of soil CO_2/CH_4 fluxes in two cool-temperate forests in Japan

*Lifei Sun[1], Naishen Liang[1], Takashi Hirano[2], Yoshiyuki Takahashi [1], Munemasa Teramoto[3], Kentaro Takagi[2], Toshiaki Kondo[4], Jun Koarashi[5], Mariko Atarashi-Andoh[5], Reiko Ide[1], Xin Zhao[1], Sachinobu Ishida[6], Masahiro Takagi[7], Tomotsugu Yazaki[8]

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Forests cover about 30% of global land surface and the total forest carbon stocks (860 Pg) are responsible for about 45% of the carbon in the terrestrial biosphere. Forest soil carbon fluxes which include CO_2 and CH_4 play an important role in global climate change due to both high soil respiration and CH_4 absorption. Consequently, clarifying of mechanisms in forest soil carbon fluxes is critical for understanding the future global carbon cycle and climate change.
To investigate soil CO_2/CH_4 fluxes, we installed multi-channel automated chamber measurement systems in two cool-temperate forests of Tomakomai (natural recovered forest following the typhoon in 2004) of Hakkaido and Fuji-Hokuroku (65-year-old larch plantation) of central Japan. The chambers were separated into 3 groups each with control, trenching and covering understory treatment, respectively. Soil carbon fluxes were continuously measured at hourly and two-hour intervals during snow-free season.
In both forests, soil CO_2/CH_4 fluxes showed high seasonal variation. Soil respiration increased exponentially with changing in soil temperature, whereas soil CH_4 uptake was negatively correlated with soil moisture. Though both the soil temperature and moisture were not significant difference between two forests, we found significant larger soil respiration as well as CH4 absorption in Fuji-Hokuroku larch forest as compared with that of Tomakomai natural forest probably due to both the higher root biomass and soil organic carbon.

Keywords: Soil carbon fluxes, Chamber, Temporal variation, Spatial variation

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Decomposition of coarse woody debris produced through land conversion from a forest to an oil palm plantation

*Takashi Hirano[1], Shoko Murata[2], Guan Xhuan Wong[3], Joseph Wenceslaus Waili[3], Kim San Lo[3], Frankie Kiew[3], Edward Baran Aeries[3], Ryuichi Hirata[4], Tomohiro Shiraishi[4], Masato Hayashi[6], Masayuki Itoh[5], Lulie Melling[3]

1. Research Faculty of Agriculture, Hokkaido University, 2. Japan Science and Technology Agency, 3. Sarawak Tropical Peat Research Institute, 4. National Institute for Environmental Studies, 5. University of Hyogo, 6. Japan Aerospace Exploration Agency

Tropical peatlands are widely distributed in Indonesia and Malaysia and have accumulated a huge amount of biomass and soil carbon as peat, coexisting with swamp forest. Recently, however, the huge carbon pool has been threatened by deforestation and peat decomposition through land conversion to oil palm plantations. The land conversion produces a large amount of coarse woody debris (CWD). The CWD is usually piled high in a row (stacking rows) in plantations and would become a large CO_2 source through decomposition, though quantitative information on CO_2 emission is still lacking. Thus, we conducted a field experiment to quantify how much CO_2 is emitted through CWD decomposition.

The study was conducted in a newly developed oil palm plantation from a tropical peat swamp forest in Sarawak, Malaysia. After land preparation, CWD was piled up at the center of each subrow (0.3 ha). We measured the effective volume of a 90-m-long stacking row four times between November 2011 and May 2020, assuming that the shape of a cross section is a triangle. In addition, we determined the moisture and carbon content of CWD samples taken from the stacking row.
The width and height of the stacking row had decreased gradually. The mean cross-sectional areas of the first three measurements were 4.9, 4.1 and 3.5 m^2, respectively. The total amount of carbon in the stacking row was estimated at 19.0 t in November 2018 and 9.0 t in May 2019 from the effective volume and carbon content. The carbon amount was converted to 56.8 and 30.1 t C ha^{-1}, respectively, which indicates that 26.7 t C ha^{-1} (= 16.1 g C m^{-2} d^{-1}) was lost between the two measurement dates for 166 days.

Keywords: Tropical peatlands, Coarse woody debris, Oil palm plantation, Decomposition, CO2 emissions

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Anticipation of research development on the atmosphere-land interactions of the terrestrial nitrogen cycle

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The Haber–Bosch process established in the early 20th century enables artificial creations of ammonia (NH_3) from dinitrogen (N_2). Artificially created reactive nitrogen (Nr: nitrogen species other than N_2) from NH_3 as the commencing material provides great benefits for human, ca. 80% of which is used for chemical fertilizer of crop production. The enhanced capacity of crop production has also increased livestock production providing feed crops, and then fed the global population growth since the 20th century. However, the nitrogen use efficiency of food production is low, that is, ca. 50% and 10% for crop and livestock production, respectively, as global mean. The remain is eventually lost to the environment as Nr and N_2. The Nr lost to the environment moves over the environmental media changing its physicochemical forms and provides a variety of effects according to its properties such as global warming, ozone destruction, air pollution, water pollution, eutrophication, and acidification until finally converted to N_2 again, which is known as the nitrogen cascade. Thus, the nitrogen use by human is a tradeoff between the benefit as fertilizer to earn food and the threat as various environmental impacts, which is called as the nitrogen issue. To cope with the nitrogen issue, quantitative information of Nr flows between human sector and environmental media and that within the environment is indispensable.
Hereafter the topic is narrowed into the Nr impacts on terrestrial ecosystems. There are various and active exchange processes of nitrogen between land and the atmosphere, even involving the inert N_2. For example, biological nitrogen fixation (BNF) and nitrogen deposition (wet and dry deposition of Nr) are key fluxes from the atmosphere to land, and gas emissions with denitrification (N_2 and nitrous oxide [N_2O]), NH_3 volatilization, and gas and particle emissions with wildfire are key fluxes from the land surface to the atmosphere. The N_2 flows with BNF and denitrification are large in quantity, and the Nr flows with nitrogen deposition, NH_3 volatilization, and N_2O emissions are particularly important in terms of environmental impact.
Numerical model and satellite remote sensing are advantageous to grasp the atmosphere–land exchanges of nitrogen in regional and global scales. Flux observation research at the ground surface has an important role that provides verification data to model and remote sensing research. The observation research is further indispensable for elucidating unknown mechanisms of nitrogen cycling in terrestrial ecosystems. Regular monitoring networks of atmospheric deposition are relatively common, whereas only accumulated respective studies are available for other processes. A wide-area expansion of nitrogen exchange observation research in collaboration with model and satellite sensing research has not been realized yet. In this presentation, cropland N_2O emissions are highlighted with particular interest. According to the Global N_2O Budgets (Tian et al., 2020), agricultural land is the biggest anthropogenic emitter of N_2O accounting for 52% from 2007 to 2016 on average, and its emissions have been increasing in contrast with the decreasing trends in other anthropogenic sources. Considering that the world population and food demand will continuously increase, it is required that effective measures to reduce the agricultural N_2O emissions are introduced and their effects are evaluated correctly. Furthermore, the effects of increased atmospheric CO_2 levels and climate change on the nitrogen cycle and N_2O emissions are unknown. Observational research is an important approach that brings flux data and elucidation of the mechanism. Therefore, in this presentation, the presenter will show an idea of efficiently developing observational research on N_2O. It is hoped that a chance for its realization will be created though discussion with participants.

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Keywords: Nitrogen, N2O emissions, Denitrification, Biological nitrogen fixation, Atmospheric deposition, Flux observation

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Simulation of snow algal blooming in the global scale using a land surface model

*Yukihiko Onuma[1], Kei Yoshimura[1], Nozomu Takeuchi[2]

1. Institute of Industrial Science, The University of Tokyo, 2. Graduate School of Science, Chiba University

Snow algae are cold-tolerant photosynthetic microbes growing on snow and ice during the melting season. The blooms of red snow algae (Sanguina nivaloides) changes the snow surface to red color due to carotenoid pigments in their cells, causing a reduction of the snow surface albedo and acceleration of the melting. Although the red snow phenomena have been reported on the snowfields and glaciers from the Arctic to the Antarctic by in-situ and satellite observations, it is still unclear how the species dispersed globally. Therefore, it is important for biegeosciences to reconstruct their blooming in the global scale. However, the snow algae model, which was proposed previously based on the in situ observations on a snowpack in Greenland, could not reproduce the timing of algal blooming in other areas worldwide, especially in the locations where the snow event frequently occurred or the day-night cycle is apparent during snow melting season. We incorporated the effect of snowfall and day-light length during the algal growth at the locations to the model. To evaluate the performance of the updated snow algae model, we conducted the model validation at fifteen sites from the Arctic to the Antarctic. The improvements enabled to reconstruct the snow algal blooming well reported previously in the various locations worldwide. Based on the model validation, we incorporated the updated snow algae model into a land surface model MATSIRO and performed a global simulation. The global snow algae model (Bio-MATSIRO) is useful to understand the global distribution of snow algal blooming, to evaluate their impact on the snow melting rate globally and to quantify carbon amount in the cryosphere.

Keywords: Snow algae, Numerical modeling, Land surface model

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Intercomparison of Data-Driven Estimation of Soil Respiration in Japan

*Hina Yamanuki[1], Kazuhito Ichii[1,2], Naishen Liang[2], Munemasa Teramoto[3], Yoshiyuki Takahashi[2], Jiye Zeng[2], Kentaro Takagi[4], Takashi Hirano[4], Sachinobu Ishida[5], Masahiro Takagi[6], Masaaki Naramoto[7], Kaneyuki Nakane[8], Toshiaki Kondo[9], Jun Koarashi[10], Mariko Atarashi-Andoh[10]

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Soil Respiration (SR), the sum of root respiration and heterotrophic respiration, is one of the most essential components of soil carbon cycles. However, large uncertainties remain in its temporal and spatial variations. So far, various efforts have been conducted to understand SRs. Many observation stations directly measure SR using chambers. Using these observation data and literature survey, several studies estimated spatial and temporal patterns of SR at global and regional scales based on semi-empirical equations and machine-learning methods. However, the database (e.g. Soil Respiration Database; SRDB) used in these large-scale studies contains inconsistently observed datasets. These inconsistencies may produce additional uncertainties in estimated fluxes. The largest SR observation network across Asia developed and maintained by NIES, Japan can be a good candidate to estimate spatio-temporal variations in SR across Asia, since these observations have been conducted with a consistent observation protocol and quality controls.

In this study, we updated our data-driven estimation of SR across Japan with observation data (eight sites across Japan), remote sensing data (MODIS land products), and random forest regression. Our estimation shows a reasonable performance with R^2=0.87 for remote sensing only model and R^2=0.91 for remote sensing and in-situ combined model. Based on the established model, we also produced upscaled estimations of SR across Japan with 1km spatial resolution from 2000 to 2020.

Intercomparison of our estimation with other available datasets was also conducted to understand advantages of our estimation. Our results show spatially more explicit variations compared with other global products. In addition, our advantage is to capture temporal variations (e.g. 8days). We also confirmed that previous estimations do not reproduce our observation network datasets, indicating consistent observation approach is important to upscale soil respiration.

Keywords: Carbon Cycle, Soil Respiration, Remote Sensing, Machine Learning, Upscaling, CO2 Flux

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Overview of the Regional Carbon Budget Assessment and Processes (RECCAP2), and activities on Southeast Asia

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1. Center for Global Environmental Research, National Institute for Environmental Studies

Understanding the mitigation potential of the land and ocean against anthropogenic GHG emissions hinges upon accurate assessment of their net carbon fluxes. The net amount of carbon exchanged between the atmosphere and land, and the atmosphere and ocean comprises of multiple pathways of carbon fluxes, such as from atmosphere to terrestrial ecosystem, terrestrial ecosystem to inland water, inland water to atmosphere and to estuary, and estuary to ocean. Until today, our ability to diagnose carbon fluxes of terrestrial ecosystems (forests, grasslands, and crops), hydrosphere (rivers, lakes, and estuaries), and ocean have progressed by the development of observation networks and modelling in respective fields. Under the circumstances that anthropogenic emissions exacerbate climate change, a need for accurate assessment of the net land and ocean carbon budgets has been growing, which requires collective efforts of multiple fields towards integration of data, knowledge, and assessment of carbon fluxes.

Bringing together expert researchers from institutes and academia across the world for GHG budget assessment of the land and ocean, the REgional Carbon Cycle Assessment and Processes (RECCAP) was formed under an umbrella of the Global Carbon Project. Here I describe the overview of the second phase of RECCAP (RECCAP), including the objective and methodology, progress over the previous RECCAP1, current state of the project, etc. As an example among the 11 land, 4 ocean, and special interest regions (permafrost, semi-arid, coastal blue carbon, global synthesis) to be analyzed in RECCAP2, this presentation shares the research plan, aim, current state of GHG budget assessment for Southeast Asia.

Keywords: Carbon budget, RECCAP, Southeast Asia

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

Sat. Jun 5, 2021 3:30 PM - 5:00 PM JST | Sat. Jun 5, 2021 6:30 AM - 8:00 AM UTC | Ch.08 Zoom Room 08

[A-CG37] 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(Arid Land Research Center, Tottori 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-CG54.

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

[ACG37-07] Influence of fire and drainage on evapotranspiration in a tropical ex-peat swamp forest

*Shinjiro Ohkubo[1], Takashi Hirano[1], Kitso Kusin[2] (1.National University Corporation, Hokkaido University, 2.University of Palangkaraya)

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

[ACG37-08] Ground-Based Measurement of Solar-Induced Chlorophyll Fluorescence in Wetland by High-Spectral Resolution

*Kitpanuwat TANATARAKEREE[1], Tomomichi Kato[2,3], Tomoki Morozumi[3], KANOKRAT BUAREAL[2], Masahito Ueyama[4], Naohisa Nakashima[3], Hideki Ninomiya[2], Lan Wu[5] (1.Graduate School of Agriculture, Hokkaido University, 2.Graduate School of Global Food Resources, Hokkaido University, 3.Research Faculty of Agriculture, Hokkaido University , 4.Graduate School of Life and Environmental Science, Osaka Prefecture University, 5.Hainan University)

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

[ACG37-09] Accounting for the emissions of tree stems in the methane budget of forests: upscaling chamber measurements to the stand

*Daniel EPRON[1], Ayaka Sakabe[1], Kenshi Takahashi[1], Takeshi Ise[1] (1.Kyoto University)

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

[ACG37-10] Estimation of non-photosynthetic vegetation amount in the northern Gobi Desert using MODIS satellite data

*Jing Wu[1], Yasunori Kurosaki[1], Gantsetseg Batdelger[2], Batjargal Buyantogtoh[1], Ishizuka Masahide[3], Thomas Sekiyama[4], Jiaqi Liu[1] (1. Arid Land Research Center, Tottori University, 2.Information and Research Institute of Meteorology, Hydrology and Environment, 3.Kagawa University, 4.Meteorological Research Institute)

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

[ACG37-11] Mapping Peatland Fires in Indonesia Using a Drone Equipped with an Infrared Camera

*Taishin Kameoka[1], Osamu Kozan[2,3] (1.Educational Unit for Studies on Connectivity of Hills, Humans and Oceans, Kyoto University, 2.Center for Southeast Asian Studies, Kyoto University, 3.Research Institute for Humanity and Nature)

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

[ACG37-12] Incorporating non-structural carbon dynamics in individual-based vegetation model SEIB-DGVM

*Hideki Ninomiya[1], Tomomichi Kato[1] (1.Hokkaido University)

Influence of fire and drainage on evapotranspiration in a tropical ex-peat swamp forest

*Shinjiro Ohkubo[1], Takashi Hirano[1], Kitso Kusin[2]

1. National University Corporation, Hokkaido University, 2. University of Palangkaraya

Tropical peat swamp forests (PSFs) play a significant role in the exchange of water between land and the atmosphere. However, fire and drainage have been expanding in PSFs in recent decades. Although there is concern on the influence of fire and drainage on water circulation, their influence on evapotranspiration (ET) is insufficiently understood. Furthermore, repeated fire occurrences and their corresponding influence on the ET by recurrent burning and smoldering is unexplored. To elucidate these influences, we examined long-term variation of ET in an ex-peat swamp forest in Central Kalimantan, Indonesia that was affected by drainage and repeated fire. The continuous observation of energy fluxes was conducted for approximately 13 y between 2004 and 2016 by using the eddy covariance technique. The site burned in 2009 and 2014, and it was drained in 2014. Monthly ET was synchronized with net radiation (R_n) and thus decreased considerably under fire-induced dense haze during the El Niño drought. Troughs of ET were simultaneous with crests of vapor pressure deficit (VPD), and troughs of ground water level (GWL) and R_n. In the case of ET > precipitation (P), ET decreased when the GWL was lower than -0.5 m. Monthly ET had a strong correlation with R_n (R=0.87, p <0.01), and moderate correlation with VPD (R=−0.51, p <0.01), GWL (R=0.68, p <0.01), and P (R=0.38, p <0.01). ET had almost no correlation with the Enhanced Vegetation Index, which represents above ground biomass (R=0.01) for the entire observation period. Alternately, the results of path analysis showed that some environmental factors controlled ET differently depending on environmental conditions. Generally, VPD negatively affects ET due to stomatal regulation functions under dry atmospheric conditions. However, the effect was negligible during the water-logged periods. This is because atmospheric dryness facilitated evaporation from exposed water on the ground surface, which canceled out the negative effect of transpiration due to stomatal closure. After drainage by canal excavation, fluctuation of GWL did not significantly influence ET. Although, the absolute quantity of ET decreased. This may be due to the hydrophobic dried peat soil, which prevents rainwater infiltration, disconnection of capillary force, or disabled root water uptake as GWL is excessively lowered. Fire potentially decreased ET due to decreased transpiration by burning of vegetation. However, the decreasing effect was cancelled by increased evaporation from the waterlogged ground surface during the subsequent La Niña event. Drainage undoubtedly lowered the GWL, and ET severely decreased in cases with extremely low GWL.

Keywords: Groundwater level, Haze, Latent heat flux, Net radiation, Precipitation, Vapor pressure deficit

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Ground-Based Measurement of Solar-Induced Chlorophyll Fluorescence in Wetland by High-Spectral Resolution

*Kitpanuwat TANATARAKEREE[1], Tomomichi Kato[2,3], Tomoki Morozumi[3], KANOKRAT BUAREAL[2], Masahito Ueyama[4], Naohisa Nakashima[3], Hideki Ninomiya[2], Lan Wu[5]

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Solar-induced chlorophyll fluorescence (SIF) has been observed and discovered to relate linearly to gross primary production (GPP) in terrestrial ecosystem [Krause and Weis, 1991; Meroni et al., 2009; Frankenberg et al., 2011; Paul-Limoges et al., 2018]. However, SIF variations under different plant growth stages and sky conditions, and water table depth effects appear to limit the understandings about SIF-GPP relationship at the field-based measurement. It remains ambiguous linked to how this relationship is affected by varying changes of palnt growth stage, sky, and water table, especially for wetland where is a critical part of carbon sinks. We conducted the ground-base measurement of canopy-top SIF in wetland, Bibai Mire, northern Japan, Hokkaido (43º19'N, 141º48'E, 16 m above sea level) during the growing season (from March to November) in 2020, and examined its relationship to the eddy-covariance GPP [Ueyama et al., 2020]. QEPro spectroradiometer (range of wavelength 648-808 nm, the full width half maximum (FWHM) of 0.31 nm, Ocean Optics, Dunedin, FL, USA) and the spectral fitting method (SFM; Meroni and Colombo., 2006; Meroni et al., 2010; Mazzoni et al., 2012) were used for SIF retrievals at the oxygen absorption band (O_2-A, centered around 760 nm). SIF was captured by the spectra of downwelling and upwelling at the height of 2 meters above the ground by hemisphere spectroradiometer. The downward solar irradiance was estimated from cosine corrector fiber (CC fiber) from field of view (FOV) at 180º and the upward canopy-reflected radiance was received by bare fiber FOV 25º and CC fiber FOV 180º. The slope and correlation in positive linear regression between SIF and GPP were found to vary among the growth stages (slope = -2.99, 107.60, 62.57 and 47.97 (μmolmW^{-1}s^{-1} nm) and r^2 = 0.01, 0.41, 0.73 and 0.65 in Pre-Growing (DOY74-135), Growing (DOY144-179), Mature (DOY180-256) and Senescence (DOY260-295), respectively), suggesting that vegetation growth has a strong impact on the seasonal variations of canopy SIF and its realtion to GPP. In contrast, we found that sky conditions such as sunny (clearness index > 0.5) and cloudy (clearness index ≦ 0.5) have no clear influence on relationship of SIF and GPP (slope = 59.59 and 91.06 (μmolmW^{-1}s^{-1}nm) and r^2 =) and r^2 = 0.68 and 0.75 in sunny day and cloudy day, respectively).

Keywords: Solar-Induced Chlorophyll Fluorescence , Gross Primary Production, Ground-Based Measurement, Wetland, High-Spectral Resolution

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Accounting for the emissions of tree stems in the methane budget of forests: upscaling chamber measurements to the stand

*Daniel EPRON[1], Ayaka Sakabe[1], Kenshi Takahashi[1], Takeshi Ise[1]

1. Kyoto University

Forests are a well-known carbon sink, which mitigate the rise in atmospheric CO_2 and hence global warming. However, methane emissions by stems of living trees become a major concern due to the increasing contribution of methane to global warming. Indeed, methane is the second most important anthropogenic greenhouse gas. Until now, global and regional methane budgets of forests, which cover one third of the land area (67% in Japan) have only considered the source and sink functions of soils, ignoring stem emissions. However, there are growing evidences that trees emit methane through their stem, and the role of trees, in addition to that of the soil, must be considered in the methane budget of forests.

Our objective was to evaluate how to upscale stem CH_4 emissions to the ecosystem level and a prerequisite was first to understand the variability of stem CH_4 emissions across individuals and species, and within individuals: does tree size influence stem CH_4 emission and how do these emissions vary spatially along the stem?

Measurements were carried out in the Ashiu experimental forest from August to December on two to three trees per species and two positions along the trunk. The trunk of five major species at this site emitted CH_4, with a large variability among species. While the temporal variation was low (both diurnal and day to day), CH_4 emission were higher for large trees than smaller ones for a given species and varied with the position along the trunk.

We have used these preliminary results to provide an estimate of the CH_4 emission from the whole trees and we present avenues for estimating these emissions at the stand level considering tree species diversity (contribution of the main species) and the stand structural attributes (tree diameter and height), using species-species allometric relations.

Keywords: Methane, Forest, Upscaling

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Estimation of non-photosynthetic vegetation amount in the northern Gobi Desert using MODIS satellite data

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The focus of monitoring vegetation amount has been mainly on green vegetation during the growing season. Comparatively less research has been done in estimations of non-photosynthetic vegetation (NPV) that includes litter and standing dead vegetation, although monitoring its coverage and mass is of great importance in various applications in arid and semi-arid regions, such as fire risk management, livestock forage assessment and wind erosion risk assessment. The present study intended to estimate the NPV amount based on MODIS vegetation indices and field observation data at one of the main source regions for Asia Dust, Tsogt-Ovoo (TsO) located in the northern Gobi Desert, Mongolia.

We compared the measured NPV coverage (fc_{NPV}) and mass (m_{NPV}) with NDVI and other six potential vegetation indices using the short wavelength infrared region (SWIR) bands. We found that the combination of band 6 (1.6 μm) and band 7 (2.1 μm), namely the Soil Tillage Index (STI) and Normalized Difference Tillage Index (NDTI), had a good performance in estimating fc_{NPV} and m_{NPV}.

We propose the roughness length z_0 and threshold friction velocity (u_{*t}) for sand saltation, which had been observed at non-stony and stony sites in TsO, as representative parameters for the vegetation amount. Using the parameters, we verified suitability of fc_{NPV} estimated from STI. At both sites, the observed z_0 and u_{*t} increased as the estimated fc_{NPV} increased. We established the relationship between the observed z_0 and the estimated fc_{NPV} at the sites. The predicted z_0 in the absence of NPV were 0.0010 cm and 0.0085 cm at non-stony and stony sites, respectively. These values are reasonable in accordance with those of other studies. We also established the relationship between the observed u_{*t} and the estimated fc_{NPV}. The predicted u_{*t} in the absence of NPV were 0.23 m s^{-1} and 0.30 m s^{-1} at non-stony and stony sites, respectively. The threshold wind speed at 10 m height (u_{10t0}) converted from u_{*t} were 5.3 and 6.7 m s^{-1}, close to the value of 6.5 m s^{-1} that commonly used in dust models.

Those verifications indicate that STI is suited to estimate the NPV amount at least at TsO in the Gobi Desert.

Keywords: non-photosynthetic vegetation , Soil Tillage Index, roughness length, threshold friction velocity, arid regions

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Mapping Peatland Fires in Indonesia Using a Drone Equipped with an Infrared Camera

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In this study, we created a peatland fire map using an infrared camera mounted on a drone to plot the position and scale of peatland fires to contribute to their prevention. We expect that this method offers a high potential for future activities and academic research on enhancing the detection and management of peatland fires. Fires occurring in peatlands, which store large amounts of organic matter, are of an especially serious concern. Indonesia has a substantial carbon stock, with an estimated 22.5 million hectares under peatlands and an estimated carbon storage capacity of 57.4 billion tons. Approximately 860,000 hectares of peatlands burned in 2015, resulting in the release of large amounts of soil carbon. Indonesia established the Peatland Restoration Agency in 2016 to conserve peatland areas. Large peatland fires had been difficult to occur since 2016 because of conservation activities and enough precipitation. However, it decreased the amount of rainfall in 2019 in Indonesia, frequent occurrences of peatland fires during 2019 indicate that the problem has not been solved. Peatland fires are difficult to detect visually since they persist underground. This characteristic causes serious problems in the field because it is not easy to extinguish them completely. In addition, certain fires remain undetected until they are large because they occur in remote areas that people cannot access. Therefore, drones equipped with infrared cameras can be a useful tool for detecting peatland fires.

Keywords: Carbon Dioxide, Drone, Indonesia, Infrared Camera, Petaland fire, Remote Sensing

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Incorporating non-structural carbon dynamics in individual-based vegetation model SEIB-DGVM

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To understand the effect of climate change on the terrestrial ecosystem, the response of vegetation to atmospheric carbon is critical. As global warming is getting worse, it would contribute to widespread tree mortality related to drought, increased temperature, pest outbreak to name a few. Then, the tree mortality results in the negative impact on the earth; biological diversity, wild animal habitat, hydrological and carbon cycle, and vulnerability to invasion by unexpected exotic species (Adams et al, 2013). However, it is challenging to estimate the negative impact mainly because the mechanism of how plants are killed is poorly understood. To overcome these tree mortality, trees have grown to control their carbon resources and strategically allocate them to growth, respiration, storage, reproduction, and defense (Hoch et al, 2003; Henrik et al, 2018). The percentage of carbon allocation to each compartment is giving much attention today. Among carbon resources, non-structural carbon (NSC) is commonly considered a repository depending on the balance between the supply of assimilated carbon and carbon demand. Hence, the size of stored C pools can be considered an indicator of the carbon balance of the plant. Additionally, NSC could be the threshold of the conceptual “carbon starvation” as one of the mechanisms after drought (Hoch et al, 2003; McDowell et al., 2008). The objectives of the research are to apply the process representing NSC dynamics to the ecological model and expect the potential effect of NSC in the future.

The process-based Spatially Explicit Individual-Based Dynamic Global Vegetation Model (SEIB-DGVM; Sato et al., 2007), representing three-dimensional tree structure and individual tree growth, was used in this study. In a 30m×30m grid, each plant establishes and dies while sharing incoming solar photons with other plants. Here, we newly introduced a process of accumulating NSC in plants to SEIB-DGVM. Carbon from photosynthesis is mainly allocated to maintenance respiration and growth respiration of plant structure: leaf, stem, and root. In the research, I created a simple NSC pool. All carbon is not consumed but some of them are stored in three organs of plants each day. When photosynthesis rate declines, NSC compensates for maintenance respiration and gradually close to zero. We validated the NSC dynamics at a point and global scale. Firstly, we chose 4 sites representing different plant functional types for the validation: Austria, Swiss, Canada, and Panama, and used observation data as climate data. Secondly, we validated them depending on climate zones: tropical, temperate, and boreal. The climate data for global is Model for Interdisciplinary Research on Climate- Earth System Model (MIROC-ESM, Watanabe et al, 2011). The study contributes to improving the physiological leaf life cycle of the model. In addition, we can understand how NSC will affect the vegetation distribution, gross primary production (GPP), net primary production (NPP) in the future.

Keywords: Nonstructural carbon, Individual-based model, SEIB-DGVM, Carbon allocation, Vegetation dynamics

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

Sat. Jun 5, 2021 9:00 AM - 10:30 AM JST | Sat. Jun 5, 2021 12:00 AM - 1:30 AM UTC | Ch.16 Zoom Room 16

[H-QR04] Quaternary, Diachronic dynamics of human-environment interactions

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Yusuke Yokoyama(Atmosphere and Ocean Research Institute, University of Tokyo), Koji Okumura(Graduate School of Letters, Hiroshima University), Yasufumi Satoguchi(Lake Biwa Museum), Chairperson:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Tsutomu Nakazawa(Geological Survey of Japan, AIST)

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.

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

[HQR04-01] Distribution and classification of buried flat surfaces beneath the post-LGM deposits in central Tokyo

*Junko Komatsubara[1], Yoshinori Miyachi[1], Susumu Nonogaki[1], Toshio Nakayama[2] (1.National Institute of Advanced Industrial Science and Technology, 2.Civil Engineering Support and Training Center)

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

[HQR04-02] 240 ka Ata-Th tephra layer found in Tokyo and its geological significance

*Kunihiko Endo[1], Mari Sumita[2], Toshihiko Sugai[4], Hisashi Fujine[3], Masaaki Suzuki[5], Kyota Uemura[6], Yusuke Suginaka[7], Marie Noguchi[3], Shigeko Ishiwata[8], Reisuke Kondo[9], Takato Takemura[10] (1.Nihon University, 2.GEOMAR, 3.Paleo Labo, 4.Tokyo University , 5.Education Center of Bunkyo, 6.The Institute of Natural Sciences, College of Humanities and Sciences, Nihon University, 7.RCCM, 8.GaNT, 9.Atmosphere and Ocean Research Institute, The University of Tokyo, 10.Nihon University college of humanities and sciences)

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

[HQR04-03] Estimation of sedimentary condition in Kinu River and Kokai River lowland using micro tremor survey

*Mamoru Koarai[1], Kanaho Miki[1], Keiichi Takami[1], Shigeki Senna[2] (1.Earth Science course, College of Science, Ibaraki University, 2.National Research Insutitute of Earth Science and Disaster Resilience)

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

[HQR04-04] Ground-type classification based on Quaternary stratigraphy and sedimentary facies and the corresponding ground motion characteristics, with special reference to the 3D Urban Geological Map of Central Tokyo

★Invited Papers

*Tsutomu Nakazawa[1], Ikuo Cho[1], Junko Komatsubara[1], Tomonori Naya[1], Susumu Nonogaki[1], Yoshinori Miyachi[1], Masanori Ozaki[1], Kentaro Sakata[1], Hiroomi Nakazato[2], Takehiko Suzuki[3], Toshio Nakayama[4] (1.Geological Survey of Japan, AIST, 2.NIRE, NARO, 3.Tokyo Metropolitan University, 4.Civil Engineering Support and Training Center, Bureau of Construction, Tokyo Metropolitan Government)

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

[HQR04-05] Stratigraphic division, age and distribution pattern of the Middle to Upper Pleistocene Shimosa Group in central Tokyo area

*Tomonori Naya[1], Tsutomu Nakazawa[1], Susumu Nonogaki[1], Kentaro Sakata[1], Hiroomi Nakazato[2], Takehiko Suzuki[3], Toshio Nakayama[4] (1.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2.Institute for Rural Engineering, NARO, 3.Tokyo Metropolitan

University , 4.Civil Engineering Support and Training Center, Bureau of Construction, Tokyo Metropolitan Government)

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

[HQR04-06] Paleoenvironmental change in Paleo-Tokyo Bay during MIS 5e inferred from ostracode assemblages of the Pleistocene Kioroshi Formation, Shimosa Group, northern Chiba Prefecture, central Japan.

*Mai Harashima[1], Tsutomu Nakazawa[2], Hirokazu Ozawa[3], Minoru Kaneko, Hiroyuki Ishikawa, Masahiro Nomura[4], Sachiko Agematsu[1] (1.University of Tsukuba, 2.Geological Survey of Japan, AIST, 3.Nihon University, 4.Surugadai University)

Distribution and classification of buried flat surfaces beneath the post-LGM deposits in central Tokyo

*Junko Komatsubara[1], Yoshinori Miyachi[1], Susumu Nonogaki[1], Toshio Nakayama[2]

1. National Institute of Advanced Industrial Science and Technology, 2. Civil Engineering Support and Training Center

The Tokyo Lowland in the eastern part of Tokyo metropolitan area is underlain by the thick post-Last Glacial Maximum (LGM) deposits. Many studies have been conducted on the post-LGM deposits in the Tokyo Lowland since the 1923 Kanto earthquake. Based on those previous works and borehole logs of the Civil Engineering Support and Training Center, Tokyo Metropolitan Government, the most detailed three-dimensional geological map, 3D Urban Geological Map of Central Tokyo has been published by Geological Survey of Japan, AIST. As a part of this achievement, we introduce a classification result of buried flat surfaces (BFSs) beneath the post-LGM deposits. In this study, a base of the post-LGM deposits is defined as the bottom of conglomerate around the incised valley areas and top of conglomerate in buried terraces areas.

BFSs are classified into one valley floor and four other higher flat surfaces. The valley floor is located along the axis of incised valley formed during LGM. It has an altitude of −50 to −80 m and is covered with thick conglomerate. BFSs 1–4 are 0 to −10 m, −18 to −36 m, −21 to −25 m, −45 to −54 m altitude, respectively. BFS 1 and BFS 3 lack conglomerate. BFS 2 and BFS 4 are accompanied by widely traceable conglomerate on them.

BFS 1 is interpreted mostly as Holocene wave-cut platform, partly as remains of MIS 5a marine terrace. BFS 2, known as Honjo buried terrace, is interpreted MIS 3 fluvial terrace and correlated with Tachikawa II surface in Tamagawa area, western Tokyo. The age and origin of BFS 3 remain unknown, and BFS 4 is interpreted as a fluvial terrace formed during MIS 3 or older age.

BFS 1 and BFS 2 have a potential to be subdivided due to their wide range of altitudes. Drilling core survey on those surfaces for volcanic ash soil and/or tephrostratigraphy may provide clues for subdivision.

Keywords: Tokyo Lowland, post-LGM deposits, buried flat surfaces, basal conglomerates, borehole logs, 3D geomodelling

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240 ka Ata-Th tephra layer found in Tokyo and its geological significance

*Kunihiko Endo[1], Mari Sumita[2], Toshihiko Sugai[4], Hisashi Fujine[3], Masaaki Suzuki[5], Kyota Uemura[6], Yusuke Suginaka[7], Marie Noguchi[3], Shigeko Ishiwata[8], Reisuke Kondo[9], Takato Takemura[10]

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1. Introduction

Our recent study (Endo et al., 2020) shows that drilled cores and their geological information are extremely useful tools for understanding hidden underground, like densely populated Tokyo where almost no exposure exists nowadays. Here, we propose new geomorphic/geologic division of the Tokyo area together with the underground geology and geological history of Musashino Upland interpreted from the numerous drilled cores. Many of the cores included several tephra layers, and they provided the temporal geological evolution of the area very well. Also, we will discuss on the correlation of two major tephra layers that were found in the several cores, Ata-Torihama ash layer (Ata-Th ash) from Southern Kyushu and TCu-1 (Tm-2) sourced Hakone Caldera.

2. Tephra occurrence and correlation

Two clearly defined tephra layers were found in the NU-AKD-1 core, drilled site at Akabane-dai NE Musashino Upland, at 24 m below the surface, specifically from 24.15 m to 24.35 m. These two layers seem deposited almost no erosional interval, the upper (“24.2 m ash”) consist from very fine ash almost entirely of bubble-wall glass shards, and 15 cm thick lower unit (“24.3 m pumice”) consist from pale yellowish coarse-grained pumice lapillus. Similar ash and pumice were also found at Hongo and Kami-Nakazato site and probable correlation to Ata-Th ash and TCu-1(Tm-2) pumice by using mainly refractive index analyses of the glass shards and minerals (Suzuki et al., 2020).

3. Major element analyses of the tephra layers

According to the major elements chemical analyses of glass shards by EDS and EPMA, a) “24.2 m ash”, ash from Hongo and Kami-Nakazato site were similar to those of the matrix glass of Ata-Torihama pyroclastic flow deposits (240 ka; Machida and Arai, 2004) sourced Ata Caldera, southern Kyushu, b) “24.3 m pumice”, and pumice samples of Hongo and Kami-Nakazato site were similar to TCu-1 (Tm-2) pumice and pyroclastic flows in Oiso Hills, main Hakone tephra type locality 15 km away from Hakone volcano.

The other tephra lenses (pumice) were found southern Tokyo in the NU-SKG-1 core, from the basal gravel layer of the Tokyo Formation of MIS 5.5 transgression. These pumice were chemically similar to Tu-1, Tu-7 to -8 pumice fall layers from the Hakone volcano, however, it is possible to distinguish from TCu-1 (Tm-2) by SiO2 vs. K2O plot.

4. Geological significance

Ata-Th tephra correspond to Tm-4 in Oiso Hills, which is separated by two tephra units above the TCu-1 (Tm-2). As the interval between Tm-4 (= Ata-Th) and TCu-1 (Tm-2) decrease towards to the east, these

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two units became thinner and more closely overlain each other farther east in Tokyo. This unique unit combination would help for define the broad stratigraphical correlations. Thus, Ata-Th and Tm-2 became one of the most useful marker horizons of 240 ka and/or MIS7 in the middle Pleistocene geological sequences in Musashino Upland areas in Tokyo and the surroundings.

References

Danhara, T. et al. (2010) The Quat. Res., 19, 101-119.
Endo, K. and Uesugi,Y. (1972) The Quat. Res., 11, 15-28.
Endo, K. et al. (2019) The Quat. Res., 58, 353-375.
Endo, K. et al. (2020) 2020 Annu. Meet. Japan Assoc. Quat. Res.
Machida, H. and Arai, F. (2004) Tokyo Univ. Press.
Nagahashi ,Y. et al. (2004) The Quat. Res., 43, 15-35.
Naya, T. et al. (2020) Jour. Geol. Soc. Japan, 126, 575-587.
Oka, S. (1991) Bull. Geol. Surv. Japan, 42, 553-653.
Suzuki M. et al. (2020) 2020 Annu. Meet. Japan Assoc. Quat. Res.
Uemura, K. et al. (2020) Proc. Inst. Nat. Sci., Nihon Univ. 55, 155-164.
Uesugi, Y. (1976) Bull.Assoc. Kanto Quat. Res., 3, 28-38.

Keywords: Ata-Th tephra, Drilled core of Akabane-dai, Stratigraphic sequence of Tokyo, Musashino upland, Middle Pleistocene

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Estimation of sedimentary condition in Kinu River and Kokai River lowland using micro tremor survey

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The Misaka-Shinden and Oki-Shinden districts are located in the back marsh environment in the central part of the Kinu River and Kokai River lowland in the southern part of Ibaraki prefecture. These districts are located in an environment extremely vulnerable to flood disasters, and are flooded even during the 2015 Kanto and Tohoku Heavy Rain.

The authors attempted to estimate the sedimentary environment in these areas as basic information for examining the historical reasons for the settlements located in such places. Micro tremor survey is performed around the Ken-oudo High Way where there is boring data, and the boring data are compared with the S wave velocity structure obtained by micro tremor survey. From the results, the underground ground structures are estimated using the micro tremor survey at the point where there is no boring data. We also performed boring excavation with a hand auger and particle size analysis of the collected samples.

The authors set an approximate S-wave velocity range with respect to the ground from the comparison between the boring data and the micro tremor survry results. S wave velocity of less than 100 m / s is mud, around 200 m / s is sand, and over 300 m / s is gravel. Using these data, the ground conditions of the Misaka-Shinden and Oki-Shinden Districts and the surrounding areas, where there is no boring data, were estimated, and the estimated columnar sections of these areas were created.

As a result, it was estimated that there was a thick sand layer at a depth of about 5 to 15 m just below Misaka-Shinden, and that the river channel of that era was flowing around it. According to the results of boring by hand auger, it is presumed that the southern part of Oki-Shinden was a back marsh environment where flood sediments were difficult to reach, as the surface layer was almost a soft mud layer up to about 5 m.

Keywords: sedimentary environment, Kinu River and Kokai River lowland, micro tremor, boring data, Misaka-Shinden and Oki-Shinden

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Ground-type classification based on Quaternary stratigraphy and sedimentary facies and the corresponding ground motion characteristics, with special reference to the 3D Urban Geological Map of Central Tokyo

*Tsutomu Nakazawa[1], Ikuo Cho[1], Junko Komatsubara[1], Tomonori Naya[1], Susumu Nonogaki[1], Yoshinori Miyachi[1], Masanori Ozaki[1], Kentaro Sakata[1], Hiroomi Nakazato[2], Takehiko Suzuki[3], Toshio Nakayama[4]

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Ground motion characteristics in an urbanized coastal plain are influenced by shallow subsurface geologic conditions. We classified ground types in central Tokyo based on stratigraphy and sedimentary facies in reference to the 3D Urban Geological Map of Central Tokyo published in April 2021 by our research group of GSJ, AIST, and conducted microtremor observations in each ground type to clarify the corresponding ground motion characteristics.

The Musashino Upland is composed of the Middle to Upper Pleistocene strata including the Yabu (MIS 9), Kamiizumi (MIS 7e), and Tokyo (MIS 5e) formations. Of them, the Tokyo Formation contains thick inner-bay soft muddy sediments as incised-valley fills. The detailed distribution of the incised-valley fills was demonstrated by 3D geomodelling. Microtremor observations reveal that the H/V spectra show a peak at 1–2 Hz at the areas of the incised-valley fills. Particularly, a remarkable peak at 1 Hz is observed in the H/V spectra of the Setagaya Valley fills with the high mud-content. On the other hand, the H/V spectra exhibit higher peak frequencies around 4 Hz at the areas outside the incised valleys because of the hard substrate composed mainly of marine sand beds of the Yabu and Kamiizumi formations.

The Tokyo Lowland is underlain by the post-LGM deposits composed generally of fluvial to inner-bay sand and mud. The 3D geomodelling based on the detailed stratigraphic correlation reveals that the buried geomorphology almost corresponding to the base of the post-LGM deposits comprises the deepest valley floor and four buried flat surfaces. We carried out microtremor observations along a line across the deepest valley floor and the flat surfaces 1 and 2 beneath the Tokyo Lowland. The H/V spectra at the areas both of the deepest valley floor and the flat surface 2 exhibit a peak at 1 Hz. The peaks of the flat surface 2 area are clearer than those of the valley floor area because of the high contrast of physical properties between the firm buried terrace gravelly sediments and the overlying soft post-LGM deposits. On the other hand, the H/V spectra at the flat surface 1 area show flat shapes in high frequency ranges due to relatively thin soft sediments above the Pleistocene hard substrate.

Thus, the ground-type classification based on the detailed stratigraphy and sedimentary facies using the 3D geomodelling enables the efficient and accurate assessment of the earthquake hazard risks.

Keywords: Quaternary stratigraphy, 3D geomodelling, borehole logs, microtremor observation, ground motion characteristics

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Stratigraphic division, age and distribution pattern of the Middle to Upper Pleistocene Shimosa Group in central Tokyo area

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The Middle to Upper Pleistocene deposits, mainly composed of shallow marine and fluvial sediments, are distributed in the upper subsurface of the central Tokyo area. This Pleistocene deposit has been called “Tokyo Formation” for a long time, and especially “Tokyo Gravel Bed” at the basal part of “Tokyo Formation” has been paid attention from the viewpoint of applied geology because of its importance such as a bearing layer for a mid–high rise buildings, an important aquifer for groundwater utilization, and a key bed for active tectonics analysis. However, the detailed age of “Tokyo Formation” has remained undetermined for many decades.

We are preparing a 3D geological map of the central Tokyo area (Urban Geological Map: Central Tokyo Area), which is scheduled to be released in April 2021, as part of GSJ project to develop geological information on urban area. In order to develop the Urban Geological Map, we have re-examined the stratigraphy and age of “Tokyo Formation” based on reconstruction of depositional environments according to facies analysis, tephra analysis, and pollen assemblages of borehole cores (Nakazawa et al. 2019, 2020: Naya et al. 2020). The results indicate that the strata previously considered to be “Tokyo Formation” are a mixture of several depositional cycles formed under the influence of eustatic sea-level changes in different periods. In the Middle to Upper Pleistocene Shimosa Group of Boso Peninsula, a sedimentary cycle formed by a single transgression–regression event is defined as a single formation. In this study, the criteria of the Shimosa Group in Boso Peninsula are applied to the stratigraphic division of the central Tokyo area, and the previous “Tokyo Formation” is subdivided into three formations; the Yabu, Kamiizumi, and Tokyo formations. In addition, based on this stratigraphic division, a 3D geological model was created using a large amount of borehole data over a wide area, and the distribution pattern of each formation was also clarified. In this presentation, we introduce an overview of the newly applied stratigraphic division, age and distribution pattern of the Shimosa Group in the central Tokyo area.

Nakazawa et al. (2019) The Journal of the Geological Society of Japan, 125, 367–385.

Nakazawa et al. (2020) Bulletin of the Geological Survey of Japan, 71, 19–32.

Naya et al. (2020) The Journal of the Geological Society of Japan, 126, 575–587.

Keywords: Middle Pleistocene, Upper Pleistocene, Stratigraphy, 3D geological map, Tokyo Formation, Shimosa Group

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Paleoenvironmental change in Paleo-Tokyo Bay during MIS 5e inferred from ostracode assemblages of the Pleistocene Kioroshi Formation, Shimosa Group, northern Chiba Prefecture, central Japan.

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The Pleistocene Kioroshi Formation, Shimosa Group which is distributed beneath the Shimosa Upland in Chiba Prefecture, central Japan is composed mainly of shallow marine deposits accumulated in Paleo-Tokyo Bay during MIS 5e. The depositional sequence of the Kioroshi Formation comprises a lower incised valley system and an upper barrier island system. Ostracode assemblages have been reported from the Kioroshi Formation by Yajima (1978, 1982) and Okazaki et al. (2018), but the succession of ostracode assemblages throughout the Kioroshi Formation including both incised valley and barrier island systems has not been examined so far. We report ostracode assemblages from the lower and upper parts of the Kioroshi Formation in sediment cores and interpret paleoenvironmental change in Paleo-Tokyo Bay during MIS 5e.

Fossil ostracodes were collected from two sediment cores: GS-NT-1 (Narita City, Chiba; oceanward) and GS-NY-1 (Nagareyama City, Chiba; landward) recovered from the sites within a buried incised valley. We identified 81 ostracode species from GS-NT-1 and 77 species from GS-NY-1. Based on the ostracode assemblages, the examined intervals in cores GS-NT-1 and GS-NY-1 are divided into four zones, respectively; zones NT-I–IV and zones NY-I–IV in ascending order.

Zone NT-I is characterized by *Spinileberis quadriaculeata–Bicornucythere bisanensis* assemblage accompanied with *Cytheromorpha acupunctata*, indicating an enclosed inner-bay environment near a middle bay. Zone NT-II characterized by *S. quadriaculeata–B. bisanensis–C. acupunctata–Pontocythere miurensis* assemblage shows an inner bay environment with coastal currents. Zone NT-III is characterized by *Neomonoceratina delicata* assemblage accompanied with *S. quadriaculeata* and *C. acupunctata*, seems to represent an inner bay environment under the influence of a warm current. Zone NT-IV is characterized by *Aurila* spp.*–P. miurensis* assemblage accompanied with *Cythere omotenipponica*, indicating an open bay environment near seaweed beds influenced by open-ocean water. According to Nakazawa et al. (2017), zones NT-I–NT-II, zone NT-III and zone NT-IV correspond to the sand bar facies which is incised valley system, the sand bar facies–the central basin facies, and the central basin facies–the flood tidal facies which is barrier island system, respectively.

Zone NY-I is characterized by *S. quadriaculeata–C. acupunctata* assemblage, indicating an enclosed inner bay environment slightly near a middle bay. Zone NY-II is characterized by *C. acupunctata* assemblage accompanied with *N. delicata* and *S. quadriaculeata,* seems to represent an inner bay environment under the influence of a warm current. Zone NY-III is characterized by *Loxoconcha uranouchiensis* assemblage accompanied with *S. quadriaculeata* and *C. acupunctata*, indicating an inner bay environment near seaweed beds. Zone NY-IV characterized by *Aurila* spp.*–Loxoconcha optima* assemblage accompanied with *C. acupunctata* and *Xestoleberis hanaii* shows an open bay environment near seaweed beds influenced by open water. The boundary between zones NY-I–NY-III and zone NY-IV correspond with lithologic divisions respectively the lower incised valley system and the upper barrier system.

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References:

Nakazawa, T., Sakata, K., Hongo, M. and Nakazato, H. (2017) Transition from incised valley to barrier island systems during MIS 5e in the northern Chiba area, Kanto Plain, central Japan. Quaternary International, 456, 85–101.

Okazaki, H., Ishii, A., Kaneko, M., Tamura, T., Chigaku Club of Gunma Prefectural Ota Girls' High School, Kato, H., Isaji, S. and Tanaka, G. (2018) An Excavation Report of a Baleen Whale, from the Pleistocene Kioroshi Formation, Shimosa Group - Sedimentary Facies, Microfossils, Ground Penetrating Radar Analysis. J. Nat. Hist. Mus. Inst. Chiba, 14(1), 19–28 (in Japanese with English abstract).

Yajima (1978) Quaternary Ostracoda from Kisarazu near Tokyo. Trans. Proc. Palaeontol. Soc. Japan, N. S., 112, 371–409.

Yajima (1982) Late Pleistocene Ostracoda from the Atsumi Peninsula, central Japan. Trans. Proc. Palaeontol. Soc. Japan, N. S., 146, 49–76.

Keywords: Ostracoda, Kioroshi Formation, MIS 5e, Paleo-Tokyo Bay

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

Sat. Jun 5, 2021 10:45 AM - 12:15 PM JST | Sat. Jun 5, 2021 1:45 AM - 3:15 AM UTC | Ch.16 Zoom Room 16

[H-QR04] Quaternary, Diachronic dynamics of human-environment interactions

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Yusuke Yokoyama(Atmosphere and Ocean Research Institute, University of Tokyo), Koji Okumura(Graduate School of Letters, Hiroshima University), Yasufumi Satoguchi(Lake Biwa Museum), Chairperson:Koji Okumura(Graduate School of Letters, Hiroshima University), Yusuke Yokoyama(Atmosphere and Ocean Research Institute, University of Tokyo)

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

[HQR04-07] Middle Pleistocene terraces in the Chita Peninsula, near Nagoya, central Japan

*Taku Komatsubara[1], Misao Hongo[2], Yoshiki Sato[1] (1.Institute of Geology and Geoinformation, Advanced Industrial Science and Technology, 2.Alps Technical Research Laboratory Co., Ltd.)

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

[HQR04-08] **Unveiling the black box: monthly measurements on dissolved inorganic radiocarbon in Fuji Five lakes water to understand the lake specific reservoir ages**

*Ota Kosuke[1,2], Yusuke Yokoyama[1,2], Yosuke Miyairi[2], Shinya Yamamoto[3], Toshihiro Miyajima[2] (1.Earth and Planetary Science Department, Graduate school of Science, University of Tokyo, 2.Atmosphere and Ocean Research Institute, University of Tokyo, 3.Mount Fuji Research Institute, Yamanashi Prefectural Government)

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

[HQR04-09] Eventual sediments presumed in lake deposits of coastal lakes along the western coast of Kyushu Island, Japan

*Kaoru Kashima[1], Yu Fukumoto[2], Tsuyoshi Haraguchi[2] (1.Department of Earth and Planetary Sciences, Kyushu University, 2.Osaka City University)

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

[HQR04-10] Origin and evolution of a delta-margin mangrove in Can Gio, southern Vietnam

★Invited Papers

Daniel S Collins[1,6], Lap V Nguyen[2], Oanh TK Ta[2], Limi Mao[3], Yuji Ishii[1], Hiroyuki Kitagawa[4], Rei Nakashima[1], *Toru Tamura[1,5] (1.Geological Survey of Japan, AIST, 2.HCMC Institute of Resources Geography, Vietnamese Academy of Science and Technology, 3.Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, 4.Institute for Space-Earth Environmental Research, Nagoya University, 5.Graduate School of Frontier Science, The University of Tokyo, 6.Shell International Ltd)

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

[HQR04-11] Discussion

Middle Pleistocene terraces in the Chita Peninsula, near Nagoya, central Japan

*Taku Komatsubara[1], Misao Hongo[2], Yoshiki Sato[1]

1. Institute of Geology and Geoinformation, Advanced Industrial Science and Technology, 2. Alps Technical Research Laboratory Co., Ltd.

1. Introduction
The Middle Pleistocene terraces in the Chita Peninsula had been subdivided into two surfaces and formations since Matsuda (1969). The authors re-examined topographic features and stratigraphy of them and tried to date them by pollen analysis.

2. Field survey

A large outcrop (Fig. 1) in the central area of the peninsula shows that the highest terrace that named “Taketoyo terrace” is subdivided two terrace surfaces, and its deposits are also subdivided two units by an unconformity. The higher one (newly named “H 1 terrace”) is composed by gravelly deposits and distributed on the top of hills that constitute watershed between the Kinuura on the east of peninsula and the Ise bay on the west of peninsula.. The H 1 terrace deposits contain a lot of rhyolite gravels. The lower one (newly named “H 2 terrace” is composed by sand and mud with bioturbation. The other Middle Pleistocene terrace 1 step lower than H 2 terrace (newly named “H 3 terrace”) is composed with two marine mud and fluvial top gravels. Rhyolite gravels are common in the H 2 terrace and H 3 terrace deposits in the western coast, however, it is few in them in the eastern coast.
3. Pollen analysis
Results of the pollen analysis in each terrace deposits are shown in Table 1.

4. Dating
All of the H1 ~ H3 terraces are late Middle Pleistocene (Chibanian) interglacial ones, because of red (2.5 ~ 5 YR in the Munsell color index) surface soil, degree of weathering of gravels (intensely weathered to be soft and brittle) and warm temperate pollen assemblages. H I is thought to be dated to a warm climate stage around MIS 11 fluvial terrace, H2 is thought to be MIS 9 marine terrace, H 3 is thought to be MIS marine to river mouth terrace.

Keywords: Middle Pleistocene terrace, Pollen analysis, Dating, Chita peninsula, Chibanian

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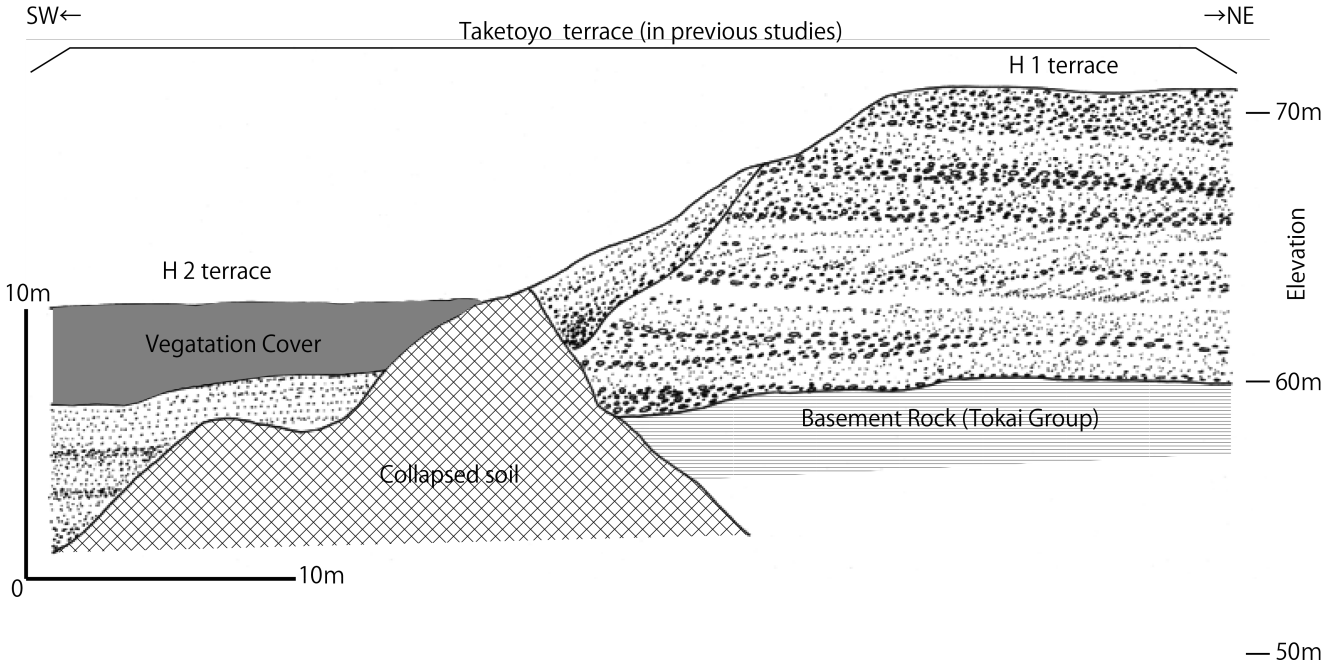

Fig. 1 Newly recovered outcrop in the central part of th Chita Paninsula (near Besso pond, Taketoyo town)

Table 1 Pollen assemblage in the Middle Pleistocene terrace deposits

Horizon	numver of tree pollen	Major taxon (Pollen assemblege)	Age
H3 Uppermost tidal deposit	211	Rhamnaceae, *Scidopitys*, *Quercus* (Subgen. *Lepidobalanus*)	MIS7 late subintergl acial age
H3 upper part debris flow deposits	221	*Pinus* > *Cryptomeria*, *Betula* > *Podocarpus*	
H3 lower marine layer ?	114	*Cryptomeria*, *Alnus* > *Quercus* (Subgen. *Cyclobalanopsis*), *Castanopsis* / *Pasania*, *Trema*, *Lagerstroemia*	MIS 7 early interglacia l age
H3 lower marine layer	99	*Cryptomeria* > *Quercus* (Subgen. *Lepidobalanus), Pinus*	
H3 lower marine layer	212	*Cryptomeria*, *Pinus* > *Quercus* (Subgen. *Cyclobalanopsis*), *Quercus* (Subgen. *Lepidobalanus*) > *Podocarpus*, *Betula,* Castanopsis / Pasania	
H3 lower marine layer	35	*Cryptomeria*, *Pinus*	
H3 lower marine layer	115	*Cryptomeria* > *Pinus*, *Betula*, *Camellia*	
H2 top of marine layer	40	*Cryptomeria, Pinus*, *Quercu* s (Subgen. *Cyclobalanopsis*), *Q*. (Subgen. *Lepidobalanus*),*Mallotus*, *Castanopsis* / *Pasania*, *Camellia*	MIS 9
H2 marine layer	224	*Pinus*, *Fagus* > *Quercus* (Subgen. *Lepidobalanus*) > *Abies*, *Tsuga*, *Sciadoptyis*, *Podocarpus*, *Sapium*	
H1upper part in fluvial layer	202	*Clethra* > *Quercus* (Subgen. *Lepidobalanus*), *Alnus, Cryptomeria* > *Quercus* (Subgen. *Cyclobalanopsis*), *Castanopsis* / *Pasania*	around MIS 11
H1 middle part in fluvial layer	11	*Pinus, Sciadopitys, Cryptomeria, Betula, Alnus, Quercus* (Snbgen. *Lepidobalanus*), *Fagus*	

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Unveiling the black box: monthly measurements on dissolved inorganic radiocarbon in Fuji Five lakes water to understand the lake specific reservoir ages

*Ota Kosuke[1,2], Yusuke Yokoyama[1,2], Yosuke Miyairi[2], Shinya Yamamoto[3], Toshihiro Miyajima[2]

1. Earth and Planetary Science Department, Graduate school of Science, University of Tokyo, 2. Atmosphere and Ocean Research Institute, University of Tokyo, 3. Mount Fuji Research Institute, Yamanashi Prefectural Government

Lake sediments are important for paleoenvironmental studies, and it is important to estimate the radiocarbon reservoir effects within lake water with high accuracy. Although radiocarbon dating has a large range of uses, the radiocarbon reservoir effect causes water and sediment ages to appear older. This is due to the exchange of ^{14}C-depleted substances derived from biological remains and host rocks during the process of fixing, and from transporting modern carbon from the atmosphere. The radiocarbon reservoir effect from lake samples is known to be highly variable, showing a maximum of about 2200 years which can lead to problems for high-precision dating. Yet, there are few studies of radiocarbon reservoir effects on land due to complicated carbon transfer processes and lack of appropriate measurement techniques, and no studies have been performed on seasonal variations.

We study Fuji Five Lakes to unveil the mechanisms behind variability of their reservoir ages. Lakes Motosu, Shoji and Sai only have temporal inflow and outflow rivers, and the lake water is defined by precipitation and groundwater inflow. Therefore, the transportation pathway of water is simple and suitable for estimating the radiocarbon transport process around these lakes. By measuring the radiocarbon concentration ($\Delta^{14}C$) of precipitation, groundwater, and lake water, it is possible to clarify the effect of groundwater on the reservoir effect of lake water. In this study, for the first time, we measured lake water $\Delta^{14}C$, $\delta^{18}O$, and δD monthly at the Fuji Five Lakes, and compared results with groundwater $\Delta^{14}C$. The results show that Lake Kawaguchi had the lowest $\Delta^{14}C$ in August and Lake Motosu had the highest $\Delta^{14}C$ in January. In Lakes Motosu and Kawaguchi, $\Delta^{14}C$ was found to increase in winter. No clear seasonal changes were observed in Lake Sai and Lake Yamanaka. Regarding the relationship between the lake water and the sediment, the lake water $\Delta^{14}C$ coincided with surface sediment $\Delta^{14}C$ in the summer at Lakes Motosu and Kawaguchi. Sediment $\Delta^{14}C$ in both lakes may be defined by the fixation of lake water ^{14}C due to elevated biological production in the summer, and summer lake water $\Delta^{14}C$ can be used to estimate the reservoir effect of lake sediment. Therefore, at least seasonal measurements on lake water are recommended to better understand lake specific reservoir ages.

Keywords: Radiocarbon, Fuji Five Lakes, Lake water

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Eventual sediments presumed in lake deposits of coastal lakes along the western coast of Kyushu Island, Japan

*Kaoru Kashima[1], Yu Fukumoto[2], Tsuyoshi Haraguchi[2]

1. Department of Earth and Planetary Sciences, Kyushu University, 2. Osaka City University

In coastal lake deposits often contained several disturbed layers by past tsunami, typhoons, high tide and natural hazard events. Those eventual layers were well preserved among lake sediments which deposited under stable water conditions, were identified easily by lithofacies of the sediments. In this paper, we presumed paleo-environmental histories of those eventual layers by diatom assemblages in the sediments. The compositions of diatom assemblages were shifted by characteristics and origins of natural disasters. Along the western coast of Kyushu Island where very huge typhoons often attacked by historic documents and meteorological records, we took undisturbed lake cores at coastal lakes to presume the frequencies and historic records of the disasters. Our research areas were **(a) Ikeda-ike (Daijya-ike) at Amakusa Peninsula, (b) Nakayama area at Shimokoshiki Island, (c) Nakakoshiki area at Nakakoshiki Island** and **(d) Namako-ike at Kamikoshiki Island.**

(a) Ikeda-ike (Daijya-ike) at Amakusa Peninsula: It was a small lake (WE200m, NS 150m), and has continued freshwater environment since 6700 yBP when the sand barrier closed the oceanic side of the lake. We presumed 11 eventual layers in the core sediments. Diatom assemblages presumed six of them were hazards with clear marine water invasions into the lake, two of them were with unclear marine invasions and last three were caused by huge flooding from surrounding mountains.

(b)Nakayama area at Shimokoshiki Island: It was a freshwater lake, however it changed to be a reclamation rice field about 50 years ago. The ancient lake had continued freshwater environment since 6500 yBP. Totally 16 eventually layers were presumed in the core. Diatom assemblages presumed seven of them were caused by marine invasions, and six of them were caused by inland flooding without marine invasions. Two of them were characterized by water level increasing (maybe artificially) and the last one was caused by the artificial land reclamation.

(c) Nakakoshiki area at Nakakoshiki Island: The top part of the core was disturbed by recent land flooding, the sediment during 2000-6000 yBP was kept. Four eventually layers were observed, and three of them were caused by marine invasions. The other one was caused by inland flooding without marine invasions.

(d) Namako-ike at Kamikoshiki Island: It is a brackish lake along north east coast of Kamikoshiki Island. We took the core until 6200 yBP layers, and 9 eventually layers were observed. Six of them were caused by caused by marine invasions, and three of them were characterized by freshwater flooding into the lake

(e) Correlation of the eventual layers in the cores: We found the strong correlation between the eventual layers at the research sites. The frequencies of the hazards surrounding 2.4ka, 2.8ka, 3.2ka, 3.7ka, 4.2ka, 4.7ka and 5.2ka were increased. They could be correlated to the hazard layers of Korean Peninsula**,** and were probably related to the global climatic processes in East Asia.

Keywords: The Holocene, Climatic Change, Hazard Deposits, Coastal lakes, Kyushu Island, Diatom

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Origin and evolution of a delta-margin mangrove in Can Gio, southern Vietnam

Daniel S Collins[1,6], Lap V Nguyen[2], Oanh TK Ta[2], Limi Mao[3], Yuji Ishii[1], Hiroyuki Kitagawa[4], Rei Nakashima[1], *Toru Tamura[1,5]

1. Geological Survey of Japan, AIST, 2. HCMC Institute of Resources Geography, Vietnamese Academy of Science and Technology, 3. Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, 4. Institute for Space-Earth Environmental Research, Nagoya University, 5. Graduate School of Frontier Science, The University of Tokyo, 6. Shell International Ltd

Mangroves can deliver important socio-economic benefits and store significant volumes of carbon along tropical to temperate coastlines, but the distribution is controlled by complex geomorphologic, hydrodynamic and salinity conditions, as well as human-related pressures. In the Mekong delta, extensive mangroves presently occur along the northeastern delta margin (Can Gio, located 40 km southeast of Ho Chi Minh City), in an embayed, back-barrier environment subject to the highest tidal range (c. 4 m) and away from major fluvial distributary channels. However, the development of the Can Gio mangrove system during the Holocene evolution of the Mekong delta is not fully understood. This study aims to constrain the sedimentary evolution of the backbarrier mangrove in Can Gio based on stratigraphic, palynological and geochronological analyses of sediment cores. Two deep borehole cores (15 and 30 m deep) and four short auger cores (up to 4 m deep) were taken at the modern mangrove to characterize a 20-km-long shore-normal cross section dated with radiocarbon and optically stimulated luminescence (OSL) ages. The cores consist of a thick (> 20 m) subtidal mud from the base of the Holocene unit to the level of 3–4 m deep below the ground level, overlain by carbonaceous, intertidal mud. Chronological data reveal major episode of subtidal mud aggradation from 6 to 3.5 ka, forming the topography for mangrove development. Radiocarbon ages in the overlying intertidal mud range from 4 ka to modern and show some inconsistencies with the stratigraphy, suggesting mangrove root penetration and sediment mixing. The beach-ridge structure and OSL ages of the Can Gio barrier indicate that barrier formation initiated just before 3.2 ka. The transition from subtidal to intertidal mud aggradation and initiation of barrier formation, are broadly correlated with the onset of the subaqueous delta progradation and shift to a wave-dominated regime in the central delta. However, after 3.5 ka, the Can Gio shoreline had negligible sediment accretion while the central delta prograded up to 50 km seawards. Reduced sediment supply to Can Gio is consistent with more asymmetric, southwestward-dominated longshore drift after 3.5 ka. The negligible progradation at Can Gio also indicates minor sediment supply from the nearby Dong Nai River, which prevented upper intertidal accretion and translation of mangroves into a flood plain.

Keywords: mangrove, delta, coast, sea-level changes, sediment

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

[H-QR04] Quaternary, Diachronic dynamics of human-environment interactions

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Yusuke Yokoyama(Atmosphere and Ocean Research Institute, University of Tokyo), Koji Okumura(Graduate School of Letters, Hiroshima University), Yasufumi Satoguchi(Lake Biwa Museum), Chairperson:Koji Okumura(Graduate School of Letters, Hiroshima University), Yusuke Yokoyama(Atmosphere and Ocean Research Institute, University of Tokyo)

Sat. Jun 5, 2021 10:45 AM - 12:15 PM Ch.16 (Zoom Room 16)

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.

11:45 AM - 12:15 PM

[HQR04-11]Discussion

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[J] Oral | H (Human Geosciences)：H-DS Disaster geosciences

Sat. Jun 5, 2021 1:45 PM - 3:15 PM JST | Sat. Jun 5, 2021 4:45 AM - 6:15 AM UTC | Ch.16 Zoom Room 16

[H-DS10] Geohazards in humid, tectonically active countries and their precursors

convener:Satoru Kojima(Department of Civil Engineering, Gifu University), Taro Uchida(University of Tsukuba), Yoshihiko Kariya(Department of Environmental Geography, Senshu University), Chairperson:Yoshihiko Kariya(Department of Environmental Geography, Senshu University), Satoru Kojima(Department of Civil Engineering, Gifu University)

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.

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

[HDS10-01] Weathering styles and landslide types of granite

*Masahiro Chigira[1], Yasuto Hirata[2] (1.Fukada Geological Institute, 2.Central Research Institute of Electric Power Industry)

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

[HDS10-02] Slope failures induced by the 2020 July heavy rain in the Chubu Region

*Hidehisa Nagata[1] (1.Fu-Sui-Do Company Limited)

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

[HDS10-03] **Landslides in humid-temperate mountainous areas in northwestern Vietnam perceived by satellite images**

*Takahisa Furuichi[1,2,3], Hiromu Daimaru[1], Wataru Murakami[1], Takashi Okamoto[1] (1.Forest and Forest Products Research Institute, 2.University of the Sunshine Coast, 3.Miyagi University of Education)

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

[HDS10-04] Estimation of subsurface structure in the linear depression spreading over the landslide crown

*Hikaru Osawa[1], Issei Doi[2], Noriyuki Arai[2], Yosuke Yamakawa[1], Takuma Watakabe[3] (1.Mountain Science Center, University of Tsukuba, 2.DPRI, Kyoto University, 3.Forestry and Forest Products Research Institute)

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

[HDS10-05] Study on the landslide mechanism of the Iya area where the deep-seated landslide occurred by Typhoon Talas in 2011 using Drone Airborne TEM

*Atsuhiko Kinoshita[1,2], Suguru Shibata[2], Takao Yamakoshi[1], Hiroaki Nakaya[1], Yasumasa Fujiwara[3], Hideki Nakano[3], Akira Jomori[4], Katsushi Kawato[5], Muneki Mitamura[6], Tamotsu Matsui[7] (1.National Institute for Land and Infrastructure Management, 2.Sediment Disaster Prevention Technology Center, 3.Eight-Japan Engineering Consultants Inc., 4.NEOSCIENCE CO.LTD., 5.NIPPON ENGINEERING CONSULTANTS CO.,LTD., 6.Osaka City University, 7.Osaka University)

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

[HDS10-06] Creating a Landslide risk map of the Nachi River basin

*Makoto Msatsuzawa[1], Tatsuya Ito[1], Chiyoshi Minami[1], Atsuhiko Kinoshita[2], Suguru Shibata[2], Taku Yamada[3], Toshiaki Kotake[3], Yasutaka Tanaka[4] (1.PACIFIC CONSULTANTS CO., LTD., 2. Sediment Disaster Prevention Technology Center, 3.Kiisankei sabo office, 4.HOKKAIDO UNIVERSITY)

Weathering styles and landslide types of granite

*Masahiro Chigira[1], Yasuto Hirata[2]

1. Fukada Geological Institute, 2. Central Research Institute of Electric Power Industry

Weathered granite areas have suffered from many landslides induced by rain storms: For example, Hiroshima rainstorm disasters in 1999, 2014, and 2018, and southern Miyagi rainstorm disaster induced by typhoon 19 in 2019. The basic causes of these landslides were in two types of weathering styles: micro-sheeting and spheroidal weathering. Micro-sheeting forms loosened soil layers on slope surfaces, which fail during rainstorms; and spheroidal weathering forms corestones, which are destabilized when the intervening gruss is eroded in the ground. These two types of weathering have been known, but the reasons why were not known. Topographically, granite forms characteristic features like tors and boulder fields, but the reasons why have not been known. We investigated granite with high angle joints using UAV and SfM and found that columnar joints develop in granite body in 10 places. Many of these areas have tors, which we found were surrounded by columnar joints. We also investigated the boulder field at Kui, Hiroshima prefecture, and found that many columnar prims are included in the field as well as rounded corestones, which suggests that the boulder field is made through the collapse of rock columns weathered in the ground. Columnar joints of granite are probably made in the upper marginal part of a granite body near the surrounding rocks and not in the depths, in which granite is massive rock and later experiences sheeting and micro-sheeting. Such a history suggests that the fate of granite body after being exposed to the ground surface is already determined when it is emplaced in the depths.

Keywords: Granite, Weatheirng, Landslide, Spheroidal weathering, Micro-sheeting

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Slope failures induced by the 2020 July heavy rain in the Chubu Region

*Hidehisa Nagata[1]

1. Fu-Sui-Do Company Limited

A weather front stayed in July, 2020 brought much rainfall to the Japanese Islands. As well as the Kyusyu Region, the Chubu Region including Gifu, Nagano and Aichi Prefectures were also suffered from slope disasters in various localities. An overview of the landslides occurred in the Chubu Region from geological and geomorphological standpoints is mentioned. The following cases were observed as slope failures. 1) Shallow rapid landslides on the slopes consist of pulutonic rocks and welded tuff: At Nishibora, Takayama city, Gifu Prefecture, both Mesozoic medium-grained granodiorite and crystalline welded tuff ("Nohi Rhyolites") are strongly weathered into decomposed sandy saprolite (Masa). Many slopes collapsed at the surface no more than 1 m depth, maximum width is 20 m. 2) Deep-seated rapid landslides on the slope of Jurassic accretionary complex: Weathered sandstone of the Mino Belt were in failure at Okudabora, Gujo City, Gifu Prefecture, and Kamiya, Kiso Town, Nagano Prefecture. Weathered meta-chert with small amount of granite and diorite of the Ryoke Belt were collapsed at Toko, Tenryu Village, Nagano Prefecture. Depths of landslides reach about 20m in the Okudabora and Toko, and their volumes are 50,000 m^3 and 100,000 m^3, respectively. In the case of Kamiya landslide, only two surface failures are visible, but they are located at the toes of larger deep-seated landslide of which 400 m wide. Also, the Okudabora landslide occurred in the larger gravitational deformed area. 3) Artificial slope failures in suburban area: Cut slope for railroad were collapsed by flooding water flowed from a road above the slope at Oshikamo, Toyota City, Aichi Prefecture. Embankment for widening of dwelling site along a terrace scarp broke involving retaining wall at Okacho, Okazaki City, Aichi Prefecture.

Keywords: plutonic rocks, welded tuff, accretionary complex, artificial slopes

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Landslides in humid-temperate mountainous areas in northwestern Vietnam perceived by satellite images

*Takahisa Furuichi[1,2,3], Hiromu Daimaru[1], Wataru Murakami[1], Takashi Okamoto[1]

1. Forest and Forest Products Research Institute, 2. University of the Sunshine Coast, 3. Miyagi University of Education

Introduction

Landscape in northern Vietnam is characterized by intensive land-use on relatively steep mountain slopes, on which landslides often occur, induced by heavy rainfall brought by typhoons (or tropical storms) and convergence zones. Landslides are a major process of the geomorphic evolution in northern Vietnam and various studies for better understanding of landslides along the biophysical contexts in northern Vietnam have been progressing. We report here initial reconnaissance, which was only remotely possible due to COVID-19, on recent landslides in northewestern Vietnam, i.e. the region to the west of the Hong River (Red River).

Topography, Geology and Land-use

Three major rivers in northwestern Vietnam, namely the Hong River, Da River and Ma River, parallelly flow in the direction of NW-SE, which are aligned parallel to the Red River Fault Zone that represents the regional tectonic structure. The Con Voi Mountains have built between the Hong and Da Rivers up to the elevation higher than 2500 m. Paleozoic and Mesozoic sedimentary rocks that commonly include limestone units extensively occur in the area, while Mesozoic volcanic and pyroclastic rocks and metamorphic rocks predominantly underlie specific areas. Mountain slopes are extensively used for cultivation and forestry and are often terraced up to the ridge. Bare lands are occasionally distributed due to deforestation or intensive land-use.

Rainfall

Northwestern Vietnam is under a humid-temperate climate and experiences heavy rainfall mostly during the rainy season from April to September, which is either brought by typhoons (or tropical storms) or due to a strong wind convergence developed by the tropical disturbance together with the persistent Asian monsoon. A statistical analysis indicated an increase of heavy rainfall in northern Vietnam during both La Nina and El Nino events, suggesting an effect of the ENSO cycles on heavy rainfall in northern Vietnam. A GSM-based simulation projected an increase of heavy rainfall in the middle and late 21st century compared to the late 20th century in northern Vietnam.

Areas, characteristics and occurrence of landslides

We used multiple-year satellite images available on Google Earth as well as multiple-year images taken by the Worldview-2 and Pleiades satellites. Landslide features have been identified in various areas in northwestern Vietnam and most critical ones can be picked up in Yen Bai and Lai Chau provinces. Landslides in those areas likely occurred during the 2018 rainy season when three tropical storms, namely Ewiniar in June, Son-Tinh in July and Bebinca in August, brought heavy rainfall in northwestern Vietnam. In the Yen Bai site, numerous shallow landslides appear on deforested mountain slopes underlain by plutonic rocks at the altitudes of 1500-2000 m. In the Lai Chau site, a massive, deep-seated landslide with a dimension of 100 m in width and 650 m in length is found on broadly deforested mountain slopes underlain by on basaltic bedrocks at the altitude approximately 600 m. A village located immediately above the landslide body was disappeared after the devastating landslide. Landslide debris were

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deposited along an approximately 4-km section of the valley, which also caused damage.

Working progress

Geomorphic attributes, such as topography, bedrocks, soil layers, hydrology and land-use, will be investigated in the Yen Bai and Lai Chau sites to uncover conditions and mechanisms of the 2018 landslides. Results should provide key features for creating landslide risk maps in the areas and proposing a concept of disaster-preventive land-use planning that accords with regional or local biophysical (and social) contexts. Importantly, climate change adaptation should be considered in the map and concept as heavy rainfall is projected to increase through the 21st century in northern Vietnam.

Keywords: Landslide, Northwestern Vietnam, Satellite image, Geology, Land-use, Heavy rainfall

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Estimation of subsurface structure in the linear depression spreading over the landslide crown

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1. Mountain Science Center, University of Tsukuba, 2. DPRI, Kyoto University, 3. Forestry and Forest Products Research Institute

In recent years, deep-seated catastrophic landslides caused by heavy rainfall have occurred one after another in Japan, and there is a need to clarify the relationship between landslides and depressions in slopes, which are known as precursors to collapses, in order to mitigate the damage. In the 2011 Kii Peninsula heavy rainfall disaster, linear depressions and small mountain- and valley-facing scarps remained characteristic of the upper region of the landslide, which can be closely related to the mechanism of landslide occurrence (Chigira et al. 2013; Arai and Chigira 2019). According to Yokoyama (2019), the subsurface structure within these linear depressions is prone to storing water, suggesting that a rise in the groundwater level within the depressions may affect landslide occurrence. However, there are very few studies that have empirically clarified the subsurface structure in the depressions (Nishii and Ikeda, 2013). In this study, we conducted a geological survey and a surface-wave exploration inside and outside the linear depressions in order to clarify the subsurface structure in the linear depressions adjacent to the landslide, which is considered to have a significant influence on the mechanism of deep-seated landslide.

The study area was the uppermost stream of the Kogouchi River along Kangyou-mine in northern Shizuoka Prefecture. This area is locally known as "Goshiki-gare", where green, red, and weathered brown rocks are conspicuous, and there spreading over clear linear depressions at the head of the landslide.

As a result of ortho-imaging from aerial photographs taken by UAV, the size of the leaf-shaped landslide was 200 m in length and 150 m in width. The geological survey revealed that the area in and around Goshiki-gare is dominated by greenstone with basaltic hyaloclastite, and red mudstone is partially incorporated. Blocked greenstone was present at the top of the landslide. In the middle to upper part of the area, fractured and clayed greenstone and red mudstone were observed. At the end of the slope in the sub-catchment including the landslide, slate toppled outcrops with a north-south orientation of 60° and eastward trending were observed, suggesting gravitational deformation. We also found a 20-30 m wide greenstone fracture zone on the landslide 150 m west of Goshiki-gare. This is considered to be a fault outcrop of the Sasayama Tectonic Line.

As a result of the surface wave exploration of two lines crossing the depression and one longitudinal line, the S-wave velocity was less than 160 m/s from the ground surface to a depth of about 3 m, 200-300 m/s at a depth of about 3-6 m, and 400 m/s at a depth of about 7 m or more. Comparing the results with the geological cross-section, it is inferred that they correspond to soil layers, weathered bedrock, and basement rock, respectively. The depth at which the S-wave velocity is 160 m/s for the concave and convex portions of the transverse measurement line was compared. As a result, the depth of the convex part was 1.6 m while that of the concave part was 2.8 m, indicating that the concave part was deeper. This trend was the same for the two measurement lines in the transverse direction. The depths at which the S-wave velocities in the concave longitudinal survey line were 160 m/s and 300 m/s were 1.4-2.5 m and 3.3-6.4 m, respectively, indicating that the velocities varied even in the concave area.

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References: Chigira et al. (2013): *Geomorphology*, 201(1), 479-493. Arai and Chigira (2019): *Engineering Geology*, 260(3), 105236, Yokoyama (2019): *Geomorphology*, 352(1), 106977. Nishii and Ikeda (2013): *J. of Geography*, 122(4), 755-767.

Keywords: Gravitational slope defomation, Accretionary complex, Surface wave exploration

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Study on the landslide mechanism of the Iya area where the deep-seated landslide occurred by Typhoon Talas in 2011 using Drone Airborne TEM

*Atsuhiko Kinoshita[1,2], Suguru Shibata[2], Takao Yamakoshi[1], Hiroaki Nakaya[1], Yasumasa Fujiwara[3], Hideki Nakano[3], Akira Jomori[4], Katsushi Kawato[5], Muneki Mitamura[6], Tamotsu Matsui[7]

1. National Institute for Land and Infrastructure Management, 2. Sediment Disaster Prevention Technology Center, 3. Eight-Japan Engineering Consultants Inc., 4. NEOSCIENCE CO.LTD., 5. NIPPON ENGINEERING CONSULTANTS CO.,LTD., 6. Osaka City University, 7. Osaka University

In 2011 Typhoon Talas, the total precipitation on the Kii Peninsula exceeded 1,000 mm in a wide area. As a result, deep-seated landslides occurred at 72 slopes around the Peninsula. Immediately after the disaster, researches on the mechanisms of the deep-seated landslides have been conducted from various viewpoints. In this study, taking the Iya district in Tanabe City, Wakayama Prefecture as an example, the mechanism of deep-seated landslides has been investigated from the viewpoint of guiding and blocking of the flow of groundwater by the fault crush zones that cross the slope. In particular, the behavior of groundwater around the fault crush zones caused by the heavy rain is clarified by using Drone Airborne Transient Electromagnetics (Drone Airborne TEM) technology that has rapidly become to be used in recent years.

For the purpose of the survey was grasping the rough geological characteristics, the distribution of the height of the groundwater and the distribution of the springs, and the presence of fault crush zones. We investigated the resistivity distributions of about 0-200 m underground was investigated. The date of the survey was two days after the total rainfall of 98.5 mm, and it is probable that the effects of the rainfall remained. Next, the electrical prospecting (about 700 m length) about 0-200 m underground was carried out (November 25-27, 2020) for the purpose of investigating the location of the fault crush zones and the underground crush structure in detail. The location of the electrical prospecting was located on the upper right side of the landslide slope viewed from the bottom of the landslide slope in which the results of the field survey reveal that fault crush zones are concentrated. At the start of the measurement, it was no rainfall for 4 days. And so, the resistivity distribution during the dry period was obtained. Drone Airborne TEM was conducted two times around the time of the electrical prospecting and at the same location as the electrical prospecting. The surveys were conducted in the days when was 3 days after the end of rainfall of 217 mm in total rainfall of Typhoon CHAN-HOM (October 13, 2020) and the day when was in the dry period and without rainfall for 11 days (December 2, 2020). In the Drone Airborne TEM, the resistivity distributions about 0-200 m underground and about 700 m length. Then, by taking these differences, the behavior of groundwater around the fault crush zone at the time of Typhoon CHAN-HOM in 2020 was clarified.

It was found that there are four fault crush zones around the landslide slope in the Iya area. In addition, it was found that three of these fault crush zones are of the type that blocks the flow of the groundwater. Also, it was found that the other one is a type that induces the groundwater from the surroundings. It is probable that at the time of the disaster in 2011, groundwater was induced by these faults, and the groundwater was blocked, causing the deep-seated landslide.

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Keywords: Drone Airborne TEM, fault crush zone, groundwater

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Creating a Landslide risk map of the Nachi River basin

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1. PACIFIC CONSULTANTS CO., LTD., 2. Sediment Disaster Prevention Technology Center, 3. Kiisankei sabo office, 4. HOKKAIDO UNIVERSITY

Due to the 2011 Kii Peninsula flood, Landslides occurred frequently in the Nachi River basin in Wakayama Prefecture, and the debris flow that accompanied it caused 28 deaths, missing persons, and many casualties. Most of the slope failures were Shallow Landslides. In the Nachi River basin, private houses are concentrated along the Nachi River, and it has been reported that debris flows caused by Landslides have caused casualties in the past during heavy rains. Therefore, in this study, we attempted to create a Landslide risk map based on the relationship between the topographical and geological classification and the Landslide area ratio in 2011.

Keywords: Landslide risk map, Shallow Landslide, Degree of Mountain Denudation, Granodiorite, Mudstone, Geologic Boundary

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[J] Oral | H (Human Geosciences)：H-DS Disaster geosciences

Sat. Jun 5, 2021 3:30 PM - 5:00 PM JST | Sat. Jun 5, 2021 6:30 AM - 8:00 AM UTC | Ch.16 Zoom Room 16

[H-DS10] Geohazards in humid, tectonically active countries and their precursors

convener:Satoru Kojima(Department of Civil Engineering, Gifu University), Taro Uchida(University of Tsukuba), Yoshihiko Kariya(Department of Environmental Geography, Senshu University), Chairperson:Taro Uchida(University of Tsukuba), Satoru Kojima(Department of Civil Engineering, Gifu University)

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.

3:30 PM - 3:50 PM JST | 6:30 AM - 6:50 AM UTC

[HDS10-07] Back analysis for landslide occurrence based on the relationship between the rain and the slope condition.

★Invited Papers

*Reiko AKIYAMA[1], Kuniaki MIYAMOTO[2] (1.Oriental Consultants Co., Ltd., 2.Nippon Koei Co., Ltd.)

3:50 PM - 4:05 PM JST | 6:50 AM - 7:05 AM UTC

[HDS10-08] Spatial Variability of Rainfall-runoff Characteristics in a Large-scale Landslide-prone Area Underlain by Accretionary Sedimentary Rocks

*Yosuke Yamakawa[1], Kouji Koshimizu[2], Taro Uchida[1] (1.Faculty of Life and Environmental Sciences, University of Tsukuba, 2.Graduate School of Science and Technology, University of Tsukuba)

4:05 PM - 4:20 PM JST | 7:05 AM - 7:20 AM UTC

[HDS10-09] Observation of an effect of interstitial water saturation and water quality on changes in formation resistivity

*Yamato SUZUKI[1], Hiroaki NAKAYA[1], Atsushi FUNAYAMA[2], Toshihiko SAKASHIMA[2], Koushiro TANAKA[2], Akira JOMORI[3], Tetsuya TOYAMA[3] (1.National Institute for Land and Infrastructure Management, 2.Pacific Consultants Co., Ltd., 3.Neo-science Co. Ltd.)

4:20 PM - 4:35 PM JST | 7:20 AM - 7:35 AM UTC

[HDS10-10] Valley floor environmental changes and disasters associated with glacial collapse of mountain glaciers
-A case study of the 2003, 04 and 2021 floods in the Himalayas -

*Jiro Komori[1] (1.Teikyo Heisei University)

4:35 PM - 4:50 PM JST | 7:35 AM - 7:50 AM UTC

[HDS10-11] Characteristics of slope disasters triggered by sudden topographic deformation in the Himalayan region

*Hiroshi YAGI[1], Daisuke Higaki[2], Ching-Ying Tsuo[3], Akihiko Wakai[4], Yusuke Yamamoto[5] (1.Faculty of Art, Science and Education, Yamagata University, 2.Nippon Koei Co.,Ltd., 3.Faculty of Agriculture and Life Science, Hirosaki University, 4.Graduate School of Polytechnics, Gunma University, 5.Geoscience Research Laboratory Co.,Ltd.)

4:50 PM - 5:00 PM JST | 7:50 AM - 8:00 AM UTC

[HDS10-12] Discussion

Back analysis for landslide occurrence based on the relationship between the rain and the slope condition.

*Reiko AKIYAMA[1], Kuniaki MIYAMOTO[2]

1. Oriental Consultants Co., Ltd., 2. Nippon Koei Co., Ltd.

Studies on the prediction of the location and time of landslide occurrence have been actively conducted. The method of dynamic prediction by the slope stability model from the slope conditions, and the groundwater depth generated has made possible for landslide simulation based on the digital elevation model.In this study, the landslide occurrence based on the infinite slope stability model is normalized by the slope gradient and the unit volume weight of the soil layer. Then the water conditions and slope conditions at the time of the landslide occurrence are reversed for the landslide cases. Application results by the method are introduced in this report. The infinite slope stability model is generally expressed by the ratio of shear stress to resistance in the surface soil layer (Eq-1). This was organized by Fc and Fw as described in Imaizumi *et al.*[2003].In this time, the normalization parameter F_{CC} composed of the slope conditions (including the soil cohesion) was introduced into the soil cohesion force term, and when the safety factor Fs equals 1.0, it was normalized by the internal friction angle of the soil. It is shown as the relationship between the slope gradient, and the groundwater depth term due to the groundwater depth normalized by the soil layer thickness (Eq-2).In this paper, examples of estimating the soil layer thickness, and soil cohesion by applying the method to shallow landslides caused in Izu Oshima in the 2013, as well as to the landslides in the Amehata River basin in 1960-1970 are introduced. In this report, the result of trying to back analysis the assumed soil depth from the slope angle where the landslide is distributed is explained.

Keywords: Landslide, infinite slope stability model, back analysis, soil depth

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$$F_s = \frac{W}{G} = \frac{c + (\bar{\rho} g D - \rho g h)\cos I \tan\phi}{D \bar{\rho} g \sin I} < 1.0 \quad \cdots\cdots \text{Eq-1}$$

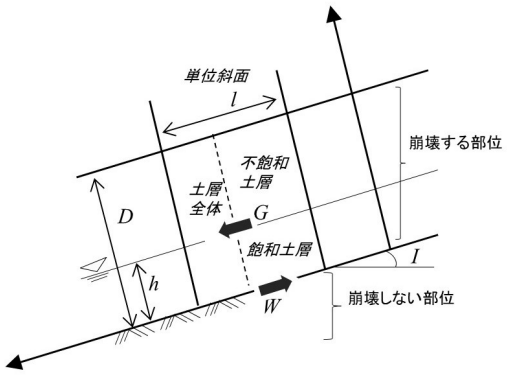
$$\bar{\rho} = \left\{ G_s(1-\lambda) + \lambda S_r + (1-S_r)\lambda \frac{h}{D} \right\} \rho$$

In case $F_s = 1.0$

$$F_{cc} = 1 - \frac{1 - F_w}{\frac{\tan I}{\tan\phi}} \quad \cdots\cdots \text{Eq-2}$$

$$F_w = \frac{\rho}{\bar{\rho}} \frac{h}{D}$$

$$F_c = F_{cc} \frac{\tan I}{\tan\phi} = \frac{1}{\bar{\rho}} \frac{c}{D g \sin I} \frac{\tan I}{\tan\phi}$$



c=Soil cohesion, ϕ = Internal friction angle, Gs=soil particle density
ρ=Water density, h= Water depth, g=Gravitational acceleration,
D=Soil depth, I=Slope angle, λ=Porosity, Sr= Degree of saturation

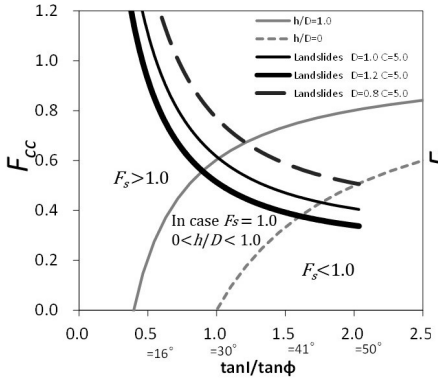


Fig.1 Okanesawa (c=5.0 kN/m²)

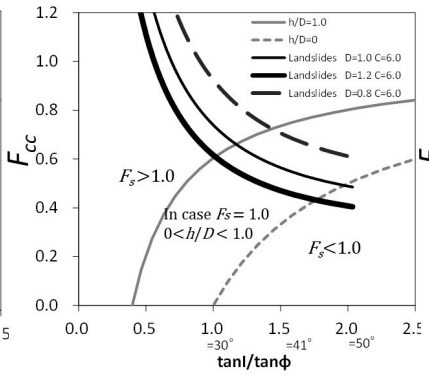


Fig.2 Okanesawa (c=6.0 kN/m²)

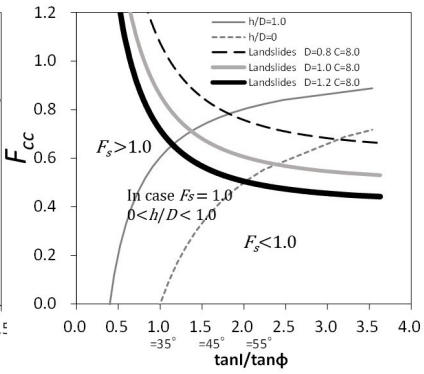


Fig.3 Inamatadani river(1982) (c=8.0 kN/m²)

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Spatial Variability of Rainfall-runoff Characteristics in a Large-scale Landslide-prone Area Underlain by Accretionary Sedimentary Rocks

*Yosuke Yamakawa[1], Kouji Koshimizu[2], Taro Uchida[1]

1. Faculty of Life and Environmental Sciences, University of Tsukuba, 2. Graduate School of Science and Technology, University of Tsukuba

Understanding spatial variability of rainfall-runoff characteristics is essential for clarifying the mechanism that landslides due to rainfall occur selectively within a watershed. We investigated the relationship between antecedent precipitation conditions and runoff discharges for some tributary watersheds of the upper Ooi River, Shizuoka prefecture, central Japan, in consideration of their geographical conditions and geological structures. The upper Ooi River, underlain by Late Cretaceous accretionary complex, is a large-scale landslide-prone area. In this study, we especially focused on the hydro-geological structures related to the difference between dip and anti-dip slopes. As the results of in-situ measurement, specific discharge as base flow from the anti-dip slope dominated watersheds trended to be relatively high compared to dip slope dominated watersheds. Additionally, there were higher correlations between specific discharge and long-term antecedent precipitation on the anti-dip slope dominated watersheds rather than on dip slope dominated watersheds. These implied relatively long residence time of rainwater and gradual recession of discharge on the anti-dip slope dominated watersheds.
This work was supported by JSPS KAKENHI Grant Numbers JP19H02989, JP 20H00434.

Keywords: Rainfall-runoff, Accretionary sedimentary rocks, Dip/anti-dip slope, Large-scale landslide

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Observation of an effect of interstitial water saturation and water quality on changes in formation resistivity

*Yamato SUZUKI[1], Hiroaki NAKAYA[1], Atsushi FUNAYAMA[2], Toshihiko SAKASHIMA[2], Koushiro TANAKA[2], Akira JOMORI[3], Tetsuya TOYAMA[3]

1. National Institute for Land and Infrastructure Management, 2. Pacific Consultants Co., Ltd., 3. Neo-science Co. Ltd.

In this observational study, effects of interstitial water saturation and water quality of pore water on formation resistivity were investigated, in order to estimate hydraulic geological structure from changes in formation resistivity. First, we compared formation resistivity under different conditions of antecedent precipitation rate. Relationships between the changes and ground permeability by geological reconnaissance were observed. Next, laboratory investigation of formation resistivity was carried out using samples taken at the study site. Effects of interstitial water saturation and water quality were measured for the adjusted test samples. The result showed a clear change in the formation resistivity around the depths with high permeability. After carefully considering possible influences such as measurement errors, the comparison of formation resistivity with different amounts of antecedent precipitation was regarded to show changes in the condition of pore water. Furthermore, another result of laboratory investigation indicated that interstitial water saturation and water quality have non-negligible impact on changes in formation resistivity. In particular, it was duly interpreted that a clear change can appear in response to the effects of precipitation recharge, since there was a large change between water quality of precipitation and mountain runoff water. The obtained relations among factors are useful for better estimation of hydraulic geological structure such as distribution of aquifers based on changes in formation resistivity.

Keywords: formation resistivity, pore water, antecedent precipitation rate, interstitial water saturation rate, water quality

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Valley floor environmental changes and disasters associated with glacial collapse of mountain glaciers -A case study of the 2003, 04 and 2021 floods in the Himalayas -

*Jiro Komori[1]

1. Teikyo Heisei University

On the morning of February 7, 2021, the Rishi Ganga River (a tributary of the Burahi Ganga River in the Alaknanda system, which is the northeastern basin of the Ganges River basin) in the Chamoli district of Uttarakhand, India, flooded along Raini village and its downstream. As a result, more than 190 people were killed or missing (as of February 10), and major physical damage was caused to the Rishi Ganga hydroelectric power plant (13.2 MW; elevation of water intake: 2050 m; 12 km from the glacier-collapsed valley floor) and Tapovan Vishnugad hydroelectric power plant (520 MW; elevation of water intake: 1800 m; elevation of the valley floor) were washed away.

This event was initially suggested to be a glacial lake outburst flood, but the cause was attributed to glacier collapse from a 0.2 square kilometer of hanging glacier (Twitter, @Scott Watson https://bit.ly/3rHlPWu) and underlying slope bedrock collapse (Twitter, @Simon Gascoin https://bit.ly/3s4R3qM ; Higaki et al,(2021) Disaster Response Committee Web site, Association of Japanese Geographers https://bit.ly/3av8kTR). At the bottom of the valley (N 30.401, E 79.738. EL. 3800 m) on the slope of collapsed glacier (distribution elevation: about 6000-5500 m), sediments covered with rock debris are distributed in long and thin strips, and the existence of an ice body is expected from the sinking and cracking. It is known that this snowdrift-like ice body existed continuously along the valley floor as late as 2003 and continued to disappear until October 2017, the latest satellite images from Google Earth were available (Komori, (2021) Disaster Response Committee Web site, Association of Japanese Geographers https://bit.ly/3 dmH23Q). In particular, two periods, from 2013 to June 2014 and from May 2015 to October 2017, the distribution is more than 1 km longer than that of the earlier ice bodies. This indicates that there have been repeated collapses from the vicinity of the hanging glacier in the past, although on a smaller scale than the present collapse.

In this presentation, we will show an overview of this disaster and discuss the collapse history of the hanging glacier. In addition, we will compare glacier collapses and floods that occurred in 2003 and 2004 in the southeastern Annapurna massif, Nepal, and how similar glacier collapses (e.g., Kolka Glacier in the northern foothills of the Caucasus Mountains in 2002 and Gayari Glacier in the southern foothills of the Karakoram Range in Pakistan in 2012) have changed the valley floor.

Rescue work is continuing in the area. We sincerely pray for the safety of as many people as possible and the souls of the victims.

Keywords: hanging glacier, snow patch, Turkistan type glaciers, global warming, 2021 Uttarakhand flood, 2003 and 2004 Madi river flood

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Characteristics of slope disasters triggered by sudden topographic deformation in the Himalayan region

*Hiroshi YAGI[1], Daisuke Higaki[2], Ching-Ying Tsuo[3], Akihiko Wakai[4], Yusuke Yamamoto[5]

1. Faculty of Art, Science and Education, Yamagata University, 2. Nippon Koei Co.,Ltd., 3. Faculty of Agriculture and Life Science, Hirosaki University, 4. Graduate School of Polytechnics, Gunma University, 5. Geoscience Research Laboratory Co.,Ltd.

Debris flow occurred in Chomoli district, the watershed of Alakananda river. It’ s source area is located on steep rock slope of high relief near Mt. Nanda Ghunti, it’ s altitude is ranging 5200-5600m a.s.l. It initiated as rock slide at first and then turned into rock avalanches and debris flow, considering from distribution of Rock Flour due to fracturing of the rock mass slid on steep slope over 35 degrees. Same phenomenon accompanying Rock Flour due to rock slide occurred in the Seti river watershed in 2012 and Langtang Himal area triggered by Nepal Earthquake 2015. Their source areas are located in high relief and high altitude areas in Nepal Himalayas and their mass-movement type are rock slide. Rock avalanches traveled very long distance over 50km.
There distributed many remnant of landslides and landslide dams in Manag area behind Annapurna Himal, Nepal, the upper reach of Marsyandhi river. And very thick debris deposit over 100m are distributed along the middle course of Marsyandhi river in the southern mount foot area of Annapurna Himal, forming higher terraces of the last glacial age. That implies debris flow deposits which were turned from rock slide and rock avalanches reached to the the Midland area traveled long distance across the Himalayan range in the last glacial age.

Keywords: Rock slide, rock avalanches, rock flour, debris flow

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[J] Oral | H (Human Geosciences) | H-DS Disaster geosciences

[H-DS10] Geohazards in humid, tectonically active countries and their precursors

convener:Satoru Kojima(Department of Civil Engineering, Gifu University), Taro Uchida(University of Tsukuba), Yoshihiko Kariya(Department of Environmental Geography, Senshu University), Chairperson:Taro Uchida(University of Tsukuba), Satoru Kojima(Department of Civil Engineering, Gifu University)

Sat. Jun 5, 2021 3:30 PM - 5:00 PM Ch.16 (Zoom Room 16)

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.

4:50 PM - 5:00 PM

[HDS10-12]Discussion

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

Sat. Jun 5, 2021 9:00 AM - 10:30 AM JST | Sat. Jun 5, 2021 12:00 AM - 1:30 AM UTC | Ch.17 Zoom Room 17

[H-CG23] Nuclear Energy and Geoscience

convener:Eiji Sasao(Tono Geoscience Center, Japan Atomic Energy Agency), Shinji Takeuchi(Department of Earth and Environmental Sciences, College of Humanities & Sciences, Nihon University), Takuma HASEGAWA(Central Research Institute of Electric Power Industry), Chairperson:Takuma HASEGAWA(Central Research Institute of Electric Power Industry)

Peaceful use of nuclear power is one of the most promising ways to solve energy problems and environmental problems. On the other hand, various problems are upcoming after nuclear disasters of Fukushima-Daiichi Nuclear Power Plant. The session provides 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 nuclear power plants, and volume reduction and reuse of cesium contaminated soils are welcomed. Through these presentations, we 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

[HCG23-01] Recent trends on long-term supply of uranium resources

*Eiji Sasao[1] (1.Tono Geoscience Center, Japan Atomic Energy Agency)

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

[HCG23-02] Geological Descriptive Model and AI Geo-Database of Coastal Area by Using Published data from National Public Research Institutes in Japan

*Atsunao Marui[1], Norikazu Imai[2], Teruhiko Suzuki[2], Akinari Honda[2] (1.Goelogical Survey of Japan, AIST, 2.GMLabo Co. LTD)

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

[HCG23-03] Attempt to identify the origin of deep-seated fluids in terms of hydrogeochemical characteristics

*Yuichi Tomioka[1], Hirofumi Kondo[1], Fumitake Kusuhara[1], Ayumi Sugiyama[1,2] (1.Central Research Institute of Electric Power Industry, 2.Asano Taiseikiso Engineering Co., Ltd.)

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

[HCG23-04] Characterization and Distribution of fractures in Granite, Ningyo-Toge, Okayama Pref., Japan

*Takesue Norito[1], Tsuyoshi Nohara[1] (1.Japan Atomic Energy Agency)

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

[HCG23-05] Study on the hydro-mechanical characterization of the calcareous concretion

*Shinji Takeuchi[1], Hidekazu Yoshida[2], Sachiko Nakamura[1] (1.Department of Earth and Environmental Sciences, College of Humanities & Sciences, Nihon University, 2.Nagoya University Museum)

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

[HCG23-06] Estimation of ^{137}Cs uptake from forest floor in Japanese cedar and Japanese konara oak stands of the Abukuma Mountains, Fukushima

*Tadafumi Niizato[1], Yoshito Sasaki[1], Satomi Ito[1], Takayoshi Watanabe[1], Hiroki Amamiya[2] (1.Japan Atomic Energy Agency, 2.QJ Science)

Recent trends on long-term supply of uranium resources

*Eiji Sasao[1]

1. Tono Geoscience Center, Japan Atomic Energy Agency

It is necessary to consider the long-term supply of uranium for the stable use of nuclear energy. Information on uranium resources is periodically reported by international and national organizations of various countries. For example, the OECD/NEA (Nuclear Energy Agency, The Organization for Economic Co-operation and Development) and IAEA (International Atomic Energy Agency) jointly prepare periodic report (currently every two years) called Uranium, which is updating on world uranium resources, production and demand. This report is commonly known as the “Red Book” and its latest update is the 2020 edition, published in December 2020 (OECD/NEA-IAEA, 2020). In this paper, supply and demand of uranium are reviewed mainly based on the Red Book, and future possibility on increase in uranium resources in Canada and Australia, the principal supplying countries, is discussed.

According to Red Book 2020 edition, total identified resources recoverable (reasonably assured and inferred) in the world as of 1 January 2019 amounted to about 8 million tonnes of uranium metal(tU) in the <USD 260/kgU (<USD 100/lb U_3O_8) cost category. Annual uranium requirements were 59,200tU as of 1 January 2019, that means identified resources are sufficient for about 135 years. Annual uranium requirements by the year 2040 are projected to increase to a total of between 56,640 tU and 100,225 tU, so that the number of years that uranium can be supplied by identified resources will vary (decrease) depending on the amount required.

Additionally, the COVID-19 pandemic affected uranium supply. In Canada, operation at the Cigar Lake mine were temporally suspended, and the McClean Lake mill was ceased accordingly. In Kazakhstan, Australia, Namibia, and other countries, the production volume decreased due to the furlough of workers.

One of the topics related to uranium mining is the termination of production at mine in which Japanese companies have participated. One of those, the Ranger mine in Australia ceased production on January 8, 2021. The Ranger Mine has remaining resources, and mining of the remaining resources was initially planned. However, the mine is located in an indigenous traditional land, and since the indigenous traditional land owners did not support the creation of a new Ranger Authority, which would provide the regulatory mechanism to enable mining after 2021, it was decided to close the mine. There is the Jabiluka deposit (approx.120,000tU) near the Ranger mine, but it cannot be mined either because the indigenous people have not given their permission. In Australia, there are five uranium projects awaiting better market conditions before proceeding with development: Honeymoon deposit in South Australia, Kintyre and Yeelirrie deposits, Wiluna and Mulga Rock deposits in Western Australia. Regarding the Mulga Rock deposit (approx. 29,000tU) was once discovered by the Power Reactor and Nuclear Fuel Development Corporation (PNC) but its concession was abandoned due to high mining costs, and was later obtained by an Australian company.

In Canada, a development plan of the Wheeler River project in the Athabasca region of Saskatchewan, the largest uranium deposit in the world, is underway. This project is expected to be the first application of in-situ recovery (ISR) mining method to an unconformity-related deposit at the Phoenix deposit (approx. 26,900tU). ISR method is generally used for sandstone-type uranium deposits. Since most deposits in the Athabasca Basin are considered hard rock mines, open-pit, and underground mining with explosives or

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mechanical exploitations are required to mine uranium ore. The Phoenix deposit is located just above the unconformity between impermeable hard basement rock and relatively permeable soft Athabasca sandstone that lacks impermeable layer unlike sandstone-type deposits. Therefore a “freeze wall” will be constructed around the orebody and drilled approximately 300 boreholes for chemical injection and monitoring. And rock fracturing will be conducted as used for shale oil to increase the contact area between the chemical solution and the deposit. Furthermore, Phoenix has a higher grade (19.1% U_3O_8) than sandstone deposits, and thus the uranium is directly precipitated from the chemical solution and the chemical solution is reused (a circulation system is constructed), which results in relatively low cost and low environmental impact.

Reference

OECD/NEA-IAEA, 2020, Uranium 2020: Resources, Production and Demand.

Keywords: uranium resource

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Geological Descriptive Model and AI Geo-Database of Coastal Area by Using Published data from National Public Research Institutes in Japan

*Atsunao Marui[1], Norikazu Imai[2], Teruhiko Suzuki[2], Akinari Honda[2]

1. Goelogical Survey of Japan, AIST, 2. GMLabo Co. LTD

A lot of public research institutions including Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology release the geological and groundwater data of the whole country. However, there is problems as the notation methods, and there is a correspondence of land and the sea area, and it is difficult to understand the data of the coastal area continuously. Then, it was planned to make the database of documents and papers in addition to the published data from former research institutions, to make geological descriptive model which seemed to be probable one, moving ahead step by step. In this research, we will see the method of modelling by using the data of public institutions, first of all. And then, the 3D model has been continuously increase of more probable by the document data etc. for the lack part and no matching section. The finally, we evaluate and show the groundwater flow system and its long-term stable area in the 3D geological model of the coastal area. It is thought that the result of the study contributes to the groundwater profit use in the coastal area, and digging up of lack data for development and unused water resource.

Keywords: Coastal area, Geo-environment, Groundwater, Modeling, SDM

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Attempt to identify the origin of deep-seated fluids in terms of hydrogeochemical characteristics

*Yuichi Tomioka[1], Hirofumi Kondo[1], Fumitake Kusuhara[1], Ayumi Sugiyama[1,2]

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For the safety assessment of the HLW geological disposal, it is necessary to evaluate the groundwater chemical and physical stability and inflowing of deep-seated fluids which is idiomatically classified as slab-derived fluid, fossil seawater, and oil-field brine. Among them, the slab-derived fluid, known as non-volcanogenic spring water, found in some areas in Japan which is recently elucidate their origin and behavior, they often have high temperature, high CO_2 gas, and high salinity sometimes over seawater. The features may have adverse impact for geological disposal systems. So, consolidation of the methodology for finding the fluid is required.
According to previous studies, typical features of slab-derived fluids show hydrothermal isotope shift of water, dissolved Li/Cl (w/w) tends to be exceeded 0.001, and isotope ratio of dissolved He gas is higher than the air. Fossil seawaters and oil-field brines have basically opposite features in slab-derived fluids, although some of them have high Li/Cl and hydrothermal shift of water isotopes. Identifying the origin of groundwaters is complicated problem. In this presentation, the authors show the results of sorting out the features of deep-seated fluids based on previous studies adding our field sampling results collected from over 40 of springs and boreholes to identify the origin of deep-seated fluids in terms of hydrogeochemical characteristics.

This study was funded by the Ministry of Economy, Trade and Industry, Japan as part of its R&D supporting program titled “Establishment of Advanced Technology for Evaluating the Long-term Geosphere Stability on Geological Disposal Project of Radioactive Waste (FY 2018-2020).

Keywords: deep-seated fluid, slab-derived fluid, fossil seawater, oil-field brine

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Characterization and Distribution of fractures in Granite, Ningyo-Toge, Okayama Pref., Japan

*Takesue Norito[1], Tsuyoshi Nohara[1]

1. Japan Atomic Energy Agency

Ground-water flow in granitic rock is controlled by characterization and distribution of fractures and fault, have been analyzed using the distribution of fracture zone and the mean value of hydraulic conductivity. Modelling ground-water flow tend to be uncertainty by heterogeneous structures such as well-developed fractures and fault. Understanding heterogeneity and decreasing uncertainty is key to identify the ground-water flow.

We detected 2 sections (juxtaposing high-permeability and low-permeability) through boring research in granite around Ningyo-Toge. Upper high-permeability section is accompanied by distribution of parallel fractures. Fractures in lower low-permeability sections are poorly developed. These suggest that simplified structures are widely distributed around Ningyo-Toge.

Keywords: granite, fractures, ground-water flow

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Study on the hydro-mechanical characterization of the calcareous concretion

*Shinji Takeuchi[1], Hidekazu Yoshida[2], Sachiko Nakamura[1]

1. Department of Earth and Environmental Sciences, College of Humanities & Sciences, Nihon University, 2. Nagoya University Museum

Porosity distribution, hydraulic conductivity, and hardness distribution of concretions were measured in the Neogene Hayama Group to clarify the hydraulic-mechanical properties of concretions. As a result, it has been confirmed that the concretion has been lower permeable and harder than the surrounding host rock.

Keywords: Concretion, Hydraulic property, Mechanical property, Sealing, Geological disposal

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Estimation of ^{137}Cs uptake from forest floor in Japanese cedar and Japanese konara oak stands of the Abukuma Mountains, Fukushima

*Tadafumi Niizato[1], Yoshito Sasaki[1], Satomi Ito[1], Takayoshi Watanabe[1], Hiroki Amamiya[2]

1. Japan Atomic Energy Agency, 2. QJ Science

An understanding of long-term environmental dynamics of radiocesium in forested area, 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, especially for ^{137}Cs (hereinafter, radiocesium) with long half-life of 30 years. In this paper we present the radiocesium uptake from forest floor in an evergreen Japanese cedar and a deciduous Japanese konara oak stands of the Abukuma Mountains, Fukushima.

An investigation was conducted in Oct. 2015 and Sept. 2017 at Japanese cedar stand and in Oct. 2018 and Oct. 2019 at Japanese konara oak stand near the living area. The average annual rainfall (1981–2010) is 1,221 mm and 1,465 mm in the konara oak and the cedar stands, and tree density is 791 trees ha^{-1} and 740 trees ha^{-1}, respectively. The breast height diameter has mode value of 10–14 cm and 25–30 cm in the konara oak and the cedar stands, respectively. Radioactive contamination in both stands is approximately 490–500 kBq m^{-2} via airborne monitoring results decay-corrected on April 1st, 2013. According to the procedure in International Biological Programme (IBP) for calculating of annual elemental uptake, annual radiocesium uptake from forest floor to the stand is defined as follows; annual radiocesium increment associated with tree growth plus annual loss through litterfall, stemflow, and throughfall [1].

The rate of annual radiocesium uptake associated with tree growth were estimated to be 0.1 and 0.06% of the total radiocesium inventory in Japanese konara oak and Japanese cedar stands, respectively. The sum of radiocesium uptake including the loss of radiocesium amount by litterfall, stemflow, and throughfall were 1.37 and 3.13% in the konara oak and the cedar stands, respectively.
The rate of radiocesium uptake estimated in this study are lower than the elemental uptake, such as nitrogen, phosphorus, potassium, in broad-leaved deciduous stand near Kyoto and Shimane Prefecture by IBP [2,3]. This indicate that the radiocesium uptake from forest floor to the konara oak and the cedar stands is restricted and no significant increase in radiocesium concentration of tree tissues is expected in the study stands.

[1] Cole et al. 1980, Inter.Biol.Prog. 23, 341-410.
[2] Katagiri & Tsutsumi, 1978, J.Jap.For.Soc., 60, 195-202.
[3] Katagiri, 1988, Jpn. J. Eloc., 38, 135-145.

Keywords: TEPCO’s Fukushima Dai-ichi Nuclear Power Plant accident, Japanese konara oak, Japanese cedar, radiocesium uptake

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

Sat. Jun 5, 2021 10:45 AM - 12:15 PM JST | Sat. Jun 5, 2021 1:45 AM - 3:15 AM UTC | Ch.17 Zoom Room 17

[H-CG23] Nuclear Energy and Geoscience

convener:Eiji Sasao(Tono Geoscience Center, Japan Atomic Energy Agency), Shinji Takeuchi(Department of Earth and Environmental Sciences, College of Humanities & Sciences, Nihon University), Takuma HASEGAWA(Central Research Institute of Electric Power Industry), Chairperson:Shinji Takeuchi(Department of Earth and Environmental Sciences, College of Humanities & Sciences, Nihon University)

Peaceful use of nuclear power is one of the most promising ways to solve energy problems and environmental problems. On the other hand, various problems are upcoming after nuclear disasters of Fukushima-Daiichi Nuclear Power Plant. The session provides 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 nuclear power plants, and volume reduction and reuse of cesium contaminated soils are welcomed. Through these presentations, we 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

[HCG23-07] Relationship between velocities in a single fracture and retardation effects by sorption investigated with laboratory tracer experiments

*Shunichi Okamoto[1], Kotaro Nakata[1], Takuma Hasegawa[1], Yasuharu Tanaka[1] (1.Central Research Institute of Electric Power Industry)

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

[HCG23-08] Evaluation on isotope and component separation by diffusion experiment

*Takuma HASEGAWA[1], Kotaro NAKATA[1], Rhys Gwynne[2] (1.Central Research Institute of Electric Power Industry, 2.University of Waterloo)

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

[HCG23-09] A study of U(VI) sorption on illite under carbonate-rich environments: Batch experiments, TRLFS and modeling

*Huiyang Mei[1], Noboru Aoyagi[1], Takumi Saito[2], Naofumi Kozai[1], Yukio Tachi[3] (1.Advanced Science Research Center, Nuclear Science Research Institute, Japan Atomic Energy Agency, Ibaraki, 2-4 Shirakata, Tokai-mura, Ibaraki 319-1195, Japan, 2.Nuclear Professional School, School of Engineering, The University of Tokyo, 2-22 Shirakata Shirane, Tokai-mura, Ibaraki 319-1188, Japan, 3.Nuclear Fuel Cycle Engineering Laboratories, Japan Atomic Energy Agency, 4-33 Muramatsu, Tokai-mura, Ibaraki 319-1194, Japan)

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

[HCG23-10] **Immobilization of Iodide and Iodate in Layered Double Hydroxide, Magnesium oxide and Silver embedded into Metakaolin-Based Alkali Activated Materials**

*CHAERUN Raudhatul Islam[1], Manami ISHIMURA[1], Kanako TODA[1], Tsubasa OTAKE[1], Ryosuke KIKUCHI[1], John PROVIS[2], Yogarajah ELAKNESWARAN[1], Tsutomu SATO[1] (1.Hokkaido University, 2.The University of Sheffield)

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

[HCG23-11] **Evolution of reaction and alteration of mudstone with cement leachate: Flow experiments and reactive-transport modelling**

*Keith Bateman[1], Yuki Amano[1], Yukio Tachi[1] (1.Radionuclide Migration Research Group, Japan Atomic Energy Agency, 4-33 Muramatsu, Tokai-Mura, IBARAKI, 319-1194 Japan)

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

[HCG23-12] Discussion

Relationship between velocities in a single fracture and retardation effects by sorption investigated with laboratory tracer experiments

*Shunichi Okamoto[1], Kotaro Nakata[1], Takuma Hasegawa[1], Yasuharu Tanaka[1]

1. Central Research Institute of Electric Power Industry

[Introduction]

On high-level waste disposal, it is important to evaluate retardation effects of solute transport in groundwater. Matrix diffusion, sorption on the fracture surface and bulk sorption in the matrix retard the transport of solute through fractured rock. In-situ tracer experiment that has been applied in many fractured rocks, is one of the methods for evaluating properties of the solute transport. Multi-rate tracer experiment is proposed to specify several parameters related to solute transport. However, previous study has clarified that sorption distribution coefficients (K_a and K_d) depend on pumping flow rate in the target fracture. Thus, the information about the relationships between a velocity in a fracture and K_a and K_d are important can be a key to improve the accuracy of estimating them. In this study, we conducted the laboratory tracer experiments and discuss relationship between velocities in a single fracture and the retardation effects by sorption. The two-dimensional numerical model composed of a fracture and a rock matrix was applied to simulate breakthrough curve (BTC) that was obtained by lab experiments.

[Methods]

Hirukawa granite rock was cut and shaped to be rectangular prism. Stainless spacers and an acrylic board were put on the granite rock and the 0.5mm of gap between the rock and the acrylic board was used as fracture in lab experiments. Sodium naphthionate (NAP) and Rb^+ were used as nonsorbing and sorbing tracer, respectively. The fracture aperture and the longitudinal dispersivity were calculated from BTCs of NAP and K_a and K_d were estimated from that of Rb^+. The parameters described above were obtained under 2 different flow rates (0.1 and 1.0 mL/min) and they were compared to understand the retardation effect of a velocity in the fracture. In these experiments, the setting fracture aperture is constant. Therefore, different flow-rate conditions are equivalent to different velocity conditions in the fracture.

[Results and discussions]

When the velocity in the fracture is 5.33×10^{-4} m/s, estimated K_a and K_d are 7.81×10^{-5} m and 4.50×10^{-3} m^3/kg, respectively. In the case of 5.95×10^{-5} m/s, the numerical fitting cannot reproduce the experimental BTC indicating that K_d and K_a are strongly dependent on the velocity in the fracture. Thus, revising curve-fitting method and/or construction of new model taking into account the effect of non-equilibrium sorption may be needed to deal with such cases.

This study was carried out under contracts awarded by the Japanese Ministry of Economy, Trade and Industry (METI).

Keywords: Fractured rock, Solute transport, Tracer experiment, Breakthrough curve, Sorption

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Evaluation on isotope and component separation by diffusion experiment

*Takuma HASEGAWA[1], Kotaro NAKATA[1], Rhys Gwynne[2]

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On safety assessment for radioactive waste disposal, it is important to show that groundwater flow is slow. Longer residence time makes lower radionuclide concentration because radionuclide decay with time. In a case the groundwater flow is very slow, diffusion will be the dominant transport mechanism (diffusion-dominant domain). It is a most promising condition for radioactive waste disposal. Indicating a diffusion-dominant domain, separation of component and fractionation of isotopes by diffusion will be useful index. Using rock core from Horonobe Underground Research Laboratory, diffusion experiments were conducted to confirm component separation and isotope fractionation.
The diffusion coefficients of water isotopes are three to four times higher than those of anions. The isotope fractionation factor of Cl and Br ranges 1.0017-1.0021 and 1.0007-1.0010, respectively. Moreover, effective porosity of diffusion was measured. The effective porosity for water isotope and anion is little bit different, but it will be small compared to the difference of diffusion coefficients. It is confirmed experimentally that component separation between water isotope and anion occur by diffusion. Therefore, it will be important index for the component separation of water isotope and anion, and isotope separation of Cl and Br to identify diffusion dominant domain.
This study entitled “FY2020 Research and development project on high-level radioactive waste disposal in geological formation (Development and Improvement on groundwater flow evaluation technique in rock)” supported by the Japanese Ministry of Economy, Trade and Industry. Some samples were provided from Japan Atomic Energy Agency.

Keywords: diffusion dominant domain, isotope fractionation, componetn separation

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A study of U(VI) sorption on illite under carbonate-rich environments: Batch experiments, TRLFS and modeling

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The safety assessment for radioactive waste repositories largely relies on understanding the mechanisms involved in radionuclide retention by minerals in host rocks. Argillaceous rocks have been considered as one of the potential host-rock formations for geological repository in several countries. Carbonate ion is contained at relatively high concentrations in sedimentary groundwater in Japan (> 2,000 mg/L as HCO_3^- in some cases) and exerts a significant influence on the fate of radionuclides by formation of aqueous complexes. However, it is not clear whether the ternary surface complexes containing carbonate will be formed, which may affect the distribution of surface species and the subsequent construction of the predictive model. Thus, we investigate U(VI) sorption on illite (one of the main constituents of argillaceous rock) as functions of pH and HCO_3^- concentrations, by combining batch experiments, cryogenic time-resolved laser fluorescence spectroscopy (cryo-TRLFS), and surface complexation modeling using the 2 Site Protolysis Non-Electrostatic Surface Complexation and Cation Exchange sorption (2SPNE SC/CE) model. The cryo-TRLFS uses near liquid helium temperature to enhance the quality of fluorescence spectra (e.g., spectral intensity, resolution), which helps identify the surficial uranyl complexes in complicated environmental systems. In the talk, we will present the macroscopic and microscopic results of the (surface) speciation of U(VI) with illite in the presence of HCO_3^- and discuss the modeling of the sorption data, reflecting the speciation data.

*This work was part of “The project for validating near-field assessment methodology in geological disposal (FY2020)” supported by the Ministry of Economy, Trade and Industry of Japan.

Keywords: U(VI), illite, carbonate, surface complexation model, TRLFS

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Immobilization of Iodide and Iodate in Layered Double Hydroxide, Magnesium oxide and Silver embedded into Metakaolin-Based Alkali Activated Materials

*CHAERUN Raudhatul Islam[1], Manami ISHIMURA[1], Kanako TODA[1], Tsubasa OTAKE[1], Ryosuke KIKUCHI[1], John PROVIS[2], Yogarajah ELAKNESWARAN[1], Tsutomu SATO[1]

1. Hokkaido University, 2. The University of Sheffield

In March 2011, an accident had occurred in Fukushima Daiichi Nuclear Power Station (FDNPS), which caused massive damage to the reactor and released I-131 and I-129 products. The radioactivity of I-131 and I-129 in the environment has a high impact on human health under a long exposure as observed from the Chernobyl incident. The concentration of these two isotopes varies in the environment. A large quantity of I-131 was initially released, which was hard to detect owing to its short half-life (8 days). On the other hand, I-129 was initially released with a low quantity. However, it has a longer half-life (1.57 x 10^7 years); thus, this isotope persists in the environment [1]. Hence, it is crucial to solidify and immobilize I-129 isotope to achieve safe disposal system.

Geopolymer is considered to be one of the best candidates as an encapsulation matrix for radionuclide immobilization (i.e., cesium (Cs^+) and strontium (Sr^{2+})) [2]. Similar to zeolite, geopolymer is an alkaline material, whose structure contains alumina-silicate tetrahedra in polymers. It is known for cation immobilization due to association with the negatively charged alumina tetrahedra.

Previous studies have been investigating the possible natural and synthetic adsorbent materials for removing iodine. In an aqueous environment, iodine mainly exists as iodide (I^-) and iodate (IO_3^-). They may have a possibility to be immobilized by a positively-charged adsorbent within the geopolymer matrix. Layered double hydroxide (LDH), magnesium oxide (MgO), and silver (Ag) are commonly used for anion immobilization, which are proven to exert high iodine retention due to their ability to offer positively charged structures [3,4,5]. However, I^- and IO_3^- could be repelled by the geopolymer structure. There are few studies of these adsorbents' stability with iodine under alkaline environments and no openly published study of I^- and IO_3^- immobilization within the geopolymer matrix. Therefore, in this study, the adsorbed iodine in the LDH, MgO, and Ag embedded within geopolymer matrix was investigated by evaluating the leaching behaviour of iodide and iodate and their adsorbents' stability.

After 19 days of leaching experiments, the iodine leaching levels of the materials were observed as follows: geopolymer matrix had leached out 89% I^- and 96% IO_3^-, LDH had 100% leached I^- and IO_3^-, MgO had leached 98% IO_3^-, and Ag had leached out 58% I^- and 2.4% IO_3^-. The stability of I^- and IO_3^- in the adsorbents embedded within geopolymer matrix was clarified by nano-micro analysis (i.e., SEM, TEM), and their mineral phases were characterized by XRD and calculated by thermodynamic calculations. Firstly, LDH after encapsulation (0 day) and after 19 days of leaching did not change into any phase. However, LDH preferred $H_{4-n}SiO_4^n$ adsorption over I^- and IO_3^- due to the high silica activity in the geopolymer matrix. Secondly, MgO changed its phase into magnesium silicate hydroxide (M-S-H) in the geopolymer matrix after 19 days of leaching. However, M-S-H did not have the capability for iodine retention. Finally, Ag^+ was precipitated with I^- to form iodyrite or iodargyrite, which were stable after 19 days of leaching. Therefore, Ag is an excellent adsorbent for immobilization of I^- and IO_3^- in the geopolymer matrix.

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Keywords: Geopolymer, Fukushima Daiichi Nuclear Power Station, Layered double hydroxide, Magnesium oxide , Silver, Iodine retention

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Evolution of reaction and alteration of mudstone with cement leachate: Flow experiments and reactive-transport modelling

*Keith Bateman[1], Yuki Amano[1], Yukio Tachi[1]

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The construction of a repository for geological disposal of radioactive waste will include the use of cement-based materials. Following closure, groundwater will saturate the repository and the use of cement will result in the development of a highly alkaline porewater, pH >12.5 in the case of Ordinary Portland cement (OPC). The fluid will migrate into and react with the host rock. The chemistry of the migrating fluid will evolve over time, initially being high in Na and K, evolving to a Ca rich fluid and finally returning to the groundwater composition. This evolving fluid chemistry will affect the long-term performance of the repository altering the physical and chemical properties, including radionuclide behaviour. Understanding these changes forms the basis for modelling the long-term evolution of the repository. This study focused on the alteration due to OPC-type leachates on mudstone from the Horonobe URL, Hokkaido, Japan.

It was anticipated that the mudstone would react with the high pH fluids and that silicate minerals present would provide buffering together with the formation of secondary mineral phases which would evolve with time; this study was aimed at determining the specific nature and extent of these reactions. The flow experiments described here reacted in succession, fluids representing a 'young' OPC leachate, with high pH and high levels of Na and K. This was followed by an 'evolved' leachate (portlandite saturated) and finally Horonobe ground water (HGW). In addition, the experimental data were used as test cases for reactive transport geochemical modelling, to both assess and validate the predictive capability of the model.

The experiments were conducted using a small flow cell constructed from acrylic plastic, 10 mm long and 20 mm in diameter. The experiments used a dry density of 1 g/cm^3, with a typical volumetric flow rate ≈ 0.5 ml per hour. The evolution of the fluid chemistry was tracked by chemical analysis and mineralogy by characterisation of the reacted solids. A combination of PHREEQC and the 1-D reactive transport 'CABARET' geochemical codes were used to simulate the experiments.

Initially with the 'young' fluid, there was a reduction in [Na] and [K] due to ion exchange reactions with the clay mineral in the mudstone but these quickly returned to close to the initial concentrations. Si levels increased whilst Ca decreased. With the change to the 'evolved' leachate, [Ca] increased but remained below that of the 'evolved' fluid. Both [Na] and [K] decreased as did [Si]. The pH with both OPC leachates showed only a small decrease (≈ 0.2) from the initial values. With the change to the HGW, the pH returned to close to that of the HGW, as did both Na and K. Ca levels remained slightly lower than the HGW but Si levels increased.

The changes in Ca and Si with the OPC leachates were due to the formation of secondary C-S-H phases. This was confirmed by the mineralogical analysis, examination of the saturation indices (SI) for the reacted fluids and the output of the reactive transport modelling This showed continued dissolution of the primary minerals in the clay together with the saturation and hence precipitation of a variety of C-S-H phases. With the HGW, the secondary C-S-H phases re-dissolved releasing Si into solution and Ca levels were

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controlled by the formation of calcite by reaction with bicarbonate in the HGW.

In summary, the reaction of the mudstone with the successive OPC leachates demonstrated its chemical buffering capacity, leading to a reduction in pH, the dissolution of primary minerals with Ca and Si concentrations being controlled by C-S-H phase precipitation. However, when the fluid returns to the natural background groundwater composition the C-S-H phases re-dissolve, which would potentially release any sorbed radionuclides. The experimental data has been used to help validate a 1-D reactive transport geochemical model generating increased confidence in its predictive capabilities.

Keywords: Radioactive waste, Mudstone, Geochemistry, Modelling, Flow experiments

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

[H-CG23] Nuclear Energy and Geoscience

convener:Eiji Sasao(Tono Geoscience Center, Japan Atomic Energy Agency), Shinji Takeuchi(Department of Earth and Environmental Sciences, College of Humanities &Sciences, Nihon University), Takuma HASEGAWA(Central Research Institute of Electric Power Industry), Chairperson:Shinji Takeuchi(Department of Earth and Environmental Sciences, College of Humanities &Sciences, Nihon University)

Sat. Jun 5, 2021 10:45 AM - 12:15 PM Ch.17 (Zoom Room 17)

Peaceful use of nuclear power is one of the most promising ways to solve energy problems and environmental problems. On the other hand, various problems are upcoming after nuclear disasters of Fukushima-Daiichi Nuclear Power Plant. The session provides 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 nuclear power plants, and volume reduction and reuse of cesium contaminated soils are welcomed. Through these presentations, we promote intercultural communication and collaboration between science, engineering and social science.

12:00 PM - 12:15 PM

[HCG23-12]Discussion

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

Sat. Jun 5, 2021 3:30 PM - 5:00 PM JST | Sat. Jun 5, 2021 6:30 AM - 8:00 AM UTC | Ch.17 Zoom Room 17

[H-CG27] Nuclear Power and Geoscience in Japan: 10 years after the 3.11 complex disaster

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

Nuclear Power and Geoscience in Japan: 10 years after the 3.11 complex disaster
We have organized sessions in the JpGU meeting on the risk of nuclear power utilization in Japan mainly from the point of view of geoscience since 2013. It has shed new light on various aspects of the risk of nuclear power related to earthquakes, volcanic activities and tsunamis. The 2021 JpGU meeting will be held 10 years after the 3.11 complex disaster: the Great East Japan Earthquake with the Fukushima-Daiichi nuclear accident. On this occasion, we propose a reflexive session to review what we have discussed and understood through the past sessions or public debates: What should geoscience take the stance on the issue of scientific uncertainty and nuclear risk? How could scientists and engineers work together for public goods? We are also welcome to papers of other topics relevant to relationship of geoscience and nuclear utilization.

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

[HCG27-01] How was the long-term forecast of tsunami earthquake distorted?

★Invited Papers

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

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

[HCG27-02] Changes in the Treatment of Scientific Issues in Nuclear Power Plant Trials

★Invited Papers

*Kazuki Koketsu[1] (1.Earthquake Research Institute, University of Tokyo)

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

[HCG27-03] Human Capacity Building at The University of Tokyo towards Knowledge Base Development for Nuclear Risk Management

*Tatsuya Itoi[1], Naoto Sekimura[1], Tsuyoshi Takada[1,2], Takumi Saito[1], Kenji Satake[1] (1.The University of Tokyo, 2.Japan Atomic Energy Agency)

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

[HCG27-04] Scientific characteristics of high-level nuclear waste disposal site -Geological perspective at Suttsu and Kamoenai areas, Hokkaido -

★Invited Papers

*Satoshi Okamura[1] (1.Hokkaido Education University)

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

[HCG27-05] Selection of high-level radioactive waste disposal site in Japan

★Invited Papers

*Masahiro Chigira[1] (1.Fukada Geological Institute)

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

[HCG27-06] Discussion

*Daisuke Suetsugu[1] (1.institute for Marine Geodynamics, Japan Agency for Marine-Earth Science and Technology)

How was the long-term forecast of tsunami earthquake distorted?

*Kunihiko Shimazaki[1]

1. University of Tokyo

Tokyo Electric Power Co. (TEPCO) did not respond to the warning of huge tsunami publicized in 2002 by the governmental committee named Earthquake Research Committee (ERC). The 11th March 2011 tsunami and severe shakings attacked Fukushima Daiichi of TEPCO and caused level-7 severe nuclear accidents. This reports how TEPCO and related forces distorted the science. Relying on some authority they insist on one-sided argument on professional items. Several actual examples are shown. One is related to ‘Tsunami Assessment Method for Nuclear Power Plants in Japan’ by Tsunami Evaluation Subcommittee of the Japan Society of Civil Engineers, and another comes from poor Japanese seismological education on seismic hazard analysis.

Keywords: nuclear power plant, long-term forecast, March 11th tsunami

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Changes in the Treatment of Scientific Issues in Nuclear Power Plant Trials

*Kazuki Koketsu[1]

1. Earthquake Research Institute, University of Tokyo

Since strong ground motions causing damage to nuclear power plants are rare phenomena, it is difficult to state with certainty whether or not they occur in several ten years, which is the operating period of nuclear power plants, and such scientific issues involve large incertitude. However, in order to make a serious conclusion to stop the operation of a nuclear power plant, it is necessary to carry out the reasoning which is deterministic to some extent, and in the judgments until now, there were many unreasonable things on the scientific issues. However, in the judgment of Osaka District Court on "request for an order to suspend operation of the Oi nuclear power plant" in December, 2020, unreasonable reasoning was not carried out for the scientific issues in Point 2 (Rationality of the formula of Irikura and Miyake and the formula of Dan et al.) and Point 3 (Rationality of using the seismic moment calculated based on the Irikura-Miyake formula as the seismic moment of a source model). Instead, the main issue was the failure of the defendant (the electric power company) to comply with "variation clause" ("When the earthquake scale is set using an empirical formula which relates the length or area of the source model or the fault displacement in a seismic cycle with the earthquake scale, it is necessary to also consider the variation of an empirical formula, because an empirical formula (. . .) gives the earthquake scale as an average value.") in the Seismic Ground Motion Review Guide. In other words, the incertitude in scientific issues was avoided by replacing it with a procedural problem.

Until then, it had been considered that the variation in the calculation of earthquake scale had been already taken into consideration by conservatively setting an earthquake source model (i.e., the model is set on the safe side), however, in the judgment, it is considered that the latter half of "variation clause" had to be taken into consideration explicitly and independently, because it was specially added in March 2012. Furthermore, one of the reasons why it is reasonable to use the Irikura-Miyake formula for the source fault as the result of active fault investigation from the ground surface is that the source model is set conservatively, so it is not appropriate to use it as a double reason.

Keywords: Nuclear Power Plant Trials, Scientific Issues, Changes in the Treatment

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Human Capacity Building at The University of Tokyo towards Knowledge Base Development for Nuclear Risk Management

*Tatsuya Itoi[1], Naoto Sekimura[1], Tsuyoshi Takada[1,2], Takumi Saito[1], Kenji Satake[1]

1. The University of Tokyo, 2. Japan Atomic Energy Agency

For robust and effective nuclear regulation under uncertainties like the performance of safety-critical facilities like nuclear power plants exposed to natural hazards, the following items are required,
- a multi-diciplinary framework that bridges the gaps and integrates engineering, natural sciences and the social sciences,
- corporation with societies based on in-depth understanding of societies and diverse perspectives,
- human capacity building facilitating multi-diciplinary network,
- harmonization between compliance-based activities and proactive risk management including innovation.

The characteristics of decision makings under uncertainties like the performance of safety-critical facilities like nuclear power plants exposed to natural hazards that are considered important are integrating the following two aspects in a consistent manner:
- full utilization of wide range of scientific and engineering knowledge,
- impossibility to reach single decision (trans-scientific aspects).

It is considered important that higher education contributes to this field, especially for delivering experts who can discuss and make decisions on performance of safety-critical facilities considering regional characteristics and regional risk reduction including:
- holistic perspective,
- standardization,
- gap identification and change management

Based on this understanding, the University of Tokyo, collaboting with Japan Atomic Energy Agancy and supported from Japan Nuclear Regulation Authority (NRA), launched a human capacity building program towards development of knowledge base for nuclear risk management.

A proposed project comsists of:
A) Lecture for graduate students on "Disaster Risk Management of Engineering System" that provides a framework integrating engineering, natural science and the social sciences,
B) Special lectures from distinguised experts from international organizations etc.,
C) Site visit and discussion with nuclear experts,
D)
D-1) Excecises on risk-informed decitions, including treatment of updated knowledge under and management of conflicts,
D-2) Project based learning of nuclear safety research related to risk management,
E) Internships in international organization and/or research organizations,
F) Stakeholder workshops.

Keywords: Risk management, Nuclear safety, Natural hazard

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Scientific characteristics of high-level nuclear waste disposal site -Geological perspective at Suttsu and Kamoenai areas, Hokkaido -

*Satoshi Okamura[1]

1. Hokkaido Education University

The “Scientific Characteristic Map” was published in 2017 to indicate selection site for high-level nuclear waste final repository in Japan. In 2020, based on the proposals from two municipalities, Suttsu and Kamoenai in Hokkaido, a literature search, which is the first stage of the selection of the disposal site survey, was started. The two municipalities have suitable sites for the final repository after the “Scientific Characteristic Map”. The geological characteristics of both areas, however, indicate definitely non suitability for the final depository. The two areas are characterized by Middle to Late Miocene volcanic rocks, such as pillow lava, hyaloclastite, feeder dyke, and reworked volcaniclastic rocks. The mode of occurrence has very heterogeneous and concealed cracks and fractures. The Suttsu area is situated at northern part of the active fault, the Kuromatsunai Lowland active faults. It may be impossible to judge the suitability as a disposal site in Japan from the recent scientific point of view.

Keywords: Scientific Characteristic Map, High-level nuclear waste, final repository, hyaloclastite

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Selection of high-level radioactive waste disposal site in Japan

*Masahiro Chigira[1]

1. Fukada Geological Institute

I pointed out problems with the selection of high-level radioactive waste disposal site in Japan with a paper entitled “What is indispensable studies to achieve the disposal of high-level radioactive waste in Japan?” at this session of JpGU in 2018.. I said that we cannot avoid uncertainties in groundwater scenarios even though direct scenarios by fault movement, volcanic activity, uplift and erosion, and so on are cleared, so we need to find host rocks with fewer fractures as water pathways. We also need to select host rocks on which present nondestructive prospecting methods are applicable to find fractures or to develop new methods that could be used to difficult rocks. This view should have been reflected in the “Scientific Characteristic Map” published in July 2017, but this map is for the direct scenario and does not face the groundwater scenario head-on. Then, in 2020, based on the proposals from two municipalities in Hokkaido, a literature search, which is the first stage of the selection of the disposal site survey, was started. This started without any geological considerations for the groundwater scenario mentioned above, as far as I know. Although I have not directly observed the local geology, I would like to point out problems related to groundwater scenarios that would be encountered in the future from the geological literature of the area and my research experience of similar geology.

Geological sheets with a scale of 1:50000 of the two municipalities show that these areas are underlain by Miocene volcanics, such as lava and hyaloclastite intruded by volcanic dikes. The former two are generally very heterogeneous and their properties widely vary from place to place. They also have openings so that may be highly permeable. Volcanic dikes are generally permeable because of cooling joints, and their presence is not easy to detect with current nondestructive technology. These features provide conditions that make it very difficult to evaluate groundwater scenarios.

According to Japan's policy, the selection of high-level radioactive waste geological disposal sites will be carried out step by step. If the suitability as a disposal site is clearly lacking, it would be excluded from the suitable site during the investigation stage, but if it is unclear, the investigation would proceed to the next stage. If the survey is conducted on areas with complex geology and strong inhomogeneity, it is easy to assume that the suitability cannot be judged from the survey results at one stage and then proceed to the next stage. However, the local problems with the groundwater scenario mentioned above do not seem to be so easy to solve. In other words, it is necessary to keep in mind that no matter how far the investigation is conducted, it may not be possible to judge the suitability as a disposal site in a socially acceptable manner.

Keywords: High-level radioactive waste, Geological disposal, Site selection, Groundwater scenario, Volcanics, Uncertainty

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Discussion

*Daisuke Suetsugu[1]

1. institute for Marine Geodynamics, Japan Agency for Marine-Earth Science and Technology

We would like to have a general discussion on broad issues as follows: What should geoscience take the stance on the issue of scientific uncertainty and nuclear risk? How could scientists and engineers work together for public goods?

Keywords: Nuclear power plants, Geoscience

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

Sat. Jun 5, 2021 9:00 AM - 10:30 AM JST | Sat. Jun 5, 2021 12:00 AM - 1:30 AM UTC | Ch.18 Zoom Room 18

[S-SS09] Seismic wave propagation: Theory and Application

convener:Kaoru Sawazaki(National Research Institute for Earth Science and Disaster Resilience), Kiwamu Nishida(Earthquake Research Institute, University of Tokyo), Takao Nibe(JAPEX), Kyosuke Okamoto(National Institute of Advanced Industrial Science and Technology), Chairperson:Kaoru Sawazaki(National Research Institute for Earth Science and Disaster Resilience), Kurama Okubo(National Research Institute for Earth Science and Disaster Resilience)

Seismic wave propagation provides rich information on earth's heterogeneities and the excitation sources. Understanding of this information requires various research fields: mathematical/numerical studies based on wave theory, physical experiments using rock samples, seismic data analysis, etc. With recent developments of observational techniques, various wave phenomena have been elucidated: seismic waves, acoustic waves, traveling ionospheric disturbances, and tsunamis. New frameworks will be crucial for comprehensive understanding of these phenomena. This session widely invites presentations about the theories and applications related to seismic and other geophysical waves.

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

[SSS09-01] Estimation of the elastic wave velocity in rock fractures revealed by the digital rock physics and energy approach

*Kazuki Sawayama[1], Osamu NISHIZAWA[2], Tatsunori Ikeda[3], Fei Jiang[4], Takeshi Tsuji[3], Yasuhiro Fujimitsu[3] (1.Department of Earth Resources Engineering, Graduate school of engineering, Kyushu University, 2.International Institute of Carbon Neutral Energy Research, Kyushu University, 3.Department of Earth Resources Engineering, Faculty of engineering, Kyushu University, 4.Department of Mechanical Engineering, Faculty of Engineering, Yamaguchi University)

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

[SSS09-02] SH-wave propagation through the random distribution of aligned line cracks

*Haruo Sato[1] (1.Tohoku Unvieristy)

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

[SSS09-03] Continuous monitoring of seismic velocity change at Parkfield towards identifying the strain accumulation

*Kurama Okubo[1,2], Brent Delbridge[2], Marine Denolle[3,2] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Harvard University, 3.University of Washington)

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

[SSS09-04] Changes in attenuation and its anisotropy associated with seismic ground motion

*Shuhei Tsuji[1], Koshun Yamaoka[2], Ryoya Ikuta[3] (1.Graduate School of Environmental Studies, Nagoya University, 2.Earthquake and Volcano Research Center Graduate School of Environmental Studies, Nagoya University, 3.Department of Geosciences, Shizuoka University)

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

[SSS09-05] Seismic velocity response to ground water level revealed by ACROSS and seismic array

*hiromu oba[1], Ryoya Ikuta[1], Shuhei Tsuji[2], Chen Feng[2], Koshun Yamaoka[2], Toshiki Watanabe[2] (1.Shizuoka University, 2.Nagoya University)

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

[SSS09-06] On the relationship between the streamflow due to snowmelt flood and ambient seismic noise observed by Hi-net stations

*Kaoru Sawazaki[1], Shakti P.C.[1] (1.National Research Institute for Earth Science and Disaster Resilience)

Estimation of the elastic wave velocity in rock fractures revealed by the digital rock physics and energy approach

*Kazuki Sawayama[1], Osamu NISHIZAWA[2], Tatsunori Ikeda[3], Fei Jiang[4], Takeshi Tsuji[3], Yasuhiro Fujimitsu[3]

1. Department of Earth Resources Engineering, Graduate school of engineering, Kyushu University, 2. International Institute of Carbon Neutral Energy Research, Kyushu University, 3. Department of Earth Resources Engineering, Faculty of engineering, Kyushu University, 4. Department of Mechanical Engineering, Faculty of Engineering, Yamaguchi University

Recent advances in seismic velocity monitoring have enabled us to detect velocity changes not only in events with large stress changes (i.e., earthquakes), but also in geothermal reservoirs with smaller stress changes. Such velocity changes are generally interpreted by changes in porosity or crack density; however, velocity changes will also be triggered by the aperture in a fractured rock mass (e.g., seismogenic faults and geothermal reservoirs). Since the aperture will affect fluid flow behaviors in fractured rocks, velocity changes in fractures must have a correlation with hydraulic properties (e.g., fracture permeability). Although the relationship between the aperture and fracture permeability is well known, their relationships with elastic wave velocity are still unknown. It would be beneficial if changes in the aperture and fracture permeability are correlated with the seismic velocity that can be remotely monitored. In this study, we develop a method to estimate the elastic wave velocity in fractured rocks, and establish a model relating it to permeability changes. Since aperture changes are difficult to be measured in experiments, we employed an approach using digital data of real rock samples (i.e., digital rock physics).

We first analyzed the surface roughness characteristics of a single natural fracture (35 mm x 70 mm) retrieved from a geothermal area to create digital rock models. Based on the roughness characteristics, three synthetic fractures (24 mm, 48 mm, and 96 mm square) are generated by using fractional Brownian motion. We prepared digital rocks that have 10 mm thickness with 0.1 mm resolution, varying their mean aperture ranging between 0.05–0.2 mm. We then calculated the elastic moduli of the models by finite element analysis. In this analysis, the elastic energy was calculated under the isostrain condition, and the elastic moduli were calculated by the second-order derivative of the energy with respect to the strain. We also conducted fluid flow simulation using the lattice Boltzmann method on the same digital fracture model to investigate the relationship between permeability and velocity.

The numerical simulation of a single fracture shows that the P-wave velocity decreased up to 0.2 km/s and the S-wave velocity decreased up to 0.15 km/s as the aperture increases under our conditions. We also found that these velocity changes are less sensitive to the fracture size, and modeled the permeability-velocity relationship regardless of the fracture size. On the other hand, in the multi-fracture models, the velocity change depends on the fracture density, and it is necessary to estimate the fracture density in order to link it to the field observation data. In addition to elastic wave velocity direction perpendicular to the fracture plane, we also confirm the similar relationship between permeability and S-wave splitting.

Keywords: digital rock physics, elastic wave velocity, permeability, S-wave splitting, Lattice Boltzmann Method

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SH-wave propagation through the random distribution of aligned line cracks

*Haruo Sato[1]

1. Tohoku Unvieristy

Recent seismological observations have revealed that random heterogeneities spread over the solid Earth for a wide range of scales. There are two possible candidates for the source of seismic wave scattering: one is a random fluctuation of velocity; the other is a random distribution of cracks or faults. This paper studies the propagation of SH waves through the random distribution of aligned line cracks as the simplest mathematical model.
The differential scattering cross-section of a single line crack is well described by using Mathieu functions. Note that the differential scattering cross-section is anisotropic and depends on both incident and scattering angles. The random distribution of cracks assures the mutual incoherence of scattered waves, which allows us to use the radiative transfer theory. The directional scattering power per unit area is given by the scattering coefficient, which is a product of the number density of cracks and the differential scattering cross-section. Stochastically interpreting the scattering coefficient, we synthesize the space-time distribution of the wave intensity for a unit isotropic radiation from a point source by the Monte Carlo simulation. This paper precisely studies the case that the wavenumber is larger than the reciprocal of the crack length. Syntheses show that direct wavelets around the direction normal to the aligned line cracks rapidly decrease with increasing distance because of strong scattering, but those around the direction parallel to the aligned line cracks decrease according to the geometrical decay only. At large lapse times, multiple scattering produces a swelling around the source location, which is prolonged to the crack line direction. Those characteristics well reflect the anisotropy of the line crack scattering.
Our next target is to solve more realistic cases, for example, the propagation of elastic-waves through the random distribution of penny shaped cracks in a 3-D elastic medium.

Keywords: seismic waves, cracks, scattering, wave theory, radiative transfer theory

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Continuous monitoring of seismic velocity change at Parkfield towards identifying the strain accumulation

*Kurama Okubo[1,2], Brent Delbridge[2], Marine Denolle[3,2]

1. National Research Institute for Earth Science and Disaster Resilience, 2. Harvard University, 3. University of Washington

Fault zones are subject to the long-term loading of tectonic strains, to the short-term release of fault fast and slow earthquakes, and to hydrological and thermoelastic modulation from environmental forces. Each of these stresses are thought to impact the fault-zone material properties, such as elastic wave speed. In this work, we perform the continuous monitoring using nearly two decades (2002-2020) of ambient seismic noise recorded by 3-components seismometers from the Berkeley Seismological Laboratory's High Resolution Seismic Network (HRSN) to extract bulk properties, dv/v, near the rupture area of the 2004 Parkfield Earthquake on the San Andreas Fault.

Transient signals such as earthquakes and tremor are removed using a kurtosis and STA/LTA based algorithm, prior to computing the cross-correlation functions (CCFs). We compute the CCFs for all possible channel pairs and decompose them into narrow frequency bands using wavelet transform. During the stacking processes, we reject CCFs with low signal-to-noise ratio caused by the perturbation of noise sources and instrumental issues. The daily CCFs are stacked every 30 days with 15 days overlap. We explore the effects of various algorithms and waveform reference on our measurements.

This study aims to separate the potential tectonic and non-tectonic origins of the observed temporal variations in dv/v and to evaluate the effect of strain accumulation on its time history using geodetic measurements. The dv/v time history reveals the previously identified coseismic decrease in dv/v and the subsequent logarithmic recovery, as well as a newly observed long-term increase in dv/v. We show that the observed long-term increase exceeds the velocity healing model which is thought to explain the logarithmic postseimic behavior. We further show that this long-term increase cannot be explained by changes in ground water levels and does not follow the trend of decrease and recovery associated with the drought in California from 2011 to 2017. Instead, we discuss that the observed long-term increase in dv/v reflects strain change from quasi-static deformation at depth during the interseismic period.

Keywords: ambient seismic noise, velocity change, Parkfield

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Changes in attenuation and its anisotropy associated with seismic ground motion

*Shuhei Tsuji[1], Koshun Yamaoka[2], Ryoya Ikuta[3]

1. Graduate School of Environmental Studies, Nagoya University, 2. Earthquake and Volcano Research Center Graduate School of Environmental Studies, Nagoya University, 3. Department of Geosciences, Shizuoka University

We found anisotropic change in attenuation associated with seismic ground motions in dataset obtained in the experiment using an artificial seismic source, ACROSS. A larger reduction in amplitude was observed in the direction with a larger delay in travel time. The dataset we analyzed was obtained by Ikuta et al. (2002) at Awaji ACROSS test site from 2000 to 2001. At this site, the ACROSS was installed on the surface and the signal was observed at two seismometers installed at the bottom of 800m and 1700m deep borehole near the source.

We calculated changes in amplitude using the ratio of power of the transfer functions to that of the reference transfer function as reported by Tsuji et al. (2020 JpGU). In this calculation, we removed power of noise that of the transfer functions to reduce effect of temporal change in noise level from the estimated change in amplitude.

To analyze the anisotropic changes in amplitude, we reinvestigated the anisotropic change in S wave observed at the 2000 Western Tottori Earthquake (WT) and the 2001 Geiyo Earthquake (GY). We calculated the azimuthal variation of the coseismic delay of the S wave by rotating the sensor orientation with high resolution and found that the azimuthal pattern of coseismic delay cannot be approximated by an ellipse as Ikuta and Yamaoka (2004) did.

We modeled the azimuthal pattern with parameters that describe the anisotropy. By fitting the azimuthal pattern by the model on to the observation, we estimated directions of the principal axes. For WT, the directions of the major axis were N90˚E for both the 800 m and 1700 m borehole sensors. For GY, the directions were N85˚E and N95˚E for the 800 m and 1700 m borehole sensors, respectively. These directions coincide well with the results of Ikuta and Yamaoka (2004), in which the direction was N100˚E for WT and GY at the 800 m sensors.

We estimated the amplitude change in the direction of the principal axes. Changes in the amplitude and result of the model fitting in the principal axes are shown in the Figure. Dots and lines indicate amplitude changes and its fitting. The major and minor axes correspond to the axes of larger and smaller velocity change, respectively. For WT, a greater decrease in amplitude is obtained in the major axis of velocity anisotropy for both depths. For GY, no significant difference was observed for either depth. This result shows that the direction of greater attenuation corresponds to that of larger delay. That is consistent with laboratory experiments with cracked and saturated media.

Keywords: coseismic change, changes in anisotropy, changes in attenuation, artificial seismic source, ACROSS

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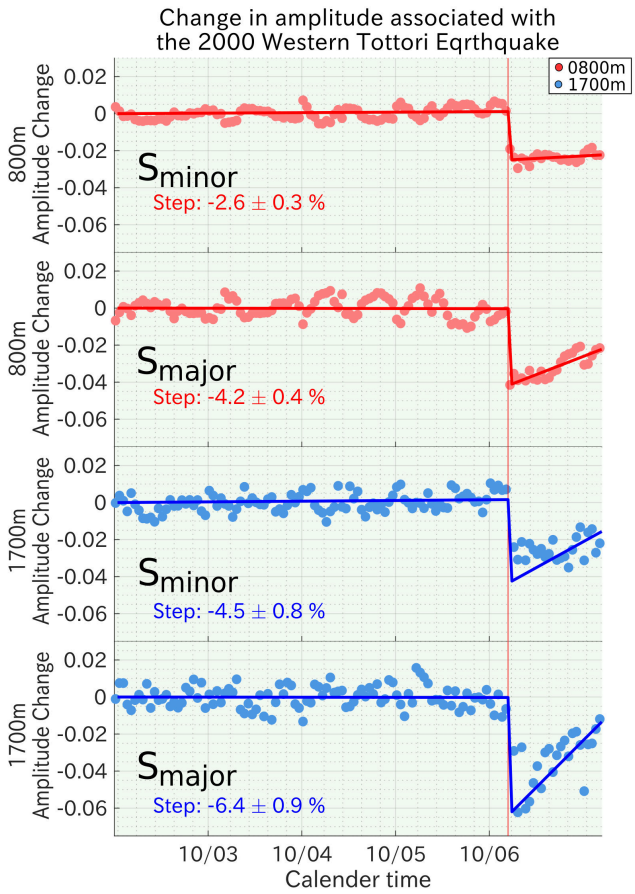

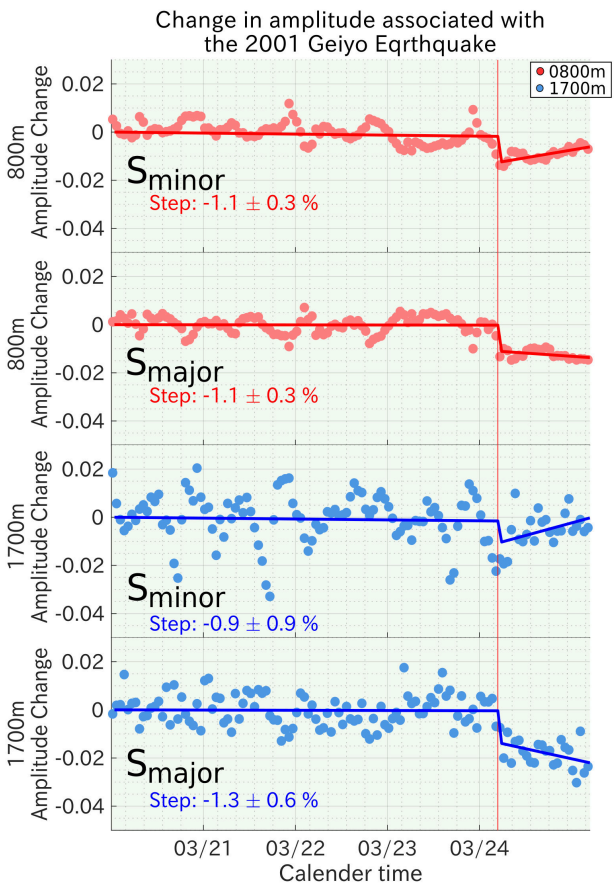

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Seismic velocity response to ground water level revealed by ACROSS and seismic array

*hiromu oba[1], Ryoya Ikuta[1], Shuhei Tsuji[2], Chen Feng[2], Koshun Yamaoka[2], Toshiki Watanabe[2]

1. Shizuoka University, 2. Nagoya University

Temporal variation in propagation property of seismic wave was monitored at the landslide area using Accurately Controlled Routinely Operated Signal System (ACROSS) and a seismic array. The ACROSS, which is a precisely-controlled seismic source, is deployed in Mori-machi, Shizuoka Prefecture, Japan, and used in this study.

Before this experiment, a preliminary observation was conducted for three weeks in each of 2017 and 2018. We set up two seismometers at a site which is 3 km away from the ACROSS source to investigate the response of seismic velocity to rainfalls by analyzing the transfer function obtained from the ACROSS signal. The temporal variation of the arrival time of the later phases showed a significant response to rainfalls. The rainfall is converted into the groundwater level to investigate the relation to the propagation property of seismic waves. We assumed a tank model in the conversion by the exponential decay function with a time constant of 20 days.

We found that there is a strong correlation between the arrival time variation of these waves and the groundwater level, and also found the sensitivity function of the two wave groups is different.

A small seismic array is deployed to identify the origin of the phases and to monitor the temporal variation. 14 seismometers were deployed following the typical array configuration of SPAC methods, which consists of a center and three triangles on concentric circles with radii of 4, 8, and 16 meters. Two additional seismometers on each of the south and north sides of the array to increase the wavenumber resolution in the source direction. The total size of the array is 70 m in NS and 30m in EW. This array arrangement is intended to estimate the shallow shear-velosity profiles by inversing the surface wave dispersion curve by SPAC method using ambient noises and analysis the ACROSS signal. The seismometers are Mark Products L-28-3D (sensitivity 120 V/m/s) of three-component velocity-type ones with a natural frequency of 4.5 Hz. The sampling frequency is 1 kHz, and the inter-channel skew of sampling is maintained within 15 μs.

The results of the array analysis of ACROSS signal showed that the phases arriving around 2.8 and 3.8 seconds, whose response to the rainfall was significant, had the same apparent velocity as the body waves (~2.5 km/s). This observation contradicts the result of the analysis of the 2017 and 2018 observations, in which the later phases are identified as Love and Raiyleigh waves based on their particle motions. The wave at 2.8 seconds had a dominant transverse component, which was regarded as a Love wave, and the wave at 3.8 seconds had retrograde motion in the vertical plane, which was regarded as Rayleigh wave.

The variation of the arrival time of the phase around 2.8 and 3.8 seconds were estimated by applying the cross-spectrum method to the transfer function during the observation period, and a strong correlation with rainfall was found in 2017 and 2018 experiments. For all observations from 2017 to 2020, there was a positive linear relationship between the change in the arrival time of the phase around 2.8 seconds and the groundwater level that is converted from the rainfalls. The sensitivity of the change in velocity [%] to the increase in groundwater level [m] was 1.04 [%/m]. In contrast, there was a third-order relationship

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between the change in the arrival time of the phase arriving around 3.8 seconds and the groundwater level. The sensitivity of the velocity change became stronger when the groundwater level increased above a certain level.

The amount of precipitation during the observation period of 2020 was much less than the previous two years, and the relation cannot be extended outside the range of the previous two years' observation. We will continue the observation during the high precipitation season and pursue the mechanism of these variations.

Keywords: ACROSS, array, surface wave, groundwater level

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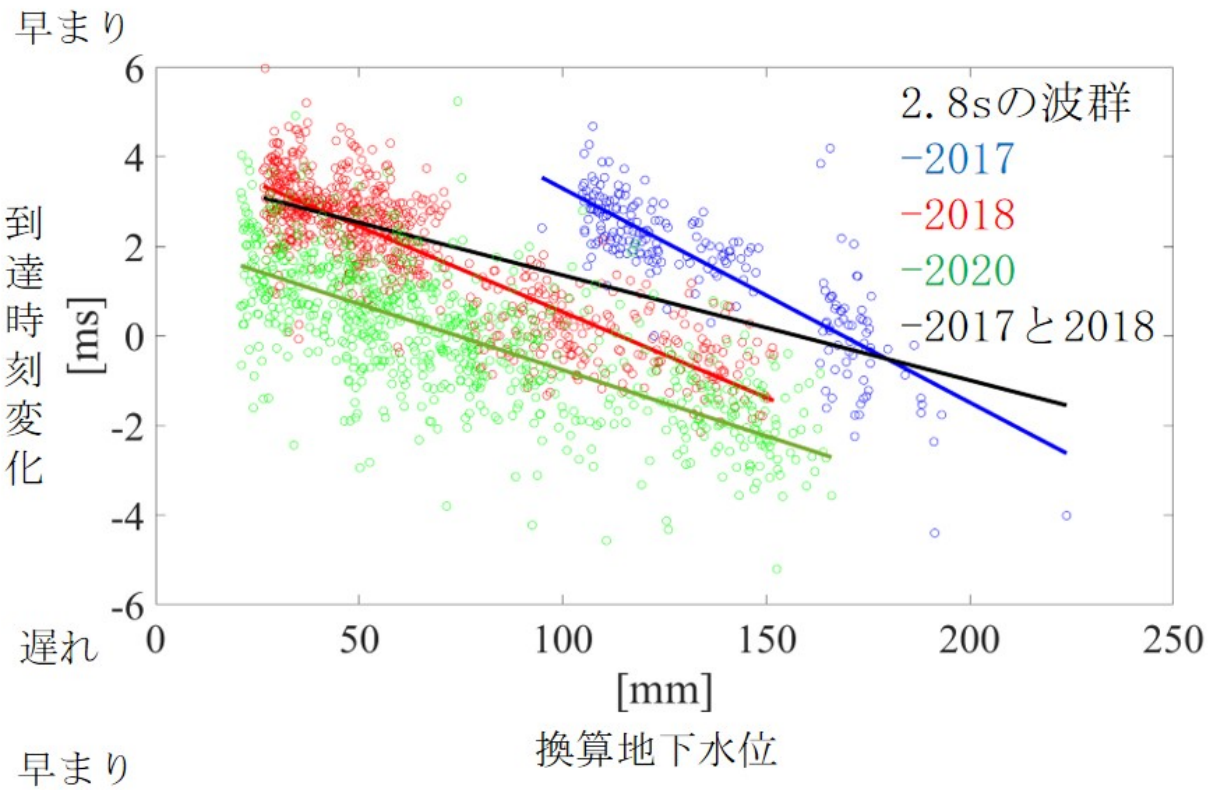

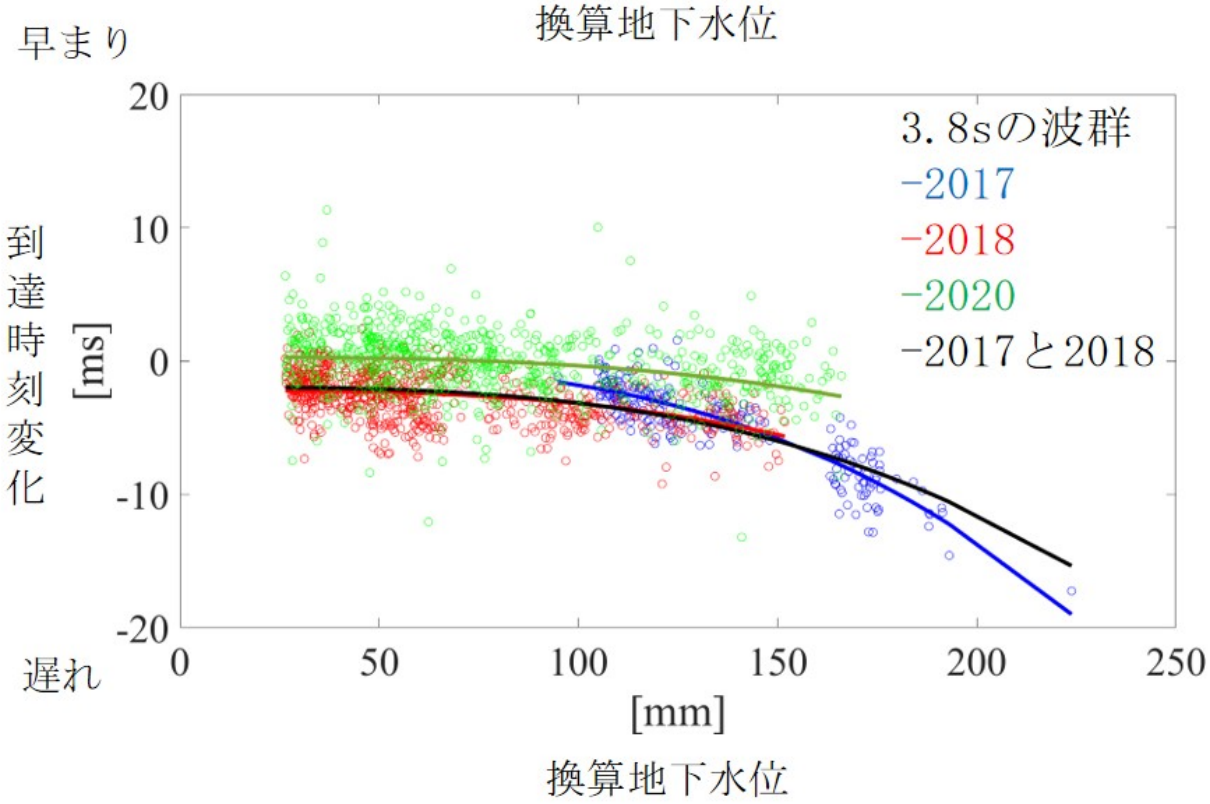

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On the relationship between the streamflow due to snowmelt flood and ambient seismic noise observed by Hi-net stations

*Kaoru Sawazaki[1], Shakti P.C.[1]

1. National Research Institute for Earth Science and Disaster Resilience

Seki River basin is located in Niigata and Nagano prefecture of Japan. Snowfall is common over the basin during the winter season. Such accumulated snow starts melting from the beginning of the spring season each year that increase the rate of streamflow in the Seki River. The variation of streamflow is synchronized by the ambient noise level of nearby Hi-net seismograph stations. In this study, we surveyed the relationship between the ambient noise power of Hi-net stations located in the basin and discharge of the Seki River, in the period from March to May in 2012.

The N.MKOH and N.MKGH Hi-net stations are located in the middle basin (elevation: 240 m asl) and upstream (elevation: 1305 m asl) of the Seki River, respectively. Ambient noise of N.MKOH station shows a clear one-day periodicity associated with social activity, whereas N.MKGH station contains much less social noise as it is located deep in the mountains. The Futagojima streamflow observation point is located about 10 km downstream from N.MKOH station (elevation: 65 m). We computed power spectra of UD component of each Hi-net station every one minute, and calculated power time series for six octave-bandwidths from 0.5 to 32 Hz. To remove transient signals like earthquakes, we selected the minimum one-minute power among every continuous 10 minutes records as the representative value of the 10-minutes ambient noise power. Then we averaged the obtained representative values every one hour. The discharge record of the Futagojima station is also measured every one hour.

Since noise power of N.MKOH exhibits one-day periodic social noise, we used only the records observed from 8PM to 12PM, within which social noise is relatively calm, for the comparison to the discharge record. As a result, clear correlations with the discharge record are observed especially at 2 - 16 Hz. More precisely, the noise power does not depend on the discharge when the discharge is less than a threshold value. It increases proportional to about the first power of the discharge above the threshold value, and proportional to 1 to 2 power as the discharge increased further. Through the target period, the ratio of the noise power with respect to the discharge did not change drastically.

On the other hand, N.MKGH does not show clear correlations with the discharge in March, but the correlations become distinctive after April. The ratio of noise power with respect to the streamflow increases as time lapses after April. According to the nearby temperature and snow depth records of AMeDAS, snowmelt may not have proceeded until April. This indicates that streamflow at upstream is very small in March and it gradually increased from April to May. Consequently, noise at N.MKGH station is excited only after April and this may be why correlations with the dicharge of Futagojima station become distinctive only after April.

Keywords: Snowmelt flood, Seismic ambient noise, Streamflow

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

Sat. Jun 5, 2021 10:45 AM - 12:15 PM JST | Sat. Jun 5, 2021 1:45 AM - 3:15 AM UTC | Ch.18 Zoom Room 18

[S-SS09] Seismic wave propagation: Theory and Application

convener:Kaoru Sawazaki(National Research Institute for Earth Science and Disaster Resilience), Kiwamu Nishida(Earthquake Research Institute, University of Tokyo), Takao Nibe(JAPEX), Kyosuke Okamoto(National Institute of Advanced Industrial Science and Technology), Chairperson:Kyosuke Okamoto(National Institute of Advanced Industrial Science and Technology), Shunsuke Takemura(Earthquake Research Institute, the University of Tokyo)

Seismic wave propagation provides rich information on earth's heterogeneities and the excitation sources. Understanding of this information requires various research fields: mathematical/numerical studies based on wave theory, physical experiments using rock samples, seismic data analysis, etc. With recent developments of observational techniques, various wave phenomena have been elucidated: seismic waves, acoustic waves, traveling ionospheric disturbances, and tsunamis. New frameworks will be crucial for comprehensive understanding of these phenomena. This session widely invites presentations about the theories and applications related to seismic and other geophysical waves.

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

[SSS09-07] Effects of subsurface heterogeneities and surface topography on long-period surface wave monitoring

*Shunsuke Takemura[1], Ryo Okuwaki[2], Takanori Matsuzawa[3] (1.Earthquake Research Institute, the University of Tokyo, 2.Moutain Science Center, Faculty of Life and Environmental Sciences, University of Tsukuba, 3.National Research Institute for Earth Science and Disaster Resilience)

11:00 AM - 11:30 AM JST | 2:00 AM - 2:30 AM UTC

[SSS09-08] Fracture detection and properties estimation using fiber optic sensors

★Invited Papers

*Keisuke Teranishi[1], Naoshi Aoki[1], Moeto Fujisawa[1], Hidehiko Shimizu[1], Shinya Onodera[2] (1.JGI, 2.JOGMEC)

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

[SSS09-09] Connection between the correlation of strain and rotation seismograms and Green's function: Surface-wave case

*Hisashi Nakahara[1] (1.Solid Earth Physics Laboratory, Department of Geophysics, Graduate School of Science, Tohoku University)

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

[SSS09-10] Ambient Noise Differential Adjoint Tomography Applied to a Linear Array in Los Angeles Basin

*Xin Liu[1,2], Gregory C Beroza[1] (1.Stanford Earth, 2.JAMSTEC)

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

[SSS09-11] Estimating finite fault slip distributions of large earthquakes based on time-reversal wave propagation simulation with data assimilation

*Yugo Shibata[1], Takashi Furumura[1], Takuto Maeda[2] (1.Earthquake Research Institute, the University of Tokyo, 2.Hirosaki University)

Effects of subsurface heterogeneities and surface topography on long-period surface wave monitoring

*Shunsuke Takemura[1], Ryo Okuwaki[2], Takanori Matsuzawa[3]

1. Earthquake Research Institute, the University of Tokyo, 2. Moutain Science Center, Faculty of Life and Environmental Sciences, University of Tsukuba, 3. National Research Institute for Earth Science and Disaster Resilience

Dense broadband seismic networks allow us to detect various phenomena, which radiate seismic waves. Especially because the effects of microseisms are weak in periods of 20-50s, this period band has been widely used in monitoring regular earthquakes, shallow very low frequency earthquakes, volcanic eruption, landslides, stormquakes…etc. (e.g., Tsuruoka et al., 2009; Matsuzawa et al., 2012; Fan et al., 2019; Takemura et al., 2019; Okuwaki et al., 2021). In this study, to achieve precise modeling of physical sources of these phenomena, we investigated the effects of subsurface heterogeneities and irregular surface topography on generation and propagation of long-period (20-50 s) surface waves using the numerical simulations via OpenSWPC (Maeda et al. 2017).
We simulated ground motions of a crustal earthquake that occurred at Awaji Island on 13 April 2013. The source parameters of this earthquake were referred from Takemura et al. (2020). We also simulated ground motions caused by a landslide that occurred at Shizuoka Prefecture. By using the estimated model parameters of Okuwaki et al. (2021), this source could be modeled by body forces on the surface. We used three heterogeneous models: (1) the Japan Integrated Velocity Structure Model (JIVSM; Koketsu et al. 2012) with ETOPO1 (Amante and Eakins, 2009), (2) the JIVSM with a flat surface, and (3) the F-net 1D crustal model (Kubo et al., 2002).

To evaluate quantities differences in simulation results, we calculated variance reductions (VRs) of simulated waveforms between the JIVSM with ETOPO1 and simplified models. In VR calculations, we did not permit any time shift, which adjusts travel time differences between synthetic and target waveforms. In the case of a crustal earthquake, high (> 90%) VRs in the F-net 1D model only appeared at distances shorter than 100 km due to non-time shift VR evaluation. In the JIVSM with a flat surface, VRs at almost all stations were greater than 90 %. This result indicates that the surface topography has limited effects on long-period surface waves from regular earthquakes. Similar characteristics were also found in the simulation results of the landslide source, but we found the directivity of VR decrease, especially in the transverse component. The VR decrease was localized around the Chugoku region. This directivity may be related to the topography around the landslide source. To achieve precise modeling of phenomena on the earth’s surface, Green’s functions, including effects of irregular topography, should be applied.

Acknowledgments: We used NIED Hi-net and F-net data https://doi.org/10.17598/NIED.0003 https://doi.org/10.17598/NIED.0005. Numerical simulations were conducted on the Fujitsu PRIMERGY CX600M1/CX1640M1 (Oakforest-PAC) in the Information Technology Center, University of Tokyo. This study was also supported by the ERI JURP 2020-S-04

Keywords: long-period surface wave, earthquake, landslides, ground motion simulation, topography, subsurface heterogeneity

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Fracture detection and properties estimation using fiber optic sensors

*Keisuke Teranishi[1], Naoshi Aoki[1], Moeto Fujisawa[1], Hidehiko Shimizu[1], Shinya Onodera[2]

1. JGI, 2. JOGMEC

The knowledge of fracture locations and connections which are pathways for fluid and solute transport are crucial information for developing the geothermal field. This information contributes that plan to drill the sidetrack within the suspended well and detection the drilling target for a make-up production well. The development of Distributed Acoustic Sensing (DAS) technologies enables the operation under high temperature environment and dense spatial measurement. This could be particularly valuable for acquiring high spatial resolution images of seismic reflection survey and dipping faults in the vicinity of the well.

In the feasibility study, we acquired the overnight monitoring data and conducted SSP (surface seismic profiling) survey and DAS-VSP survey which was used the suspended well in the real geothermal field. We developed the fracture detection systems in the vicinity of the well described following and investigated their applicability for the real data set.
・acquire the seismic cross section with SSP and DAS
・FWI velocity model building which correspond with check shot
・extract the diffracted wave from overnight monitoring DAS data and evaluate the indicators that detect the fractures in the vicinity of the well.

The records of SSP and DAS provide seismic reflection section and represent the faults and fractures as the characteristics of each method. Fractures are represented as a gap in SSP section and as a fault plane in DAS-VSP section. It was confirmed the fracture locations in both reflection sections were consistent. Moreover, the result of joint FWI using SSP and VSP dataset showed a better agreement with the velocity along the well estimated by the zero-offset DAS-VSP analysis. This confirmed that accurate velocity information can be estimated from the DAS-VSP dataset.

The numerical studies were performed to simulate the DAS-VSP acquisition. In the synthetic experience, the presence of later phases including diffracted waves after direct P-wave and S-wave show the potential as seismic signatures that indicates the existence of fractures near wellbore.
These results stimulated us the development of diffraction enhancement workflow. We combine Plane Wave Destruction (Fomel, 2002) and Common Reflection Surface (Dell and Gajewski, 2011) to separate the diffractions from direct arrivals in the overnight monitoring data. Comparison with the wellbore information and the distribution of the extracted diffracted waves, it was confirmed that significant PS conversion waves after the direct P-wave which generated by the vicinity of the fracture zone were observed and significant amplification was also observed in the later phases which were identified as direct S-wave.

With the development of DAS sensing technology, its dense sampling could be possible to extract diffracted waves and to estimate accurate velocity model using FWI. In this presentation, the background and developed fracture detection systems will be explained and discussed these results and further works.

Acknowledgements:

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We conducted this research as a part of Geothermal Borehole Exploration Techniques by JOGMEC. Nittetsu Mining Co., Ltd. and Kirishima Geothermal Co., Ltd. were kindly allowed us the use of their suspended well and fields. We want to thank these organizations.

Keywords: fiber optic sensors, DAS-VSP, diffraction, fracture detection

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Connection between the correlation of strain and rotation seismograms and Green’ s function: Surface-wave case

*Hisashi Nakahara[1]

1. Solid Earth Physics Laboratory, Department of Geophysics, Graduate School of Science, Tohoku University

Dynamic strain (or strain rate) is recently measured by Distributed Acoustic Sensing (DAS) techniques along a fiber-optic cable with high spatial resolutions of 10m or less. Rotational ground motion is measured by rotational seismometers that are sometimes used in combination with translational seismometers (called the six-component (6C) observation) (e.g., Schmelzbach et al., 2018). Therefore, we need to accustom ourselves to using strain and rotation seismograms by adapting the methods used for traditional translational seismograms to these new kinds of seismograms. Nakahara et al. (2020, SSJ) formulated the SPAC method for DAS axial-strain seismograms. Nakahara et al. (2021) further extended the formulation to the other components of strain, rotation and tilt records. According to seismic interferometry, it is possible to connect SPAC to Green's function (e.g., Nakahara, 2006; Sanchez-Sesma and Campillo, 2006). In this study, we clarify the connection between cross-correlation functions of strain and rotation seismograms and Green's functions for the moment tensor under an assumption that surface waves only exist. Since the formulation is conducted in the frequency domain, the connection between the cross-spectral matrix of strain and rotation at two receivers and the Green's tensor is concerned. A general framework of seismic interferometry for strain and rotation was already provided by Paitz et al. (2019). However, the physical meanings of cross-correlation functions of strain and rotation are not yet fully understood.

We start from the strict expressions of surface-wave Green’ s tensors from moment-tensor sources in the Cartesian coordinate derived by Haney and Nakahara (2016). First, we convert the expression to the cylindrical coordinate and calculate the displacement gradients of Green's tensor. Then, we derive analytical expressions for strain and rotation Green's functions from moment-tensor sources. Finally, we compare these expressions with the SPAC expressions for strain and rotation derived by Nakahara et al. (2021). We obtain the following results for the isotropic incidence of random waves with a specific ratio between Rayleigh and Love wave energies. The (i, j)-component cross-spectral matrix of strain is found to be proportional to the strain Green's tensor at one receiver for the sum of (i,j)- and (j, i)-component moment tensor source at the other receiver. Regarding the rotational component, the (i, j)-component cross-spectral matrix is found to be proportional to the rotation of Green's tensor at one receiver for the difference of (i,j)- and (j, i)-component moment tensor source at the other receiver.

So far, we proved these relations for surface waves by the concrete calculation using the analytical expressions. Now we speculate that these relations hold for body waves as well. An extension of the proof to body waves will be the next target.

Keywords: cross correlation, Green's function, seismic interferometry, strain, rotation

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Ambient Noise Differential Adjoint Tomography Applied to a Linear Array in Los Angeles Basin

*Xin Liu[1,2], Gregory C Beroza[1]

1. Stanford Earth, 2. JAMSTEC

The small time shifts that are used in ambient-field interferometric Green’ s function analysis may arise from either structural anomalies of interest, or spatio-temporal behavior of the noise source, which is usually not of interest. In seismic noise interferometry, the differential time kernel has been shown to be much less sensitive to variations in the spatio-temporal distributions of the noise source and more sensitive to the structural anomalies of interest, thus using differential measurements is an effective approach for reducing bias in tomographic images (Liu 2020). In this study, we generalize this technique by deriving the shear-wave velocity directly from differential time kernels for fundamental mode Love waves in noise cross-correlations along a linear array spanning ~37 km in the Los Angeles basin without the 1D depth conversion step that assumes a layered medium. The initial results show strong sensitivity to near-surface shear velocity structure in the uppermost 500 m. We then apply iterative inversion for shear velocity, and will present an updated near-surface shear velocity structure that should help to constrain future urban earthquake ground motion.

Keywords: ambient noise adjoint tomography, near surface shear velocity

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Estimating finite fault slip distributions of large earthquakes based on time-reversal wave propagation simulation with data assimilation

*Yugo Shibata[1], Takashi Furumura[1], Takuto Maeda[2]

1. Earthquake Research Institute, the University of Tokyo, 2. Hirosaki University

Larmat et al. (2006) proposed Time-Reversal Imaging (TRI), which has shown great success in earthquake source estimation. This method is different from general source inversion; the source imaging is performed by back-propagating array observation waveform data to the hypocenter by time inversion calculation of the equations of motion. This feature enables us to estimate the source without the prior setting of a fault plane. In addition to the significant large earthquakes, the application of the TRI to long-lasting phenomena such as tremors is being considered. On the other hand, TRI generally requires dense observation to obtain high-resolution source images (e.g., Kawakatsu and Montagner, 2008; Fukahata et al., 2014; Nakahara and Haney, 2015). Recently Furumura and Maeda (2020) introduced a calculation and observation data assimilation mechanism into TRI (DA-TRI), and showed that the K-NET/KiK-net data whose interstation distance is 20 -25 km can be used for source imaging of small and medium earthquakes occurring around Japan. In this study, we apply the TRI to estimate slip distribution on the finite fault of large earthquakes.

We set the DA-TRI calculation area as 460.8 x 460.8 km in horizontal and 57.6 km depth directions, respectively, in central Japan. The subsurface structure model of the JIVSM (Koketsu et al., 2012) was used for sedimentary layer, crust, mantle structure, and Pacific/Philippine Sea plate. Waveform data recorded at 234 KiK-net borehole stations for a duration of 180 seconds of two earthquakes that occurred off Ibaraki prefecture in 2008 (Mw6.9) and 2011 (Mw7.9) were backpropagated to the hypocenters by the 3D finite-difference calculation to estimate slip distribution (or asperity) on the fault plane, respectively. The optimal interpolation method was used for the data assimilation. The assimilation parameter was set based on the assumption that the error distribution of the seismic wavefield follows the Gaussian distribution of the correlation distance 5 km, and that the error of calculation and observation data is equivalent.

First, we analyzed the 2008 off-Ibaraki earthquake. DA-TRI was used to find the time variation of elastic energy of all grids in the finite difference method calculation (Top of Figure 2a). The time before and after the peak was regarded as the fault rupture time. The maximum value of elastic energy at the upper surface of the Pacific plate at that time was displayed as a source image (Bottom of Figure 2a). The obtained source image showed a strong concentration of elastic energy in a range of 25 km x 35 km, on about 10 km northeast of the hypocenter after five seconds from the earthquake origin time based on the catalog of the Japan Meteorological Agency. This position coincides well with the position of the large source fault slip estimated by Yamanaka (2008) from the far-field body wave analysis.

For the larger 2011 earthquake, the temporal variation of elastic energy (Top of Figure 2b) obtained from DA-TRI had two peaks at 2 and 23 seconds from the catalog origin time, suggesting the existence of two large fault slips around each time. Thus, we obtained the slip distribution of this earthquake by superimposing wave amplitudes on the Pacific plate at the two time-steps. A concentration of strong elastic energy was obtained in an area of 30x20 km at about 20 km southeast of the hypocenter, while a concentration of weak elastic energy in 30 x 20 km at 40 km northwest. The locations of energy

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concentration coincide with the asperity locations obtained from near-field strong motion records (Kubo et al., 2013), however, our results were unstable. This is because the calculation of the backpropagation of seismic waves continues to the past beyond the focal time, which we are tackling to improve.

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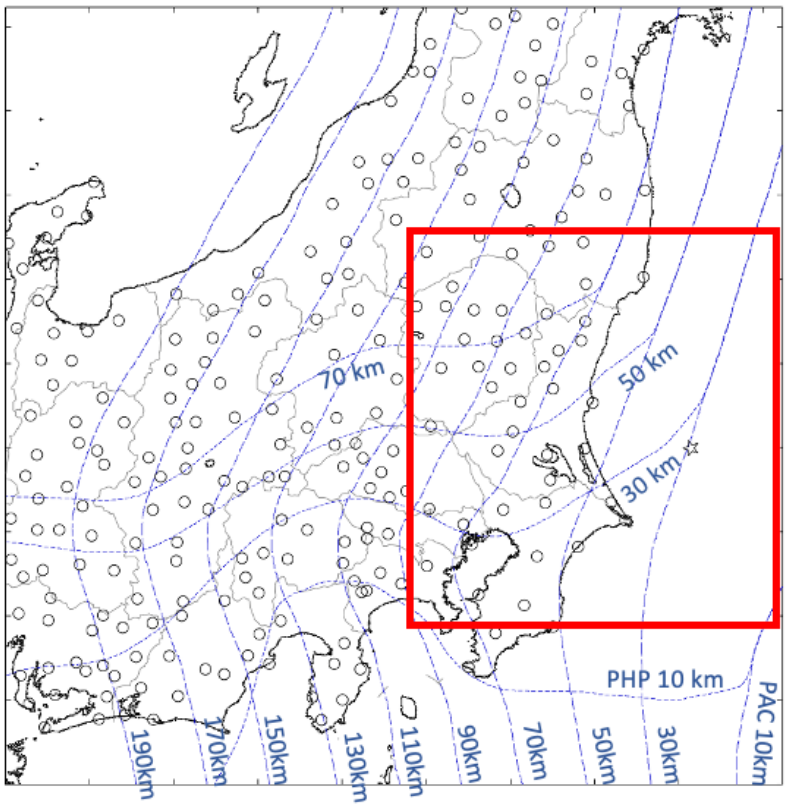

図1 この実験での計算領域と、KiK-net観測点の位置を示す。破線は、太平洋プレート（PAC）とフィリピン海プレート（PHP）の深さを示す。星印は、2011年茨城県沖地震の震央である。なお、赤枠は、図2の表示領域に対応する。

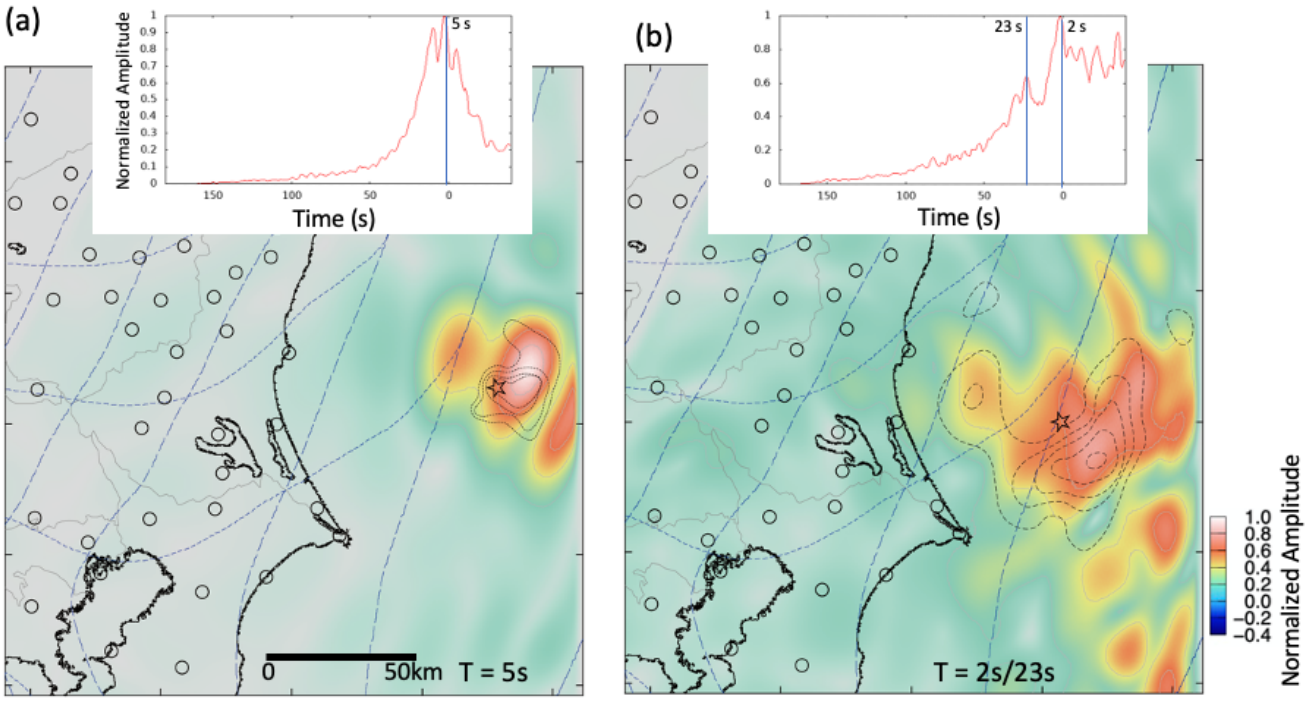

図2 DA-TRIにより求まった太平洋プレート上面での震源イメージ
(a) 2008年茨城県沖地震 （Mw 6.9）、コンターは山中 (2008)によるアスペリティの位置（0.3 m間隔）を表す。(b)2 011年茨城県沖地震 （Mw 7.9）、コンターはKubo et al. (2013) によるアスペリティの位置（1.26 m間隔）。星印は各地震の震央で、図中のグラフは、震源域全体のエネルギー振幅の時間変化 （時刻=0が発震時に対応）。

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

Sat. Jun 5, 2021 1:45 PM - 3:15 PM JST | Sat. Jun 5, 2021 4:45 AM - 6:15 AM UTC | Ch.18 Zoom Room 18

[S-SS09] Seismic wave propagation: Theory and Application

convener:Kaoru Sawazaki(National Research Institute for Earth Science and Disaster Resilience), Kiwamu Nishida(Earthquake Research Institute, University of Tokyo), Takao Nibe(JAPEX), Kyosuke Okamoto(National Institute of Advanced Industrial Science and Technology), Chairperson:Kiwamu Nishida(Earthquake Research Institute, University of Tokyo), Takashi Hirose(National Research Institute for Earth Science and Disaster Resilience)

Seismic wave propagation provides rich information on earth's heterogeneities and the excitation sources. Understanding of this information requires various research fields: mathematical/numerical studies based on wave theory, physical experiments using rock samples, seismic data analysis, etc. With recent developments of observational techniques, various wave phenomena have been elucidated: seismic waves, acoustic waves, traveling ionospheric disturbances, and tsunamis. New frameworks will be crucial for comprehensive understanding of these phenomena. This session widely invites presentations about the theories and applications related to seismic and other geophysical waves.

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

[SSS09-12] Imaging the solar interior using noise tomography

★Invited Papers

*Shravan Hanasoge[1] (1.Tata Institute of Fundamental Research)

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

[SSS09-13] Incorporating wind information in the inversion of co-located pressure and seismic data for shallow elastic structure

*Toshiro Tanimoto[1] (1.Department of Earth Science, University of California, Santa Barbara, CA93106, USA)

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

[SSS09-14] Study on Microseisms excited by Typhoons around Japan

*Hiroki Kawakami[1], Naoki Suda[1] (1.Hiroshima University)

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

[SSS09-15] Extraction of P-wave reflections of mantle discontinuities from ambient seismic noise beneath Japan

*Shota Kato[1], Kiwamu Nishida[1] (1.Earthquake Research Institute, the University of Tokyo)

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

[SSS09-16] A centroid catalog of P-wave microseisms

*Kiwamu Nishida[1], Ryota Takagi[2] (1.Earthquake Research Institute, University of Tokyo, 2.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University)

Imaging the solar interior using noise tomography

*Shravan Hanasoge[1]

1. Tata Institute of Fundamental Research

Helioseismology is the science of imaging the solar interior using observations of acoustic oscillations at the surface. These waves are stochastically excited by turbulence in the near-surface layers of the Sun, which then traverse the interior and re-emerge at the surface. Much as in terrestrial noise tomography, we measure cross-correlations of the surface wavefield to infer interior properties. Drawing parallels with noise tomography, I will describe the data, methods and the many successes of helioseismology in obtaining constraints on solar interior structure and dynamics.

Keywords: Noise tomography

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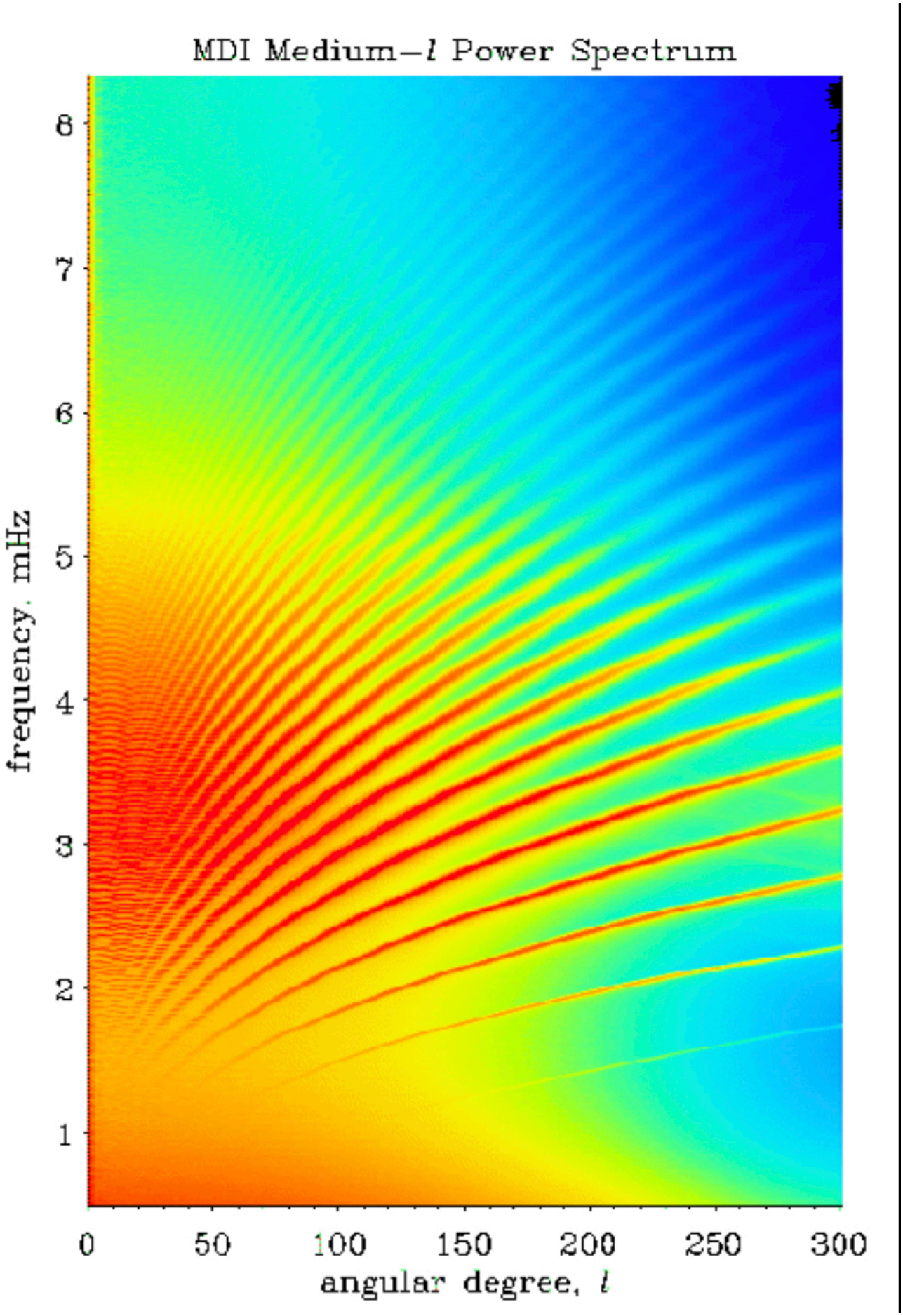

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Incorporating wind information in the inversion of co-located pressure and seismic data for shallow elastic structure

*Toshiro Tanimoto[1]

1. Department of Earth Science, University of California, Santa Barbara, CA93106, USA

When surface pressure is large, seismic noise between about 0.01 Hz and 0.05 Hz is mostly generated by wind-related surface pressure changes. By analyzing this phenomenon using co-located pressure and seismic data, we can derive shallow elastic structure in the uppermost 50-100 m.

However, there still remains a difficult question on seismic excitation by wind-related surface pressure because of complexity in wind behaviors. Roughly speaking, it consists of the mean shear flow part and the turbulent part. The mean flow part should act like a moving pressure source on the surface while the turbulent parts act like a stochastic source as the surface pressure field becomes heterogeneous.

We point out that this complexity may be reduced by selecting time intervals of stable wind directions. During such time intervals, pressure changes occur in the direction of winds, which justifies us to use a relatively simple, moving pressure source model. We quantify the stability of wind direction by the standard deviation of wind direction data.

For stations with co-located wind, pressure, and seismic data, we propose to select time intervals with stable wind directions first and apply our inversion method based on the moving pressure model. In the absence of wind data at a station with co-located pressure and seismic data, we propose to analyze the high-pressure end of data, as this selection partially satisfies the stable wind condition. Some representative results will be shown by using data from the EarthScope Transportable Array.

Keywords: Shallow elastic structure, Inversion of pressure and seismic data, Low-frequency seismic noise excited by winds

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Study on Microseisms excited by Typhoons around Japan

*Hiroki Kawakami[1], Naoki Suda[1]

1. Hiroshima University

Seismograms include not only intermittent, high-amplitude oscillations due to earthquakes, but also continuous, low-amplitude ones due to atmospheric and oceanic disturbances. The oscillations at 0.05-0.5 Hz are generally called microseisms and have relatively large amplitudes. Microseisms are classified into weak primary microseism at 0.05-0.1 Hz and strong secondary microseism at 0.1-0.5 Hz. The former is thought to be excited by the ocean waves themselves, and the latter by the interaction of ocean waves. Microseisms are mainly composed of Rayleigh and Love waves, so that the energy of microseism efficiently propagates in the solid earth. Studies linking typhoons that excite large ocean waves and microseisms have been conducted so far, but the source and excitation mechanism of microseisms have not yet been fully understood. Locating the source area of microseism is important not only for understanding the interaction between atmosphere, ocean and solid earth, but also for estimating the Earth's internal structure using microseisms. In this study, we estimated the source areas of the primary microseism excited by typhoons approaching Japan.

We used seismic records from the F-net broadband seismograph network as the seismic wave data. We obtained 1st percentile power spectra for all the 72 F-net stations to select quiet 20 stations with the consideration of the station distribution. For typhoon information, we referred to the database of the Japan Meteorological Agency. In this study, we analyzed the seismic records in the periods of six large typhoons approaching Japan with the maximum wind speed of 33 m/s or more in 2019 and 2020, FRANCISCO (typhoon number 1908), KROSA (1910), FAXAI (1915), HAGIBIS (1919), HAISHEN (2010) and CHAN-HOM (2014).

Source areas were estimated using Rayleigh waves with a similar method to Park & Hong (2020) for locating the source areas of microseisms caused by the typhoon that passed through the South China Sea. This method utilizes the Rayleigh wave characteristic that the horizontal component is phase-shifted by $\pi/2$ in the negative direction of the time axis with respect to the vertical component. When the cross-correlation coefficient between the horizontal component rotated to a certain direction and the vertical component whose phase is shifted by $\pi/2$ in the negative direction of the time axis is maximum, the source is in that direction. In this study, we obtained the station averages of the cross-correlation coefficients computed for source grids with an interval of 0.1 degrees on the surface to estimate the source distribution of the primary microseism during the approach period of typhoon. We defined the area with high correlations as the source area of microseism.

The result has shown that the seismic energy of the primary microseism at 0.08-0.1 Hz is greatly excited with the approach of the typhoons, and the main source areas are almost the same as the typhoon storm areas. However, in the four typhoons HAGIBIS, FAXAI, HAISHEN and CHAN-HOM, it has been shown that the source areas stagnate after the passage of typhoon. There was a strong correlation between ocean-wave and microseism amplitudes during the stagnation. The stagnant source areas might be due to the seafloor sandwiched by topography highs, which efficiently excited the microseism even after the passage of typhoon.

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Keywords: microseisms, typhoons, seismographs, ocean waves, storms

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Extraction of P-wave reflections of mantle discontinuities from ambient seismic noise beneath Japan

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1. Earthquake Research Institute, the University of Tokyo

Seismic interferometry (SI) is the technique that extracts the Green's function between a station pair by calculating the cross-correlation function (CCF) of the random seismic wavefield. Microseisms, which are excited by ocean swell activities, and earthquake coda, multiple scattered by the heterogeneous structure, are typical examples of a random seismic wavefield. Because surface waves dominate microseisms, the extracted surface waves are used to infer the S wave velocity structure of the crust and upper mantle (e.g., Shapiro et al., 2005). Recent studies also start to utilize information on the body waves as well as the surface waves extracted by SI. For example, some groups reported reflected P waves at the 410/660 km discontinuities (P410P/P660P) (Poli et al., 2012; Feng et al., 2017) using the continental stations. This study aims to extract the P410P/P660P by applying SI to microseisms and earthquake coda, recorded by Hi-sensitivity Seismograph Network Japan (Hi-net), and discuss the effect of the source distribution of wavefield on the retrievals.
The procedures of the CCF calculation of microseisms are as follows: The dataset in this study is the vertical components of 240 Hi-net stations in Southwest Japan and 168 stations in Northeast Japan (2007–2018). We down-sampled the original 100 Hz data to 2 Hz. The 1-day-length waveform was split into 1024-second-length segments and selected based on the mean square amplitude in 0.05-0.1 Hz and 0.1–0.2 Hz. We then calculated CCFs for every pair of stations by stacking over all the selected segments with spectral whitening from 0.1 to 0.2 Hz.
The method of the CCF calculation of earthquake coda is mostly the same as that of microseisms. The time-windows are the 1500-4800 s from the origin time of large earthquakes (Mw>6.5; 534 events). The running absolute mean method (Bensen et al., 2007) was applied to all earthquake coda waveforms.
In SW Japan, both CCFs of microseisms and CCFs of earthquake coda show P410P, but no or weak P660P. The lack of extraction of P660P despite CCFs calculated from independent wavefield suggests that the structure near 660 km discontinuity in SW Japan makes the extraction of P660P difficult. The CCFs of earthquake coda show P410P/P660P in NE Japan, partly because of the coincidence between the arrival direction of wavefield and the direction of stations, suggesting that many station pairs in NE Japan have incident waves with the adequate direction for the extraction. The extraction of P410P/P660P is limited by the distribution of wave sources and the geometry of stations, especially from microseisms.
As another analysis for obtaining the information of mantle discontinuities from microseisms, the receiver function analysis of microseismic P wave was performed. We focused on the P wave excited by the weather bomb in the Atlantic Ocean (Nishida and Takagi, 2016). For the estimation of the source time function, all the vertical components were stacked over all the stations after the back-propagations to the source. The deconvolution of the radial component with the source time function was calculated using 691 Hi-net stations. The preliminary result shows the extraction of converted S waves by 410 km discontinuity (P410s) beneath Japan. However, the result shows no or weak peak corresponding to P660s. The extraction of P410s and no or weak P660s is consistent with the result of SI, which shows the P410P and weak P660P.

Keywords: Seismic Interferometry

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A centroid catalog of P-wave microseisms

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Although observations of microseisms can date back to the early 1900s [e.g., Wiechert 1904], the excitation mechanisms are still in progress. The source distribution is a key for understanding the excitation mechanism.
When we observed teleseismic P-wave microseisms at a distant station, the source can be approximated by a centroid single force practically (e.g., Nishida and Takagi, 2016). The centroid location of P-wave microseisms is crucial for understanding the origins of microseisms. Backprojection method is feasible for locating the centroids of body-wave microseisms. The technique utilizes the information of both slowness and the curvature of the wavefront. It can also utilize information on multi-phases. However, the computational cost is still expensive for making a global catalog for over ten years. On the other hand, the computational cost of beamforming is inexpensive. However, the method cannot distinguish P from PP waves because it utilizes information only on slowness. In this study, we propose a new technique that can extract information, both slowness and the curvature of the wavefront, as a natural extension of beamforming.

In this method, we first infer the initial guess of the slowness vector at the center of the seismic array based on the conventional beamforming. We estimate the beam power according to an assumed curvature for the fixed slowness in the second step. By maximizing the beam power, we infer the initial guess of the curvature at the center. We update the values (slowness vector and the curvature at the center) iteratively based on the perturbation theory. The curvature gives us information on the epicentral distance between the center of the array and the source, although the accuracy is low in general. According to the distance information, we classify the detected slowness into the corresponding phase (e.g., P, or PP). Based on the classified phase, we infer the source location from the slowness value. The curvature information is also useful for reducing the false detection of the beamforming. To improve the accuracy of the centroid locations, we estimated corrections of the measured slowness vector for a global P-wave model (LLNL-G3Dv3: Simmons et al. 2012) using three-dimensional ray tracing (PMTI, Simmons, et al. 2011). To validate the technique, we applied this method for earthquakes with moment magnitudes larger than xx listed in the global CMT catalog (Ekström et al., 2012). The results with the corrections for the three-dimensional structure are consistent with the catalog.

We applied this method for vertical components of velocitymeters at about 800 Hi-net stations in Japan, operated by the National Research Institute for Earth Science and Disaster Prevention (NIED) from 2004 to 2018. The inferred centroid locations show seasonal variations, which are consistent with past studies. We will show a new preliminary catalog of source locations of global P-wave microseisms.

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

Sat. Jun 5, 2021 3:30 PM - 5:00 PM JST | Sat. Jun 5, 2021 6:30 AM - 8:00 AM UTC | Ch.18 Zoom Room 18

[S-SS11] Strong Ground Motion and Earthquake Disaster

convener:Kazuhiro Somei(Geo-Research Institute), Yasuhiro Matsumoto(Kozo Keikaku Engineering), Chairperson:Tomohisa Okazaki(RIKEN Center for Advanced Intelligence Project), Kentaro Emoto(Graduate School of Science, Tohokuk 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

[SSS11-01] High-density estimation of site amplification characteristics from DAS observation along Route 4

*Kentaro Emoto[1], Hisashi Nakahara[1], Takeshi Nishimura[1], Mare Yamamoto[1] (1.Graduate School of Science, Tohokuk University)

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

[SSS11-02] Long-term fluctuation of microtremor at a permanent observation site in Tottori University

*Takao Kagawa[1], Soma Nishigaki[1], Tatsuya Noguchi[1] (1.Tottori University, Faculty of Engineering)

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

[SSS11-03] Numerical elucidation of the Aso Caldera graben mechanism focusing on stratum irregularities, soft clay and two consecutive earthquakes

*Kentaro Nakai[1], Toshihiro Noda[2], Akira Asaoka[3], Shinya Fukuda[1] (1.Graduate School of Engineering, Nagoya University, 2.Disaster Mitigation Research Center, Nagoya University, 3.Association for The Development of Earthquake Prediction)

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

[SSS11-04] Estimation of site amplification and S-wave velocity structure in Kumamoto Prefecture based on spectral inversion analysis of strong motion records

*Tomomi IIDA[1], Hiroaki Yamanaka[1], Kosuke Chimoto[1], Daiki Shinoyama[2], Seiji Tsuno[3], Masahiro Korenaga[3], Nobuyuki Yamada[4], Hiroe Miyake[5], Tatsuo Kanno[6], Michiko Shigefuji[6], Masayuki Yoshimi[7], Shinichi Matsushima[8], Hiroshi Kawase[8], Kimiyuki Asano[8], Tomotaka Iwata[8] (1.Tokyo institute of Technology, 2.Central Research Institute of Electric Power Industry, 3.Railway Technical Research Institute, 4.Kochi University, 5.The University of Tokyo, 6. Kyushu University, 7.National Institute of Advanced Industrial Science and Technology, 8. Kyoto University)

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

[SSS11-05] Toward Development of Spectral Inversion Method Considering with Rupture Directivity

*Kazuhiro Somei[1,2], Kimiyuki Asano[3], Tomotaka Iwata[3] (1.Graduate School of Science, Kyoto University, 2.Geo-Research Institute, 3.Disaster Prevention Research Institute, Kyoto University)

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

[SSS11-06] Broadband Ground Motion Synthesis Using Wasserstein Interpolation of Acceleration Envelopes

*Tomohisa Okazaki[1], Hirotaka Hachiya[1,2], Asako Iwaki[3], Takahiro Maeda[3], Hiroyuki Fujiwara[3], Naonori Ueda[1] (1.RIKEN Center for Advanced Intelligence Project, 2.Wakayama University, 3.National Research Institute for Earth Science and Disaster Resilience)

High-density estimation of site amplification characteristics from DAS observation along Route 4

*Kentaro Emoto[1], Hisashi Nakahara[1], Takeshi Nishimura[1], Mare Yamamoto[1]

1. Graduate School of Science, Tohokuk University

In the past few years, dense seismic observations using the distributed acoustic sensing (DAS) and fiber optic cables have been used in seismology. Compared to the conventional observation using seismometers, the cost of the DAS observation is low. Only one DAS equipment and a pre-existing telecommunication cable are required for the DAS observation. DAS observations have been used for the shallow-structure estimations and the hypocenter determination by using the record obtained in a high spatial density. Site amplification characteristics estimated from dense DAS records at a volcano was found to be in good agreement with the geological structure [Nishimura et al., 2021]. In this study, we report the site amplification characteristics calculated from the DAS observation with the fiber optic cable deployed along Route 4.

We installed the DAS equipment at Furukawa Maintenance Branch Office of Ministry of Land, Infrastructure, Transport and Tourism. The fiber optic cable is lined to the south along Route 4. The axial strain rates along the 50 km long fiber with an interval of 5m are recorded with a sampling rate of 500 Hz. The observation period is 1 month from 10 January 2020. We analyze 9 earthquakes whose magnitudes range from 2.7 to 4.8. Their hypocenters are widely distributed from Ibaraki to Hokkaido. The effect of the traffic noise can be reduced by taking the average of the results from different earthquakes.

Bandpass filters of 0.5-1, 1-2, 2-4, 4-8 and 8-16 are applied to the strain rate at each channel. The RMS amplitude of the strain rate in a 10 s time window starting from 2 s before the arrival of S-wave is calculated at each frequency range. The RMS amplitude is normalized so that its average over the channels to be one and then the average RMS amplitude over the earthquakes is calculated. We apply similar processing to P-wave as well, but the available number of earthquakes is only one.

The difference in the spatial distribution of the RMS amplitude among the earthquakes is not significant. This means that the RMS amplitude reflects the effect of the heterogeneity near the site. The large RMS amplitudes are observed at channels 10 km from the southern end of the cable. This may be affected by the road construction and the low signal to noise ratio due to the large distance from the interrogator. The local variation in the RMS amplitude ranges from 1/3 to 3. The large-scale spatial distribution of the RMS amplitude coincides with that of the amplification factor between the engineering bedrock with Vs=400 m/s and the surface provided by NIED Japan Seismic Hazard Information Station (J-SHIS). The large RMS amplitude and the large amplification areas are located in Osaki city, Taiwa town and around Sendai city. However, small-scale differences exist between the RMS amplitude and the J-SHIS amplification factors are different and the variation scale of the RMS amplitude is smaller than that of the amplification factor. The result from P-wave shows the same characteristics as that of the S-wave. The spatial power spectrum

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density of the RMS amplitude exhibits the power-law decay with the exponent of 3 at the high wavenumber range.

In this study, we have shown the possibility to estimate the site amplification characteristics in a very high spatial density from the DAS observation. We will investigate the small-scale variation of the site amplification in more detail by taking into account the effect of the coupling between the cable and the ground. The output of the DAS observation is the single component of the axial strain rate along the cable. Since the strain is the spatial derivative of the translational signal, the sensitivity to the small-scale heterogeneity of the structure can be strong. It is necessary to examine the effect of the small-scale heterogeneity on wave propagation in terms of the strain.

Acknowledgement:
DAS observation was supported by Ministry of Land, Infrastructure, Transport and Tourism, Tohoku Regional Development Bureau, Sendai Office of River and National Highway.

Keywords: DAS, Site Amplification, Dense Observation

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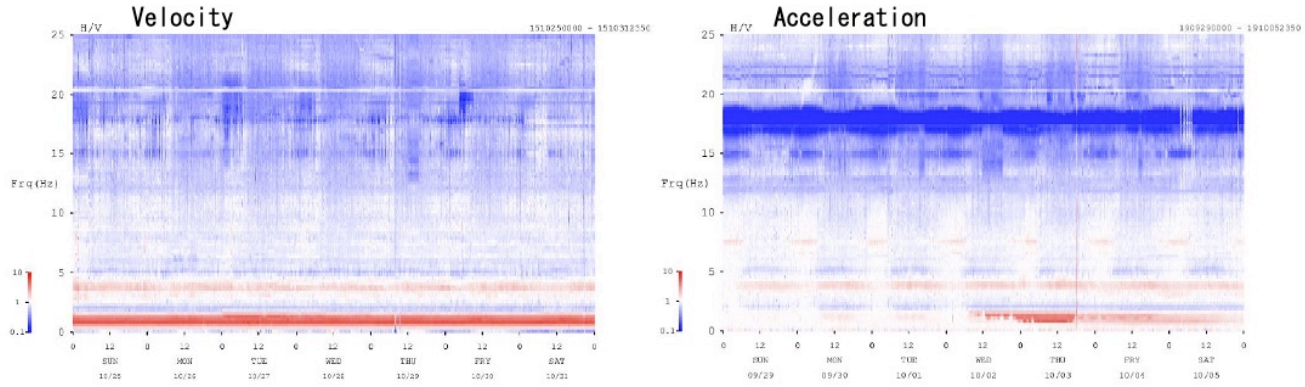
Long-term fluctuation of microtremor at a permanent observation site in Tottori University

*Takao Kagawa[1], Soma Nishigaki[1], Tatsuya Noguchi[1]

1. Tottori University, Faculty of Engineering

Long-term fluctuations of microtremors were analyzed using continuous seismic observation records installed on the premises of Tottori University. In recent years, systems that combine an accelerometer and a high-resolution recording system have become mainstream. It is important to verify the stability of the microtremor H/V spectrum ratio considering decrease in sensitivity of accelerometer especially at low frequencies. Therefore, it was verified by comparing with the records by a velocity type sensor. In low frequency band below 1 Hz, the velocity type sensor shows a stable peak for long-term, however the acceleration type sensor shows an unstable peak depending on the strength of the microtremor sources such as sea waves (see attached Figure). Due to the self-restraint of activities due to the COVID-19 from the spring of 2020, microtremor amplitude of horizontal components in the frequency band of 5 Hz or higher is smaller than the previous year on the premises of Tottori University. Microtremor amplitude also changed due to a shift in traffic flow caused by the opening of a new motorway near the observation site in May 2019. Since the stability of the peak of microtremor H/V spectral ratios captured by accelerometer in low frequency band is important for the study of ground motion characteristics, we would like to continue to analyze trends at other sites.

Keywords: Microtremor, Long-term fluctuation, H/V, Natural phenomenon, Human activity



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Numerical elucidation of the Aso Caldera graben mechanism focusing on stratum irregularities, soft clay and two consecutive earthquakes

*Kentaro Nakai[1], Toshihiro Noda[2], Akira Asaoka[3], Shinya Fukuda[1]

1. Graduate School of Engineering, Nagoya University, 2. Disaster Mitigation Research Center, Nagoya University, 3. Association for The Development of Earthquake Prediction

In the 2016 Kumamoto earthquake, graben damage extending about 10 km occurred in the northwest part of Aso Caldera. Two strong motions measuring maximum seismic intensity of 7 (foreshock and main shock) occurred in rapid succession. It has been reported that the graben damage occurred not during the foreshock, but immediately after the main shock although the shocks had the similar degree of intensity. It was thought that the Futagawa fault zone that caused the Kumamoto earthquake did not reach to the Aso Caldera, and no causal relationship has been identified between the graben damage and the Hinagu fault zone. Therefore, various causes have been considered, such as collapse of underground cavities, surface seismic faults, liquefaction-induced horizontal movement of large-scale geological blocks in deeper ground, etc. However, the definite cause of graben has not been identified yet because no trace of fault movement or liquefaction has been found. On the other hand, Yasuda et al.[1)] and Ishikawa et al. [2)] revealed that most of the grabens appeared at the ground above the old lake which existed about 9,000 years ago. In addition, they have confirmed that the lake sedimentary layer has the property that the shear rigidity decreased sharply with strong repeated shear stress from the laboratory testing, and conducted a reproduction analysis of the graben damage. However, they have still not mentioned why localized and strong repeated shear was acted on the lake sedimentary layer.

The aim of this study is to elucidate the mechanism of graben that occurred in the Aso Caldera in terms of "stratum irregularity" formed by the old lake basin in the Aso Caldera, the "presence of soft clayey soil" of the old lake deposit and the "two consecutive earthquakes" that characterize the Kumamoto earthquakes. Therefore, 2-dimensional seismic response analysis was conducted to elucidate these effects on the surface ground damage. The analysis code employed was the soil-water coupled finite deformation analysis[3)], which incorporates an elasto-plastic constitutive model that allows description of mechanical behavior of soils ranging from sand through intermediate soils to clay within the same theoretical framework[4)].

The following conclusions were obtained.
(1) By considering the effect of stratum irregularity, (a) the focal phenomena of the body waves, (b) the excitation of the surface waves and (c) the amplification interference of the body waves and surface waves ("edge effect") were numerically reproduced. Therefore, the wave propagation became complicated and the oscillation became larger at a specific point near the ground surface.
(2) The clayey lake deposit was in a soft condition. Therefore, the effective stress was easily decreased by seismic motions, which causes further increase in natural period of the ground.
(3) As mentioned in (2), natural period of the ground was increased by foreshock. The continuous occurrence of main shocks containing long-period components significantly amplified long-period oscillations. This long-period and large shaking caused graben damage at the ground surface.
It was analytically demonstrated that the graben damage of the Aso Caldera was caused by the combined effect of all of the above three characteristics (1), (2) and (3). In other words, if even one is missing, graben damage may not have occurred.

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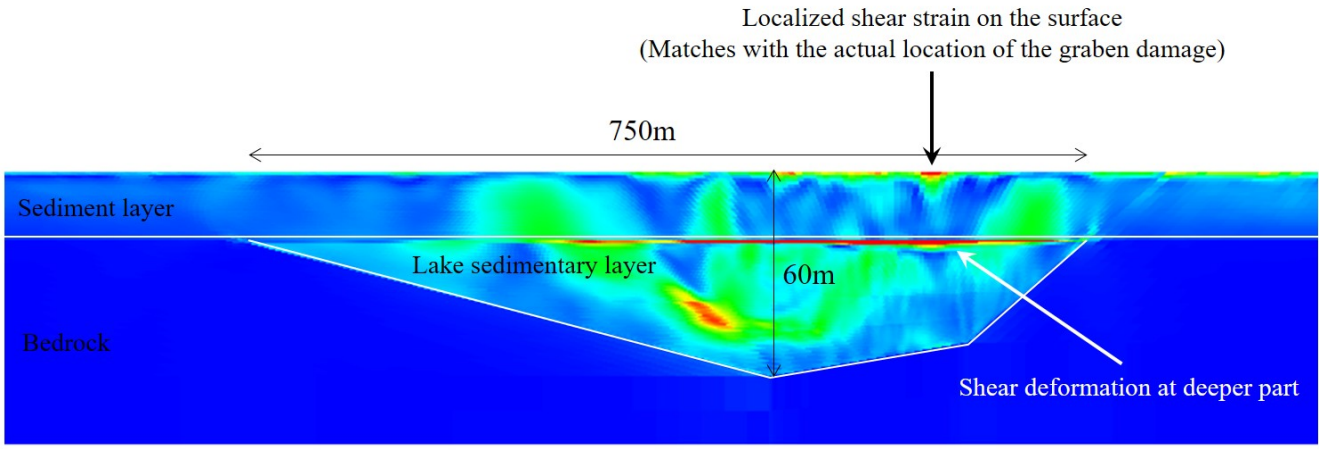
1) Yasuda, S. et al., Deformation survey of the Kario district in Aso city where caused graben damage during the Kumamoto earthquake, Proc. of 13th JAEE, 2-13, 2017.
2) Ishikawa, K. et al., Residual deformation analysis due to softening of the lacustrine sediment in the Aso caldera in the 2016 Kumamoto earthquake, Proc. of 54th JGS, 1925-1926, 2019.
3) Asaoka, A. et al., An elasto-plastic description of two distinct volume change mechanisms of soils, S&F, 42(5), 47-57, 2002.
4) Noda, T. et al., Soil-water coupled finite deformation analysis based on a rate-type equation of motion incorporating the SYS Cam-clay model, S&F, 48(6), 771-790, 2008.

Keywords: Kumamoto earthquake, Aso Caldera, Stratum irregularity, Soft clayey soil, Consecutive earthquakes, Seismic response analysis



Shear strain distribution immediately after the occurrence of main shock

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Estimation of site amplification and S-wave velocity structure in Kumamoto Prefecture based on spectral inversion analysis of strong motion records

*Tomomi IIDA[1], Hiroaki Yamanaka[1], Kosuke Chimoto[1], Daiki Shinoyama[2], Seiji Tsuno[3], Masahiro Korenaga[3], Nobuyuki Yamada[4], Hiroe Miyake[5], Tatsuo Kanno[6], Michiko Shigefuji[6], Masayuki Yoshimi[7], Shinichi Matsushima[8], Hiroshi Kawase[8], Kimiyuki Asano[8], Tomotaka Iwata[8]

1. Tokyo institute of Technology, 2. Central Research Institute of Electric Power Industry, 3. Railway Technical Research Institute, 4. Kochi University, 5. The University of Tokyo, 6. Kyushu University, 7. National Institute of Advanced Industrial Science and Technology, 8. Kyoto University

In this study, we estimated site amplifications and S-wave velocity structures for shallow and deep soils using ground motion records in Kumamoto, Japan. We first apply a spectral inversion technique to the earthquake records to estimate the effects of source, path, and site amplification. And then these site amplifications are inverted to subsurface S-wave velocity. We used the data of 256 earthquakes obtained at strong motion stations of K-NET, KiK-net, seismic intensity-meters stations by local governments, and aftershock observation stations by Yamanaka et al. (2016). The estimated Q value of the propagation path is modeled as $72f^{0.83}$ and it is similar to that from previous studies (e.g. Somei et al. 2019). The source characteristics can be approximated with the omega-square model. The site effects in the plain area show large values in a frequency range of 0.5-2.0Hz. At a high frequency above 5Hz, the site amplifications in the mountain are larger than those in the plain area. The amplifications of 0.5-1Hz are larger in the central area of the Kumamoto plain than in the other area because of the large sediments. The amplifications in Mashiki show different characteristic features around 2Hz due to the various thickness of the shallow soils. The Q value of deep soils in the plain area tends to be larger than in the mountainous area.

Acknowledgements

We used the data from the aftershock observation conducted as a part of the Comprehensive Study on the Futagawa-Hinagu fault zone after the 2016 Kumamoto earthquake, MEXT.

Keywords: Spectral inversion, The 2016 Kumamoto Earthquake, Site amplification, S-wave velocity

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Toward Development of Spectral Inversion Method Considering with Rupture Directivity

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Source, propagation path, and site effects were separated from strong motion records observed during the 2016 Kumamoto earthquake sequence using the spectral inversion method (Somei et al., 2019). Somei et al. (2020) have obtained a source spectrum for a specific station from an observed Fourier amplitude spectrum by removing the propagation path and site effects, in order to clarify the factor of variation in residual of spectral inversion results. For several events (M_w: 3.6-5.3) in the 2016 Kumamoto earthquake sequence, the azimuthal dependence of both the corner frequencies and fall-off rate was found in the displacement source spectra at stations. They thought this azimuthal dependence was caused by rupture directivity. In this study, we estimated the rupture directivity coefficient based on the variation in source spectra among stations toward developing a new spectral inversion method considering with the rupture directivity.

The rupture directivity coefficient assuming the bilateral line source model (e.g., McGuire, 2004) was estimated from the variation in the fall-off rate of the displacement source spectra among stations. The S-wave velocity was assumed to be 3.4 km/s in the rupture directivity coefficient. The take-off angle between the source and station was calculated using the 1D velocity structure model of JMA2001 (Ueno et al., 2002). The model parameters in rupture directivity coefficient are horizontal and vertical rupture directions, rupture velocity, and directivity ratio (i.e., percentage of unilateral rupture). These parameters were determined by grid searching to minimize the misfit function (Boatwright, 2007). In this misfit function, Boatwright (2007) originally used the ratio of the peak ground motion (PGA and PGV) for each station to that expected from the ground motion prediction equation, in order to estimate the directivity coefficient. We used the ratio of the fall-off rate for each station to -2 (i.e., the fall-off rate of the ω^{-2} source spectral model).

For an example of an M_w5.3 event at 17:52 on 19 April 2016 (JST) occurring in southwest of aftershock area, the estimated rupture directivity coefficient showed that the horizontal and vertical rupture directions are N214° E and 135° from vertically down, respectively, with a rupture velocity of 2.4 km/s. The best directivity ratio was 1.0, which means the rupture propagates unilaterally. On the other hand, the strong motion generation area for this event modeled by simulating the observed ground motions using the empirical Green’ s function method showed the rupture propagated southwest and shallow direction from the hypocenter (Somei et al., 2020). These results indicate that rupture directivity coefficient estimated from the variation in the fall-off rate was reasonable though the rupture directivity coefficient was upon the assumption of the line source model. Based on the rupture directivity coefficient, we will develop a new spectral inversion method considering with the rupture directivity.

Acknowledgements: The strong motion data were provided from the K-NET, KiK-net, and F-net operated by the National Research Institute for Earth Science and Disaster Resilience (NIED), Japan Meteorological Agency (JMA), Kumamoto Prefectural Government, Kagoshima Prefectural Government, and Nagasaki

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Prefectural Government. This study was supported by JSPS KAKENHI Grant Number JP20K05044. and by achievements of the collaborative research program (2020H-01) of the Disaster Prevention Research Institute of Kyoto University.

Keywords: Spectral inversion, Rupture directivity, Source spectrum

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Broadband Ground Motion Synthesis Using Wasserstein Interpolation of Acceleration Envelopes

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1. RIKEN Center for Advanced Intelligence Project, 2. Wakayama University, 3. National Research Institute for Earth Science and Disaster Resilience

Hybrid approaches to broadband (BB) ground motion synthesis combine long-period (LP) and short-period (SP) waveforms calculated by two methods suitable for each period range. They have been applied in research and practice, but it is disadvantageous that simulations are independently carried out under different assumptions, which can lead to incompatible time histories and frequency properties.

This study explores an approach for maintaining consistency between LP and SP components using an empirical relationship of past observation records. We propose a machine learning method that generate SP waveforms from LP waveforms obtained using physics-based simulations. Acceleration envelopes and Fourier amplitude spectra are transformed, and they are combined to produce a broadband waveform. To effectively obtain the relationship of envelopes from limited amount of data, we formulate the problem as the conversion of probability distributions to allow the introduction Wasserstein distance, and embed pairs of LP and SP envelopes into a common latent space to improve the consistency of the entire waveform. An experimental application to the 2008 M7 off Ibaraki earthquake demonstrates that the proposed method exhibits superior performance compared to existing methods and neural network approaches. In particular, the proposed method reproduces global properties in the time domain, which confirms the effectiveness of the embedding approach and the advantage of the Wasserstein distance as a dissimilarity measure of envelopes.

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[J] Oral | S (Solid Earth Sciences)：S-GL Geology

Sat. Jun 5, 2021 9:00 AM - 10:30 AM JST | Sat. Jun 5, 2021 12:00 AM - 1:30 AM UTC | Ch.24 Zoom Room 24

[S-GL23] Geologic structure and tectonic history of East Asia and Japanese Islands

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(Geological Survey of Japan, Research Institute of Earthquake and Volcano Geology)

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

[SGL23-01] Age spectra of detrital zircons of Paleogene fore-arc sandstones in Japan and the irreversible major change in mid-Eocene relevant to the initiation of Median Tectonic Line.

*Yukio Isozaki[1], Yukiyasu Tsutsumi[2], Tomohito Nakano[1] (1.Department of Earth Science and Astronomy, Graduate School of Arts and Sciences, The University of Tokyo, 2.Deprtment of Geology and Paleontology, National Musem of Nature and Science)

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

[SGL23-02] Zircon U-Pb ages of Momonoki Subgroup in the Koma Mountains

*Takashi Hakomori[1], Kenichiro Tani[2], Junichiro Kuroda[1], Asuka Yamaguchi[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.National Museum of Nature and Science)

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

[SGL23-03] **Tectonostratigraphic characterization of Maizuru back-arc basin during its closure: geochemical and U-Pb detrital geochronological approaches.**

*Larissa NGOMBI MAVOUNGOU[1], Kaushik Das[1,2], Yasutaka Hayasaka[1,2], Haruna Kuriu[1], Kenta Kawaguchi[3] (1.Department of Earth and Planetary Systems Science, Graduate School of Science, Hiroshima University, 2.HiPeR, Hiroshima, 3.Chonbuk National University, Korea)

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

[SGL23-04] Southwest Japan rotated clockwise during opening of the Japan Sea: Evidence from Miocene sediments in the Outer Zone

*Hiroyuki Hoshi[1], Hideki Iwano[2], Tohru Danhara[2] (1.Department of Earth Sciences, Aichi University of Education, 2.Kyoto Fission-Track Co., Ltd.)

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

[SGL23-05] Provenance of sandstones from the Eocene Urahoro Group, Hokkaido, Northern Japan: Tectonic Implications

*Toru Takeshita[1], Hiromi Kaji[1,2] (1.Department of Natural History Sciences, Graduate School of Science, Hokkaido University, 2.Oyo Co. Ltd.)

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

[SGL23-06] Shallow structure and late Quaternary slip rate on the Osaka Bay Fault: Aspects of climate-tectonic interaction

*Mari Hamahashi[1], Hironori Otsuka[1], Yoshiaki Suzuki[2], Jun Arimoto[2], Tetsuo Matsuno[1,3], Nobukazu Seama[1,3], Satoshi Shimizu[1,4], Hikaru Iwamaru[1,4], Mamoru Sano[1,4], Keita Suzuki[1,4], Katsuya Kaneko[1,3], Kazuo Nakahigashi[5], Itsuko Hidaka[1], Yuzuru Yamamoto[1,3], Yoshiyuki Tatsumi[1] (1.Kobe University, Ocean-Bottom Exploration Center, 2.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 3.Department of Planetology, Graduate School of Science, Kobe University, 4.Nippon Marine Enterprises, Ltd. , 5.School of Marine Resources and Environment, Tokyo University of Marine Science and Technology)

Age spectra of detrital zircons of Paleogene fore-arc sandstones in Japan and the irreversible major change in mid-Eocene relevant to the initiation of Median Tectonic Line.

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The unique age spectra of detrital zircons in Paleogene fore-arc sandstones in Japan, and tectonic implications of their irreversible secular change are discussed. The tectono-sedimentary setting of the Palegene fore-arc in Japan can be divied into two distinct phases; i.e. Paleocene to Early Eocene and the Late Eocene to Oligocene. The major change occurred sometime in the mid-Eocene, most probably by the initiation of the Median Tectonic Line (MTL) as a low-angle fault of arc-contraction nature. Recent studies confirmed that the Paleocene sediments unconformably lying on the Ryoke Cretaceous granitoids regionally overthrust the coeval Sanbagawa schists on the south from Kyushu to Kanto (Hasegawa et al., 2020; Isozaki et al, 2020), constraining the tectonic timing to the post-Paleocene (< 56 Ma). U-Pb ages of detrital zircons were measured for Paleocene bench sandstones deposited on the Shimanto accretionary complexes (Domeki Formation) in SW Shikoku. The age spectrum of zircons in the Domeki Fm is almost identical to those of coeval sandstones in the Ryoke belt (Upper Kokawa Fm and Nate Fm of the Izumi Group in Kinki, Kanohara Conglomerate and Yorii Fm in Kanto), suggesting the ubiquitous supply of mootonous terrigenous clastics into the Paleocene fore-arc domain for more than 80 km across the arc from the southern margin of the Ryoke belt (northern margin of the main fore-arc basin) to the central Shimanto belt (bench on slope). This confirms that the stable and continous deposition on the fore-arc crust of SW Japan arc from the Late Cretaceous to Paleocene without any major tectonic disturbance. In contrast, younger Paleogene sandsotnes in Japan show remarkably different age spectra of detrital zircons (Isozaki et al., in prep.).

Keywords: fore-arc basin, Cretaceous, Plaeogene, Japan, MTL

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Zircon U-Pb ages of Momonoki Subgroup in the Koma Mountains

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Momonoki Subgroup distributed in the western part of Yamanashi Prefecture has been considered to be trough-fill sediments formed in a trough located between Honshu arc and Izu-Bonin-Mariana arc before their arc-arc type collision has started. Previous studies have classified Momonoki Subgroup into three formations; the Lower Formation (or Yunokawa Fm.) is composed of mudstone, conglomerates, and alternation of sandstone and mudstone, the Middle Formation (or Maruyama Fm.) is composed of mudstone and alternation of sandstone and mudstone, and the Upper Formation (or Senshirosawa Fm.) is mainly composed of conglomerates (Tamura et al., 1984; Aoike, 1999; Kuroda, 2000, B.S. thesis). Depositional age and provenance of Momonoki Subgroup will provide important constraint on the timing of the collision. Previous researches have indicated that it was formed 16-15 Ma (Koyama, 1993) or 15-13.5 Ma (Aoike, 1999) or 12 Ma (Amano, 1991) based on biostratigraphy and estimated cooling age of the Kaikomagatake pluton, and that its provenance was mainly Honshu arc (Okuzawa and Hisada, 2008). In this study, U-Pb dating of zircon were applied to reconsider the depositional age and provenance of Momonoki Subgroup.

U-Pb ages of zircon grains obtained from tuff and sandstones of Momonoki Subgroup were analyzed. The zircon crystals for analysis were handpicked from heavy fraction of constituent particles separated from samples by high voltage pulsed power selective fragmentation device (SELFRAG-Lab) and stamp mill. The measurement was carried out using LA-ICP-MS installed at the National Museum of Nature and Science. Tuff sandwiched in the Lower Formation shows concordant ages concentrated at 23.5 Ma. Sandstones in the Lower Formation show concordant ages ranging from 21 to 2364 Ma. Arkose sandstone in the Middle Formation show the concordant ages ranging from 13 to 2184 Ma and concentrated around 14.6 Ma. The U-Pb age spectrums of sandstones between 100 and ~250 Ma show similarity with those of samples from Shimanto Belt (Tokiwa *et al.*, 2018).

The depositional age of the Momonoki Subgroup has been previously estimated as 16-15 Ma (Koyama, 1993) or 15-13.5 Ma (Aoike, 1999) or 12 Ma (Amano, 1991), but our new zircon age revealed that the Lower Formation may be as old as 23.5 Ma since the tuff in the Lower Formation is considered to be air-fall volcanic ash because of the concentration of zircon U-Pb ages and the absence of other ages. Though the arkose sandstone in the Middle Formation was deposited at 14.6 Ma or later, it is not clear whether the zircons that give concentrated U-Pb age around 14.6 Ma were derived from air-fall volcanic ash or from granite in the hinterland. The 9 My difference in depositional age between tuff in the Lower Formation and the arkose sandstone in the Middle Formation suggests that there may be structural discontinuities in the Momonoki Subgroup, or that the geological setting of the Momonoki Subgroup may have been different from trough-fill sediments.

The similarity of the U-Pb age spectrums of detrital zircons between the Momonoki Subgroup and Shimanto Belt suggests that the provenance of the Momonoki Subgroup is considered to have been mainly the Shimanto Belt with some influence from the Jurassic accretionary complex, with minimum contribution from the Izu-Bonin arc. In addition to the results of zircon U-Pb dating, the sandstones and conglomerates of the studied Momonoki Subgroup contain very few igneous rock fragments and conglomerates, which further provide evidence that sediment supply from the Izu-Bonin arc was

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volumetrically small. These results suggest that the collision between the Izu-Bonin arc and the Honshu arc may have started after 14.6 Ma, but further research is required for estimating the precise timing of the collision.

Keywords: zircon, U-Pb, Izu Collision Zone

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Tectonostratigraphic characterization of Maizuru back-arc basin during its closure: geochemical and U-Pb detrital geochronological approaches.

*Larissa NGOMBI MAVOUNGOU[1], Kaushik Das[1,2], Yasutaka Hayasaka[1,2], Haruna Kuriu[1], Kenta Kawaguchi[3]

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The rocks of the Maizuru terrane are considered to be related to a paleo back-arc basin that opened during early Permian and closed at the end of Permian. The deposits of this basin are exposed in the central zone of the present-day Maizuru terrane. They are mainly characterized by the Maizuru Group consisting dominantly of massive mudstone, and sandstone, with restricted occurrence of breccia that overly the Yakuno ophiolitic group considered as the basement of Maizuru back-arc basin. The breccia-dominated unit is a part of the Tonoshiki Formation with unclear stratigraphic position. The aim of this study is to understand the final stage of the evolution of Maizuru back-arc basin and for that, fixing the stratigraphic position of Tonoshiki Formation is of utmost importance. This may hold the key to defining the deformation style and mechanism of Maizuru back-arc basin rocks and the tectonic processes occurring prior to its closure. To address these issues, geochemical and geochronological studies have been conducted. Tonoshiki breccia is a collapse breccia with different sized extremely angular clasts. Clasts are made up of blocks of mafic and felsic rocks with minor but ubiquitously present mudstone. The mudstone clasts in Tonoshiki breccia and mudstone of Maizuru Group are both massive in nature and having similar mineral compositions (quartz and minor feldspar clasts in a pool of illite and chlorite-dominated matrix). Moreover, the bulk-rock chemical data indicate that those mudstones samples mostly sourced from felsic igneous rocks of the upper continental crust. The similar characteristics between the mudstone clasts in Tonoshiki breccia unit and the massive mudstone of Maizuru Group fix the stratigraphic position of the Tonoshiki Formation over the Maizuru Group. There is no known rock unit overlying this Permian sequence, making the Tonoshiki Formation as the topmost unit of Maizuru Group. The U-Pb detrital zircon geochronological studies conducted on two samples of Tonoshiki breccia show closed space probability peaks between ca. 285 Ma to 271 Ma for a sample with clasts from Yakuno ophiolites and one slightly younger single probability peak at 268 Ma for a sample with clasts of shallow crustal rocks. This indicates that there are two major possible sources for the Tonoshiki breccia. Its formation possibly occurred by debris flow during two episodes of tectonic activity that affected Maizuru back-arc basin at the end of Permian. The closure of the basin is characterized by multiple pulses of collapse breccia formation, probably induced by a faulting movement.

Keywords: Maizuru back-arc basin, Tonoshiki breccia, Maizuru Group, Timing of basin closure

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Southwest Japan rotated clockwise during opening of the Japan Sea: Evidence from Miocene sediments in the Outer Zone

*Hiroyuki Hoshi[1], Hideki Iwano[2], Tohru Danhara[2]

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There are two end-member hypotheses for the mode of migration of Southwest Japan (the southwestern half of the Japanese island arc in front of the Japan Sea) during Miocene major back-arc opening of the Japan Sea. One is that Southwest Japan split and then migrated southward from the eastern margin of the Asian continent with clockwise rotation around a pivot located near its western end. In this hypothesis, Miocene and older remanent magnetization directions clockwise deflected from an expected direction, which were reported from the Inner Zone (the area to the north of an E-W-trending fault called the Median Tectonic Line; MTL), are interpreted to be the unequivocal evidence of the clockwise rotation of Southwest Japan. This has been incorporated into the famous double-door opening model of the Japan Sea. On the other hand, another hypothesis is that Southwest Japan split and then migrated southward from the continental margin without pivotal rotation; the clockwise deflection of remanent magnetization directions is interpreted to be due to block rotations in the Inner Zone. This has been accepted by the pull-apart opening model of the Japan Sea. To determine which of the two hypotheses is correct, an effective approach is to obtain paleomagnetic data from the Outer Zone (the area to the south of the MTL) because regional geologic structures suggest that the Outer Zone has not suffered block rotation. Here we will present geochronological and paleomagnetic results from Miocene sediments of the Tanabe Group in the Outer Zone. Our new U-Pb zircon dates indicate that the lower part of the group is of late early Miocene age. Samples for paleomagnetic study were collected at eight sites in the lower part, and site-mean directions of characteristic remanent magnetization (ChRM) were determined for five sites through detailed stepwise demagnetization experiments. Thermal or ‘hybrid’ demagnetization methods were effective to isolate ChRM. A positive tilting test demonstrates ChRM acquisition before tilting. Importantly, tilt-corrected directions are almost parallel to the directions of the same age reported from the Inner Zone, indicating no relative rotation between the Inner and Outer zones. Comparison of the tilt-corrected directions with an early Miocene reference direction suggests clockwise rotation in the study area with respect to the Asian continent. Therefore, our results are more compatible with the hypothesis of clockwise rotation of Southwest Japan and cast serious doubt on the drift migration hypothesis.

Keywords: paleomagnetism, Southwest Japan, Tanabe Group, tectonics, U-Pb dating

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Provenance of sandstones from the Eocene Urahoro Group, Hokkaido, Northern Japan: Tectonic Implications

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In the southeastern Hokkaido, the Late Cretaceous to Oligocene sediments are widely distributed, and the Eocene sediments distributed in the Shiranuka hill is called the Urahoro Group. We have recently been investigating the Shitakara and Shakubetsu Formations of the Urahoro Group distributed to the east of the Urahoro-town. We have found deformation bands in the Shakubetsu Formation constituting a flexure, and analyzed microstructures in them (Kaji and Takeshita, this meeting, session S-IT19). On the other hand, we noted that sandstones from the Urahoro Group are characteristically rich in biotite and K-feldspar detrital grains, and discussed the provenance based on the mineral mode analysis of these sandstones. In this presentation, we will discuss the location of the provenance and its composition together with recently acquired U-Pb ages of detrital zircon grains from the Urahoro Group, and their implications.

The Urahoro Group is widely distributed to the east of Kushiro-city and Shiranuka hill to the west, which is covered by the Kushiro marsh in the middle. While the Urahoro Group shows moderately dipping structures with E-W strike in the east, the one distributed in the Shiranuka hill constitutes a fold and thrust belt trending N-S (Suzuki, 1958). This structure is inferred to have been formed due to the collision of the proto-Kuril arc against Honshu arc (Kimura and Tamaki, 1985). The Urahoro Group, which yields coal beds, consists of the Beppo, Harutori, Tenneru, Yuubetsu, Shitakara, and Shakubetsu Formations in ascending order (Sasa, 1940). Although the age of the Urahoro Group has been considered as the Late Eocene based on the fossils of shell and plant (Sasa, 1940) and foraminifera (Kaiho, 1983), Katagiri obtained the U-Pb age of 39.06±0.23 Ma in zircons from tuff beds of the Tenneru Formation of the Kushiro district. Further, Katagiri et al. (2020) obtained the youngest U-Pb ages of 39.54 ±0.27 Ma and 40.8 ±1.1 Ma in zircons in two samples from the Harutori Formation of the Shiranuka hill district, and confirmed that the sedimentary age of the Urahoro Group is in the Middle Eocence. However, it remains unknown where the igneous activity at c. 40 Ma which provided detrital grains for the Urahoro Group occurred. On the other hand, it has been accepted that sediments of the latest Ctretaceous to earliest Paleogene Kushiro Group which is unconformably overlain by the Urahoro Group are provided from the proto-Kuril arc, which was perhaps situated at the distribution area of the Kushiro Group. If this is true, it might be considered that the igneous activity at c. 40 Ma also occurred in the proto-Kuril arc. However, not only there is no evidence for this hypothesis, but al so it contradicts the paleocurrent direction. To resolve this discrepancy, since it is important to clarify the composition of the provenance of the Urahoro Group, we have carried out the mineral mode analysis of sandstone from one for each sample of the Shitakara and Shakubetsu Formations. Although the analyses are underway, it is safely concluded that the sandstones are a typical arkosic sandstone, and the provenance mostly consists of granite sensu stricto. Further, since the sandstone contain lithic fragments of rhyolite, it is inferred that the provenance could consist of a plutonic-volcanic rock complex of granite-rhyolite. Furthermore, biotite and K-feldspar grains are extremely fresh, and also granite conglomerates occur in the Urahoro Group, the provenance was located not far from the site of sedimentation. In this respect, one important finding is that it has been inferred that the detrital grains could have been provided from the ESE direction based on paleocurrent analysis. Therefore, the continental shelf off the Kushiro-city is the possible provenance, where the magnetic anomaly belt called “the East Hokkaido belt” is widely distributed. Nanayama et al. (1994) inferred that this magnetic anomaly belt is an extension of the Nikoro Group ophiolite of the Tokoro belt,

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based on the fact that chromian spinel was provided from it.

However, since the origin of magnetic anomaly could be equally considered as granitic rocks as the one in the “Ishikari-Kitakami magnetic anomaly belt” (Japanese nuclear fuel research, 2016), the detrital grains could have been provided from this belt mostly consisting of granitic rocks. Although the tectonics of large-scale felsic igneous activity in the continental shelf off the Kushiro city remains unknown, this problem could be argued in relation to c. 40 Ma granitic rocks (Maeda et al., 1986; Kawakami et al., 2006), and also recently found c. 40 Ma metamorphic ages (Takahashi, 2021, accepted) in the Hidaka belt.

Keywords: Eocene Urahoro Group, Provenance, Arkosic sandstone, Collision of the Proto-Kuril arc against Honshu arc, East Hokkaido magnetic anomaly belt, 40 Ma igneous activity in Hokkaido

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Shallow structure and late Quaternary slip rate on the Osaka Bay Fault: Aspects of climate-tectonic interaction

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>100 km inboard from the subduction interface in western Japan, the crustal seismogenic zone exists at ~5–20 km depth, as inferred from cut-off depths of seismicity and heat flow gradient. Active faulting is manifested under the contemporary compressional regime formed by the oblique subduction of the Philippine Sea Plate under the Japan arc at a current velocity of ~4–6 cm/yr. At the latitude of 34°N from the Ise bay to the Osaka bay, patterns of geodetic strain accumulation infer that NW-SE shortening of ~1–2 cm/yr is nearly perpendicular to existing faults, posing a major seismic hazard potential to the densely-populated areas of the Kansai region. Previous seismic reflection surveys have revealed a fold-and-thrust belt consisting of ~40° west- and east dipping reverse faults beneath the Osaka basin, Ise basin, and the Suzuka mountains. Whereas, to the west, ~70–80° east dipping, high-angle reverse faults characterize the structures around the Awaji island and contribute to the subsidence in the Osaka bay, including the Nojima fault that ruptured in the devastating 1995 Mw6.9 Southern Hyogo Prefecture Earthquake, and the offshore Osaka bay fault, which did not rupture in the 1995 earthquake.

To study the recent deformation history on the Osaka bay fault, high-resolution seismic profile data were collected along 14 survey lines in the Osaka bay, using a Mini GI air gun (Sercel; 15/15 in^3) and Boomer (100–200 J) as active sources, together with multi-beam bathymetry data on the T/S Fukaemaru and R/V Onokoro. In this study, we characterize the shallow structures of the Osaka bay fault, and assess the fault slip rates, in comparison with deep structures imaged by previous seismic surveys that targeted greater depth. The Osaka bay is filled by ~3 km-thick sediments of the Plio-Pleistocene Osaka Group, which consists of fluvial, lacustrine, and marine sequences, as revealed by multiple boreholes around the bay. Within the sedimentary section, distinct marine clay layers that correlate with global eustatic sea-level highstands are present, marking key beds useful for tying the regional stratigraphy. In this study, we assign the ages in our seismic profiles based on the age-correlated reflectors by Inoue et al. (2003), at the intersection points between our survey lines and previously acquired lines.

Our seismic profiles show that the Osaka bay fault is blind and not surface emergent, and that the deformation along the thrust reaches near surface by fault-propagation folding, characterized by a >5 km-wide asymmetric anticline of which its forelimb becomes steeper with depth. In the footwall, a >2 km-wide syncline and associated thickening of sediments develop packages of growth strata. These strata are further buried by younger sediments, where distinct on-laps of sediments onto folded strata form a regional sequence boundary. We interpret these shallow sediments to represent the Holocene alluvial sequence, overlying the late Pleistocene Upper Osaka Group strata. From the seismic profiles, we observe along-strike variation of sediment thickness of the Holocene sediments (0–20 m thick) in the hanging wall and footwall, revealing horizons where the erosional surface of the fold is exposed at the seafloor, and horizons where the fold is buried by recent sediments.

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To document the strain accommodated by the thrust, we use three approaches by measuring: 1) the sediment thickness variations between the hanging wall and footwall, 2) the offsets across the forelimb, and 3) the areas of uplift defined by the geometry of the hanging wall anticline and footwall syncline. The observed variations in shallow sediments on the thrust system indicate multiple changes in deposition, additionally affected by paleoclimate and tidal currents in the bay. We combine our observations with borehole data and regional sea-level records, and report on our assessments of fault slip rates and sediment responses through time, and their north-south variations on the Osaka bay fault.

Keywords: Osaka bay fault, Fold-and-thrust belt, Seismic reflection survey

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

Sat. Jun 5, 2021 9:00 AM - 10:30 AM JST | Sat. Jun 5, 2021 12:00 AM - 1:30 AM UTC | Ch.25 Zoom Room 25

[S-VC28] Active Volcanism

convener:Yuta Maeda(Nagoya University), Takahiro Miwa(National research institute for earth science and disaster prevention), Takeshi Matsushima(Institute of Seismology and Volcanology, Faculty of Science, Kyushu University), Chairperson:Taketo Shimano(Graduate School of Environment and Disaster Research, Tokoha University), Takahiro Miwa(National research institute for earth science and disaster prevention)

This session discusses various aspects of active volcanisms including, but not limited to, rec ent and historical eruptions, various phenomena associated with the volcanic activities, und erground structures of the volcanoes, and developments of new instruments based on geop hysical, geochemical, geological, and multidiscipline approaches. We also welcome studies o n 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

[SVC28-19] Temporal variation of conduit process during the 2018 eruptive activity at Shinmoedake volcano, Japan: Implications from a time series of ash characteristics

*Takahiro Miwa[1], Masashi NAGAI[1], Hideki Ueda[1], Taku Ozawa[1], Eisuke Fujita[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

[SVC28-20] An emplacement mechanism of submarine pyroclastic products: insight form the seismic studies on Kikai caldera

*Satoshi Shimizu[1,2], Nobukazu Seama[3,1], Reina Nakaoka[1], Keiko Suzuki-Kamata[1], Koji Kiyosugi[1], Katsuya Kaneko[3,1], Tetsuo Matsuno[1], Yoshiyuki Tatsumi[1] (1.Kobe Ocean-Bottom Exploration Center, Kobe University, 2.Nippon Marine Enterprises, Ltd., 3.Department of Planetology, Graduate School of Science, Kobe University)

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

[SVC28-21] Comparison of subaerial and submarine deposits from the Kikai Akahoya eruption

*Reina NAKAOKA[1], Keiko Suzuki-Kamata[1], Satoshi Shimizu[1], Katsuya Kaneko[2], Nobukazu Seama[2], Koji Kiyosugi[1], Takeshi Hanyu[3], Yoshiyuki Tatsumi[1], CK20-S01 Leg2 Cruise Scientists, KS19-17 Cruise Scientists, KR20-11 Cruise Scientists (1.Kobe Ocean-Bottom Exploration Center, Kobe University, 2.Department of Planetology, Kobe University, 3.Japan Agency for Marine-Earth Science and Technology)

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

[SVC28-22] Tephrostratigraphy of drilled core C9010E off the Boso Peninsula: Estimated source volcano for 9th century eruption events

*Kaori Aoki[1], Makoto Kobayashi[2,1], Masanori Murata[1], Takehiko Suzuki[1] (1.Research Center for Volcanic Hazards and Their Mitigation, Tokyo Metropolitan University, 2.Mt.Fuji World Heritage Centre, Shizuoka)

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

[SVC28-23] Caldera structure and formation at Atosanupuri and Akaigawa, Hokkaido, northern Japan: A comparison of analogue sandbox experiments and field data

*Ryuhei Sanjo[1] (1.Institute of Geography, Graduate School of Science, Tohoku University)

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

[SVC28-24] Current state evaluation and long-term prediction of volcanic activity based on historical tracking of volcanic ash deposits at Suwanosejima volcano

*Taketo Shimano[1], Atsushi Yasuda[2], Masato Iguchi[3] (1.Graduate School of Environment and Disaster Research, Tokoha University, 2.Earthquake Research Institute, University of Tokyo, 3.Sakurajima Volcano Research Center, Disaster Prevention Research Institute, Kyoto University)

Temporal variation of conduit process during the 2018 eruptive activity at Shinmoedake volcano, Japan: Implications from a time series of ash characteristics

*Takahiro Miwa[1], Masashi NAGAI[1], Hideki Ueda[1], Taku Ozawa[1], Eisuke Fujita[1]

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We investigated a time series of characteristics of ash particles to discuss change of the conduit process during the 2018 eruptive activity at Shimoedake volcano, Kirishima, Japan. The 2018 eruptive activity exhibited following a transition of three stages of eruptive style: (1) Ash emission in March 1–5, (2) dome-forming with strombolian eruptions in March 6–8, and (3) discrete vulcanian eruptions after March 9. Along with the transition, magma supply rate from the chamber inferred from tiltmeter and GNSS data was constant in the ash emission stage, increases (March 6) and subsequent decreases (March 7–8) in the dome formation stage, and constant again in the vulcanian stage (Ueda, 2018). Also, the volume of lava dome linearly increases from morning of March 6 to March 8 in the dome stage, and almost constant in the vulcanian stage, as revealed by SAR observation (Ozawa, 2018).

We analyzed twenty ash samples during the 2018 eruptive activity: two from the ash emission stage, fifteen from the dome stage, and three from the vulcanian stage. The ash particles were divided into 9 type as VCF (vecicular colorless), DCFF (dense colorless with fine microlite), DCFC (dense colorless with coarse microlite), VBF (vecicular black), DBF (dense black), LITH, ALT, PL, and MM (mafic mineral), based on the observations by stereoscopic microscope and SEM. The glossy surfaces in the VCF, VBF, DCF, and DBF indicate these particles are juvenile particles. The component analysis of the ash samples reveals that (1) the ALT and LITH dominated in the ash emission stage, (2) the VCF and DCF are abundant in the dome-forming stage with high abundant of DCFC in March 6, and (3) the DCF is rich and VCF is poor in the vulcanian stage. The textural analysis suggests the characteristics of plagioclase microlite (crystallinity, number density (MND) and crystal size distribution) are similar among the VCF, VBF, DCFF and DBF, whereas the DCFC has high crystallinity with low MND. The co-existence of parts of DCFF with DCFC were often found in a single particle. The glossy surfaces, textural similarity in plagioclase microlite, and different vesicularity in the VCF, DCF, VBF, and DBFF suggest these particles originate fresh new magma undergoing similar decompression path with different degree of outgassing. In contrast, the DCFC is interpreted as a partially-consolidated magma that ascended prior to the dome eruption or as part of the 2011 lava dome from the high crystallinity with low MND. Also the co-existence of parts of DCFF and DCFC in a single particle implies an erosion of partially-consolidated magma in the shallow conduit (DCFC) by newly ascended magma (DCFF).

Temporal variation of the conduit process during the 2018 eruptive activity at Shinmoedake volcano is explained by the enlargement of the conduit associated with increase in magma supply rate and subsequent outgasssing and sealing of the lava dome with the decrease in magma supply. During the ash emission stage in March 1–5, volcanic gas was emitted, destructing the country rock consisting of hydrothermally altered materials. In the early dome-forming stage of March 6, the increase of magma supply rate caused the erosion of the partially-consolidated magma, resulting in the enlargement of the conduit region. In the later dome-forming stage of March 7, the magma supply rate decreases, which ceased the enlargement and gradually sealed the conduit. Consequently in the vulcanian stage after March 9, the sealing of pathway of outgassing in the shallow conduit due to decrease of magma supply

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rate caused pressurization inside the dome, generating the vulcanian eruptions.

Keywords: Transition of eruptive style, Volcanic ash, Texture, Shinmoedake volcano, Kirishima

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An emplacement mechanism of submarine pyroclastic products: insight form the seismic studies on Kikai caldera

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Pyroclastic density current entering into water is not well understood on its emplacement mechanism. The emplacement mechanism in marine environment is subjects to location of vent, and temperature, velocity, density and angle of entrance of flow with water (Cas&Wright, 1991). When subaerial pyroclastic flow encounters water, it is subdivided into subaerial and subaqueous parts: subaerial flow interacts with water, making steam explosions, accelerating the flow, and generating co-ignimbrite ash cloud; subaqueous pyroclastics can be mixed with water, making ash plumes and seafloor hugging density current, or displace the water in shallow water. Many experimental studies and numerical modeling have documented for a variety of emplacement mechanisms (e.g., Freundt, 2003). However, a few attempts to explain the subaqueous emplacement with actual seafloor deposits on modern eruptions have been still controversial.

We have conducted high resolution seismic reflection studies around Kikai caldera located to the south of Kyusyu Island, Japan. Our seismic studies, together with chemical analyses of volcanic glasses, revealed that the uppermost unit distributed in an area of >4,500 km^2 with a volume of >71 km^3 is composed of pyroclastic deposits of 7.3 ka Akahoya eruption. This study is aiming to fill the gap between subaerial pyroclastic-flow deposits on proximal islands and distal islands where open water dominates the area surrounding the caldera in terms of volume and emplacement mechanism in the marine setting.

The distribution of the pyroclastic unit lying on the seafloor around Kikai caldera is confined by the basin topography. Although some areas of the unit were reworked by the mass movements observed as debris flow, slumping, and debris avalanche from the caldera rims to the basin, the east side of caldera has no evidence of such mass transports, possibly capturing the syn-eruptive deposition. This east area exhibits smooth seafloor on almost flat to slightly upward to the shelf of Tanegashima. The unit forms exponential thinning from the caldera wall to the shelf, filling the basin, depressions and fault steps. This deposition contrasts with shallow-marine deposits of Krakatau 1883 eruption that does not form systematic thinning but mottle-like thickening distribution, and bypass the annular moats, interpreted as that initially subaerial flow sank through the water column as increasing the density by gravity segregation (Mandeville et al. 1996; Legros&Druitt, 2000). Subaqueous fall-out deposition was also demonstrated by Freundt (2003); it occurs entirely in the water only on shallow-tank setting. In other deep-tank settings, either hot or cool-ash flow, generate seafloor-hugging currents, forming exponentially thinning extensive deposits. The exponential thinning of pyroclastic flow deposition was introduced by Wilson (1991), and the rate of the decay is decided by volume flux and settlement velocity of particles (Woods et al.,1998). This rate indicated in our pyroclastic unit is comparable to the values of on-land super-eruption ignimbrites that is much bigger than Kikai 7.3 ka eruption. This is possibly explained by not large mass flux as such super-eruptions generate, but slower settlement due to the subaqueous flow. The volume flux caused in the water is expected to be lower than that in the air because a large fraction of pyroclastics is elutriated from the flow into the subaerial flow over water and co-ignimbrite ash. On the other hand, the subaqueous settlement speed is supposed to be slower by reduced gravity than that in hot air entrained

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in subaerial flow. On a given mass flux, the submarine pyroclastic current can make longer run-out deposition than that made by subaqueous current. From the distribution and morphology of the unit, we can conclude that the pyroclastic density current of 7.3 ka eruption made the submarine deposit predominantly emplaced by seafloor-hugging current characterized by long run-out distance.

Keywords: Caldera, Pyroclastic Flow, Seismic Survey, Emplacement Mechanism

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Comparison of subaerial and submarine deposits from the Kikai Akahoya eruption

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The 7.3 ka Kikai Akahoya (K-Ah) eruption is a large-scale eruption of the submarine Kikai caldera volcano. It started with a Plinian Funakura pumice fall followed by an intra-Plinian Funakura pyroclastic flow (PF). This was followed by large-scale Koya ignimbrite accompanied by the Akahoya co-ignimbrite ash. On land, Funakura PF is deposited only on proximal islands, which have caldera walls. Koya ignimbrite is thickly deposited on the caldera walls and thinly deposited ~1 m in distal areas tens of kilometers across the sea. The Multi-Channel seismic survey (MCS) around the caldera showed that the Unit S-1, which is estimated to be the K-Ah products, was deposited thickly over a wide area (Shimizu et al., 2020JpGU). Based on their distribution and internal structure, it is assumed that it was deposited by flowing over the seafloor rather than as a fall deposit. The purpose of this study is to clarify the flow and depositional process of pyroclastic materials by comparing the components, depositional structures, and chemical compositions of the volcanic glass of the K-Ah ejecta on both land and seafloor.

On-land investigation and sampling were conducted in the proximal and distal areas. Marine deposits were drilled by the CHIKYU SCORE program to a depth of about 100 m at a location 4.3 km northeast of Takeshima. Also, piston cores (lengths of 1 to 4 m) were conducted by the Shinseimaru and Kairei at 7 sites in the proximal area, including near the SCORE drilling site, and at 14 sites in the distal area. SCORE drilled intermittently from 10 - 100 m below the seafloor, and Unit S-1 is identified by MCS as two different units Lower S-1 (depth 17-22 m) and Upper S-1 (depth <17 m, but not sampled below 10 m). Lower S-1 is a poorly sorted, reddish-brown pumice lapilli tuff often with lamina; Upper S-1 is a poorly sorted massive lapilli tuff with pumice and lithic fragments. These boundaries are distinct because the components are different. In the piston core near the SCORE site, 2 m of sediment corresponding to the uppermost part of Upper S-1 was collected. The submarine deposit consists of pumice lapilli, volcanic ash, lithic fragments, and crystals, and the sedimentary structure is often massive, but at some sites, there are normal grading of the pumice and weak lamination.

The chemical composition of the volcanic ash glass in each deposit was measured by EPMA. The Funakura PF contains only high SiO_2 glass (SiO_2 = ~75 wt.%). In the lower part of the Koya ignimbrite, there is only high SiO2 glass as in the Funakura PF, but low SiO_2 (SiO_2= ~65 wt.%) is mixed into the upper part (Fujihara and Suzuki-Kamata, 2013). The SCORE samples, Lower S-1 and Upper S-1, both contain only high SiO_2 glass consistent with that of the on-land K-Ah products. The piston core samples, both near and far, including the area around the SCORE site, contain both high and low SiO_2 glasses consistent with the K-Ah eruption.

On land, the Funakura PF composed of high SiO_2 magma was deposited, and then the Koya ignimbrite is presumed to have erupted only high SiO_2 magma in the early stage and gradually deposited from the lower levels with the mixing of low SiO_2 magma as the eruption continued (Fujihara and Suzuki-Kamata, 2013). The submarine K-Ah products also contain only high SiO_2 glass in the Lower S-1 and lower part of Upper S-1, suggesting that the deposits were initially deposited by the Funakura PF and later by the early Koya ignimbrite. The uppermost Unit S-1 near the seafloor by piston cores contains both high and low SiO_2 glasses, suggesting that they were deposited during the late K-Ah eruption stage. On the other hand, the

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sedimentary structure and grain size of marine deposits are different from those of on-land deposits, and they often show sedimentary structures suggestive of underwater sedimentation, suggesting that they were deposited in a different flow regime than large-scale pyroclastic flows on land.

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Tephrostratigraphy of drilled core C9010E off the Boso Peninsula: Estimated source volcano for 9th century eruption events

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We have been studying 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 354 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. Aoki et al. (2019a) showed the core C9010E included tephras from Mukaiyama tephra (AD886) to Akasakimine tephra series at ca.15-20 ka of the Niijima Volcano origin (Aoki et al., 2019b). Furthermore, Aoki et al. (2020) presented that the tephra bed of the 22 cm thickness at 32.965-33.185 m was correlated to Iz-Tos2 tephra which was provided from unknown volcanic source (Takahashi et al., 2020) and the tephra spot at the 41.21-41.23 m was correlated to Asama Itahana Kasshoku (Brown) tephra group which provided during 26-28 ka (As-BP; Arai, 1962; Aramaki et al., 1998; Takahashi et al., 2003, Takahashi et al., 2018; Shitaoka et al., 2020).

Today, we present on a source volcano of a scoria patch between Niijima Mukaiyama tephra (AD886) and Kozushima Tenjyosan tephra (AD838) in the sedimentary core C9010E. The tephra bed at the depth of 1.15-1.17 m, which was correlated to Niijima Mukaiyama tephra, includes white pumice grains and black scoria grains of the maximum diameter 2 mm. Particles smaller than 250 μm consist of mostly white to clear colored volcanic glass shards which are various forms like as pumiceous, fibrous, bubble-wall, and chunky types. Biotite, orthopyroxene, hornblende, cummingtonite, plagioclase and quartz are observed.

The tephra bed at the depth of 1.63-1.66 m, which was correlated to Kozushima Tenjyosan tephra, includes white pumice grains and black scoria grains of the maximum diameter 1 mm. Particles smaller than 250 μm consists of mostly white to clear colored pumiceous and bubble-wall type volcanic glass shards, a small amount of black scoria grains and rarely brown colored glass shards. Observed minerals are mainly plagioclase and quartz, and rarely biotite.

Between above two tephra bed, tephra patch intervened at the depth of 1.51-1.53 m. Particles larger than 250 μm includes black and dark gray scoria grains of the maximum diameter 2.5 mm, white pumice grains of the maximum diameter 1.5 mm, quartz, beta-type quarts, plagioclase, and a small amount of orthopyroxene and cummingtonite/hornblende. Particles smaller than 250 μm consist of large amount of white to clear colored pumiceous and chunky type, rarely bubble-wall type volcanic glass shards, quartz, beta-type quarts, plagioclase, rarely orthopyroxene. Major-element composition of volcanic glass shards in tephra patch at the depth of 1.51-1.53 m is rhyolite which similar to geochemistry of Niijima Mukaiyama tephra and Kozushima Tenjyosan tephra. However, the contents of CaO and K_2O is different from them, rhyolite glass shards in tephra patch at the depth of 1.51-1.53 m would be correlated to a series of tephras provided from Niijima Kudamaki/Atsuchi event (Kobayashi et al., 2020). Furthermore, the contents of Na_2O and MgO of tephra patch at the depth of 1.51-1.53 m are different from N1, N2, N3 and N4 scoria layers from 6 cent. to 9 cent.(Kawanabe, 2012) at Izu-Oshima and Fuji Hoei scoria (AD1707). Therefore, the origin of scoria grains in tephra patch at the depth of 1.51-1.53 m is presumed as basaltic magma of Niijima volcano. According to Kobayashi et al. (2020), Niijima Kudamaki/Atsuchi

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event started from eruptions of basaltic magma, and changed to eruption of rhyolitic magma. So, tephra patch at the depth of 1.51-1.53 m is likely correlated to tephra of Niijima Kudamaki/Atsuchi event.

References: Aoki et al. (2019a), JpGU2019, HQR05-05, Aoki et al. (2019b), JpGU2019, SVC38-P21, Aoki, K. (2020), Arai (1962), Aramaki et al., (1993), Kawanabe (2012), Kobayashi et al.(2020) , Takahashi, M., et al.(2003), Takahashi, M., et al. (2018), Takahashi, T., et al. (2020), Tsuchiya et al. (2009)

Keywords: tephrostratigraphy, Izu islands, marine sediment

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Caldera structure and formation at Atosanupuri and Akaigawa, Hokkaido, northern Japan: A comparison of analogue sandbox experiments and field data

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Calderas are volcanic depressions that are induced by inflation or deflation of magma chambers beneath volcanic edifices and are common features in volcanic areas. Various field data have been used to investigate caldera structure and to understand processes of its formation. Calderas are generally several km or more in diameter and the depth of magma chambers is often estimated over 10 km from the earth’s surface, whereas only a few caldera-forming eruptions have been observed scientifically because they are infrequent phenomena. Therefore, it is still controversial how the deeper structure of calderas is and how this is formed, because of these spatiotemporal problems. To overcome previously mentioned spatiotemporal obstacles, various analogue sandbox experiments have been carried out. The knowledge gained from sandbox experiments help us infer the inner structure of calderas and its processes of development. Analogue sandbox experiments generally attempt to simplify phenomena and structures in nature. Yet, natural calderas are under complex conditions (*e.g.*, topography, geological features, stress field). Hence, this study verifies whether sandbox experiments can simulate caldera structures and their development processes within different conditions or not, by comparing field data and results from sandbox experiments. Atosanupuri and Akaigawa that are under different condition each other are chosen as subject areas.

Atosanupuri Caldera is located in the center of Kutcharo Caldera, eastern Hokkaido, northern Japan. According to previous studies, Kutcharo Caldera was formed between 40 and 30 ka, whereas Atosanupuri Caldera was developed approximately 20 ka. Atosanupuri Caldera has L-shaped somma, and its diameter is about 3 km. Lacustrine terraces are developed around Kutcharo Lake, which is the caldera lake of Kutcharo, and remarkable uplift of these terraces is detected on the near part of Atosanupuri Caldera. On the other hand, the significant uplift of the basement and lacustrine deposits around Atosanupuri Caldera is also inferred by drilling surveys. Based on these field data, inflation of a magma chamber beneath Atosanupuri Caldera accompanied by uplift of earth’s surface is assumed. Accordingly, calderas induced by inflation of magma chambers are experimentally simulated in this section. The mixture of dry quartz sand and wheat flour is used as analogue upper crust, and columnar foamed polystyrene is employed as analogue magma chamber. The scale of models is 10^{-5}. When the initial depth of the magma chamber analogue is between 17.5 and 21 cm, a caldera whose diameters is about 3 cm is formed. Both the depth of magma chamber analogue and the size of experimental calderas and those of Atosanupuri Caldera are similar to each other. Thus Atosanupuri Caldera is quantitatively reproduced by sandbox experiments. In other words, analogue sandbox experiments are applicable to natural calderas within the conditions on Atosanupuri Caldera.

Akaigawa caldera is located at the southwestern Hokkaido, and is surrounded by the circular mountain range, which is called Yoichigawa Caldera. Akaigawa caldera is thought to have been formed between 2.0 and 1.6 Ma. The caldera is bounded by the subcircular lineament which is 4 km in diameter, and an uplift of basement is not confirmed by field data. They suggest that Akaigawa Caldera was induced by deflation of the magma chamber underlying the caldera. Thereupon a sandbox experiment that simulate deflation of magma chambers is carried out in this section. The scale, apparatus, and material are same as the previous section. Subcircular or circular calderas are reproduced by deflation of the magma chamber

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analogue. However, all calderas reproduced in this section are smaller in diameter than scaled Akaigawa Caldera. The caldera may have been influenced by the pre-existing structure, namely, Yoichigawa Caldera. Further field data and analogue experiments are required to verify this hypothesis.

Keywords: Caldera, Analogue experiments, Atosanupuri Caldera, Akaigawa Caldera

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Current state evaluation and long-term prediction of volcanic activity based on historical tracking of volcanic ash deposits at Suwanosejima volcano

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It would be one of the largest interests for geologists engaged in eruption prediction whether or not the deposits of ancient eruption provide any informative sign or precursor for the next serious eruption. Suwanosejima volcano is one of the most active volcanoes in Japan, and continuously releases volcanic ash. Previous studies on the stratigraphy have revealed that this volcano has been active almost continuously for about 4000 years with thick ashy deposit. On the other hand, during this period, sub-Plinian-scale eruptions that settled thick scoria layers have occurred every several hundred to one thousand years (Shimano et al., 2013). Regarding the long-term activity transition and disaster mitigation, we should understand the cause of such bimodality in eruptive activity and the mechanism of transition toward vigorous eruption (eg. VEI >4). It is because similar transition is commonly reported in geological time scale from many active volcanoes that release volcanic ash for a long period of time. It thus would be worth accumulating time-sequence of such long-term record in detail by ancient activity, and comparing with that of current activity. Then, if any sign of larger scale eruption could be obtained in advance during ash eruption period, which is relatively less active, it would surely reduce disasters caused by larger eruptions.
In this study, we report the characteristics of the volcanic ash that erupted during an activation from the end of 2020 up to date, and compare with that of the ejecta over the past 20 years based on systematic petrological analysis of time-series samples. Then, we interpret this time sequence of eruptive products based on the comparison with ash layers leading up to the latest sub-Plinian eruption of the 1813 eruption. The matrix glass composition of the recent 20 years has been relatively similar, including the 2020-21 products, but minor changes are observed with crystallization at shallow depth, probably reflecting magma ascent rate leading to small temporal changes in eruption styles. On the contrary, the pattern of glass composition from the pre-1813 ash up to the climactic sub-plinian phase changes systematically with SiO2 decrease and MgO increase. In addition, MgO increases as a stepwise manner which is followed by K2O increase due to microlite crystallization at shallow depth. We interpret such temporal change in glass composition to reflect evolution of magmatic system as well as magma ascent. Current state of the volcanic activity of Suwanosejima is less active than that for urgent sub-Plinian activity, because there is no clear evidence of large or frequent input of mafic magma as a precursory sign.

Keywords: volcanic ash, magma plumbing system, Suwanosejima, mid- to long-term prediction

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

Sat. Jun 5, 2021 10:45 AM - 11:30 AM JST | Sat. Jun 5, 2021 1:45 AM - 2:30 AM UTC | Ch.25 Zoom Room 25

[S-VC28] Active Volcanism

convener:Yuta Maeda(Nagoya University), Takahiro Miwa(National research institute for earth science and disaster prevention), Takeshi Matsushima(Institute of Seismology and Volcanology, Faculty of Science, Kyushu University), Chairperson:Urumu Tsunogai(Graduate School of Environmental Studies, Nagoya University), Takeshi Ohba(Department of chemistry, School of Science, Tokia University)

This session discusses various aspects of active volcanisms including, but not limited to, rec ent and historical eruptions, various phenomena associated with the volcanic activities, und erground structures of the volcanoes, and developments of new instruments based on geop hysical, geochemical, geological, and multidiscipline approaches. We also welcome studies o n 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

[SVC28-25] Behavior of magmatic components in fumarolic gases related to the 2018 phreatic eruption at Ebinokogen Ioyama volcano, Kirishima Volcanic Group, Kyushu, Japan

*Takeshi Ohba[1], Muga Yaguchi[2], Urumu Tsunogai[3], Masanori Ito[3], Ryo Shingubara[3] (1.Department of chemistry, School of Science, Tokia University, 2.Meteorol. Res. Inst., 3.Grad. School of Envir. Studies Nagoya University)

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

[SVC28-26] Time variation in the composition of volcanic gases at Mt Hakone (2018-2020)

*Seiya Toyoshima[1], Nozomi Numanami[1], Takeshi Ohba[1], Muga Yaguchi[2] (1.Tokai University, 2.Meteorological Research Institute, JMA)

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

[SVC28-27] **Development of an automatic volcanic plume sampler SelPS for UAS**

*Urumu Tsunogai[1], Ryo Shingubara[1], Masanori Ito[1], Yuhei Morishita[1], Fumiko Nakagawa[1], Shin Yoshikawa[2], Mitsuru Utsugi[2], Akihiko Yokoo[2] (1.Graduate School of Environmental Studies, Nagoya University, 2.Graduate School of Science, Kyoto University)

Behavior of magmatic components in fumarolic gases related to the 2018 phreatic eruption at Ebinokogen Ioyama volcano, Kirishima Volcanic Group, Kyushu, Japan

*Takeshi Ohba[1], Muga Yaguchi[2], Urumu Tsunogai[3], Masanori Ito[3], Ryo Shingubara[3]

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Direct sampling and analysis of volcanic gas was conducted at three fumaroles on Ebinokogen Ioyama volcano, Japan, between December 2015 and July 2020. Notable changes in the chemical composition of gases related to volcanic activity included a sharp increase in SO2 and H2 concentrations in May 2017 and March 2018. The analyses in March 2018 immediately preceded the April 2018 eruption at Ioyama volcano. The isotopic ratios of H2O in fumarolic gas suggested the formation of fumarolic gas. Up to 49% high enthalpy magmatic vapor mixed with 51% of cold local meteoric water to generate coexisting vapor and liquid phases at 100-160C. Portions of the vapor and liquid phases were discharged as fumarolic gases and hot spring water. The CO2/SO2 ratio of the fumarolic gas was higher than that previously estimated for magmatic vapor due to SO2 hydrolysis during the formation of the vapor phase. When the flux of the magmatic vapor was high, effects of hydrolysis were small resulting in low CO2/SO2 ratios in fumarolic gases. The high apparent equilibrium temperature (AETS) defined for reactions involving SO2, H2S, H2 and H2O, together with low CO2/SO2 and H2S/SO2 ratios were regarded to be precursor signals of fumarolic gas prior to the phreatic eruption at Ioyama volcano. The apparent equilibrium temperature (AETD) obtained from the hydrogen isotope ratio of H2O and H2 also increased significantly in May 2017 and March 2018, but there were cases where the changes did not coordinate between the fumaroles. For example, AETD of one fumarole increased, but AETD of another fumarole decreased at the same time. The distance between fumaroles is at most 200 m, and it is estimated that AETD is influenced by the phenomenon occurring in the shallow underground. AETS increased rapidly in May 2017 and March 2018 suggesting an increased flux of magmatic vapor. Between September 2017 and January 2018, AETS was low suggesting the suppression of magmatic vapor flux. During this period, magmatic eruptions took place at Shinmoedake volcano 5 km away from Ioyama volcano. We conclude that magma sealing and transport to Shinmoedake volcano occurred simultaneously in the magma chamber beneath Ioyama volcano.

Keywords: Phreatic eruption, Volcanic gas, SO2

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Time variation in the composition of volcanic gases at Mt Hakone (2018-2020)

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Mt. Hakone is an active volcano located in the western part of Kanagawa prefecture. Earthquake swarms began at the end of April 2015, and a small phreatic eruption occurred on June 29. After that, earthquake swarms occurred again in May 2019. Even now, volcanic gas is actively discharged from fumaroles in Owakudani geothermal area. In this study, we consider the volcanic activity of Mt. Hakone after 2018 based on the changes in the chemical composition of volcanic gas.

Volcanic gases were collected at three fumaroles in Owakudani (N, C) and Kamiyuba (S) once a month. The fumarole C was formed during a phreatic eruption in 2015. The chemical composition of C is similar to the steam composition of the adjacent No. 52 steam well with depth of 500 m, suggesting that the fumarole of C is representative of gas around 500 m beneath surface (Ohba et al, 2019). Titanium pipe was inserted into the fumarole to collect volcanic gas, and the interstice between the tube and the outlet of fumarole was closed with soil to prevent air contamination. Titanium pipe was connected to a rubber tube, and volcanic gas was collected by an absorption tube containing a mixed solution of potassium iodate and potassium iodide, and vacuum glass bottle containing potassium hydroxide. The composition of the collected volcanic gas was analyzed using gravimetric analysis for H2S and SO2, microdiffusion analysis for CO2, and gas chromatography for other components.

The CO2/H2S molar ratios at all points increased in harmony with the increase in the number of earthquakes observed by the Japan Meteorological Agency, peaking in August 2019. After that, it decreased at N and C, but the CO2/H2S molar ratio of S did not decrease, which increased slightly after the swarm earthquake. The SO2/H2S molar ratio increased at C to a peak in August 2019 and then decreased. In the SO2-CO2-H2S ternary diagram (Stix and de Moor, 2018), the positions of the three points were significantly different. N and S were distributed near the edge connecting the CO2 and H2S vertex because of the scarcity of SO2. Since C contains relatively high concentrations of SO2, it deviated from the edge connecting the CO2 and H2S vertices and was distributed on the line with CO2/SO2 molar ratio of about 5. N and S moved slightly toward the H2S vertex overall in 2018, but moved toward the CO2 vertex from January to August 2019, and then back toward the H2S vertex. C moved away from the H2S vertex along the line with CO2/SO2 molar ratio of about 5 from January to August 2019, and then back toward the H2S vertex.

From the variation of CO2/H2S and SO2/H2S molar ratios, it is estimated that the magmatic gas supply to the hydrothermal system of Mt. Hakone peaked in August 2019. This variation was in harmony with the increase and decrease in the number of earthquakes. After that, the activity was quieted down. Since the positions of N, S and C are significantly different in the ternary diagram, it is suggested that the process from the generation process of volcanic gas is significantly different. Fumarole C is considered to have a large magmatic contribution than other points because of the large variation in the CO2/H2S and SO2/H2S molar ratios and the high concentration of SO2. Fumarole S was distributed in the direction to the CO2 vertex compared to the other two points. The relatively small variation in the CO2/H2S ratio and the enrichment in CO2 suggest that the sulfur component of S was removed during its passage through the shallow aquifer and became relatively rich in CO2.

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References

Ohba T, Yaguchi M, Nishino K, Numanami N, Daita Y, Sukigara C, Ito M, Tsunogai U (2019) Earth, Planets and Space, doi.org/10.1186/s40623-019-1027-5

Stix J, de Moor J M (2018) Earth Planets Space, doi.org/10.1186/s40623-018-0855-z

Keywords: Mt. Hakone, Volcanic gas, Phreatic eruption

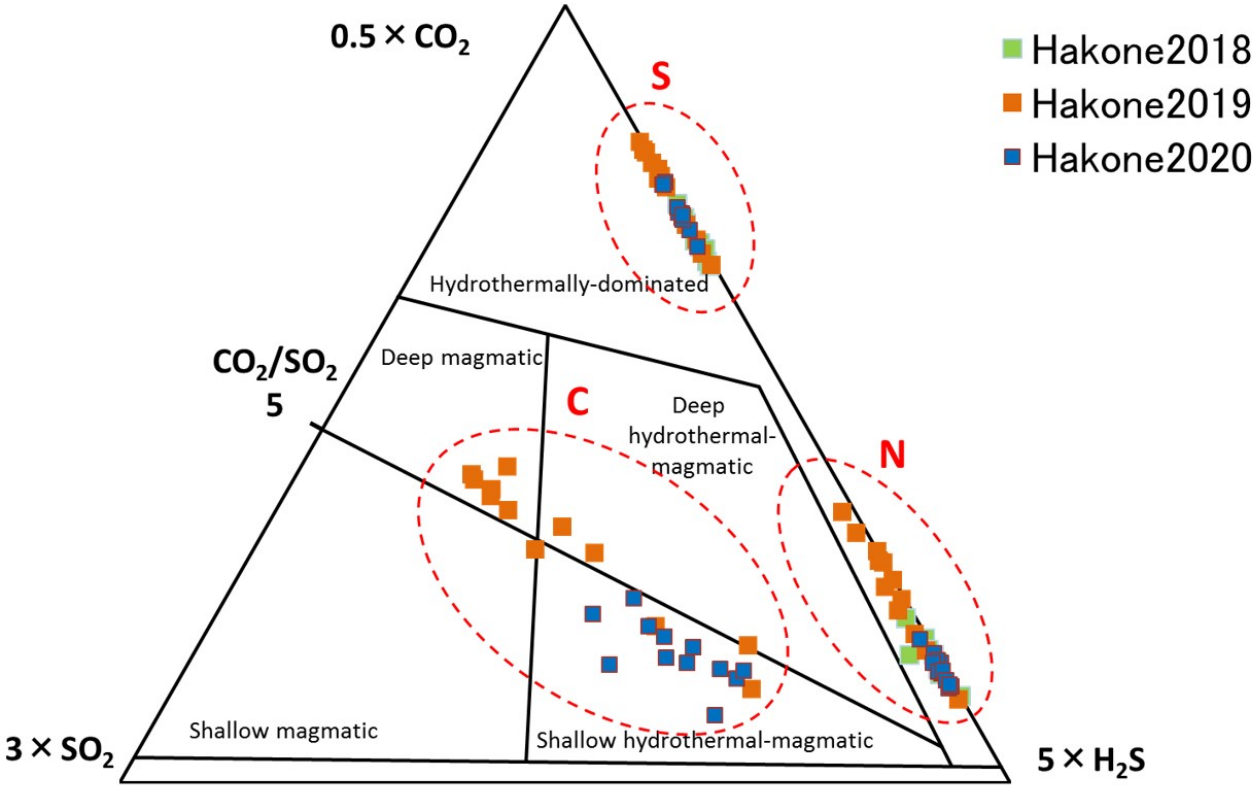

Fig.1
SO2-CO2-H2S ternary diagram for April 2018 to December 2020. Areas showing the origin of each volcanic gas component in the figure are based on Stix and de Moor (2018).

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Development of an automatic volcanic plume sampler SelPS for UAS

*Urumu Tsunogai[1], Ryo Shingubara[1], Masanori Ito[1], Yuhei Morishita[1], Fumiko Nakagawa[1], Shin Yoshikawa[2], Mitsuru Utsugi[2], Akihiko Yokoo[2]

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Both chemical and isotopic compositions of volcanic plumes are highly useful in evaluating the present status of active volcanoes. Monitoring their temporal changes can facilitate the forecasts of volcanic activity as well. In the present study, we developed a drone-borne automatic sampler for volcanic plumes in which an output signal from a sulfur dioxide (SO_2) sensor triggered a pump to collect samples when its SO_2 concentration exceeded a predefined threshold. We fitted the sampler on a drone at Nakadake central cone, Aso volcano, Japan, where only the crater rim was accessible.

In the sampling campaign done on October 2020, good consistency in isotope ratios ($^2H/^1H$) of molecular hydrogen (H_2) between samples collected by the automatic sampler and those collected directly into pre-evacuated flasks was obtained. Furthermore, by using the drone-borne sampler at Aso volcano, we obtained plume samples with much higher concentrations of H_2 and carbon dioxide (CO_2) than those taken directly into flasks at the crater rim. Our sampler can be utilized to collect volcanic plume samples for the determination of stable isotopic compositions in general by subsequent laboratory analysis and the remote establishment of fumarole outlet temperature based on the $^2H/^1H$ ratios of hydrogen, including their temporal changes. This study was supported by MEXT Integrated Program for Next Generation Volcano Research and Human Resource Development (Theme B).

Keywords: fumarolic gases, volcanic plume, carbon dioxide, Unoccupied Aerial Systems, automatic volcanic plume sampler

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

Sat. Jun 5, 2021 1:45 PM - 3:15 PM JST | Sat. Jun 5, 2021 4:45 AM - 6:15 AM UTC | Ch.25 Zoom Room 25

[S-VC31] Dynamics of volcanic eruptions and their physical and chemical processes

convener:Yujiro Suzuki(Earthquake Research Institute, The University of Tokyo), Atsuko Namiki(Graduate School of Environmental Studies, Nagoya University), Masatoshi Ohashi(Earthquake Research Institute, the University of Tokyo), Chairperson:Yujiro Suzuki(Earthquake Research Institute, The University of Tokyo), Masatoshi Ohashi(Earthquake Research Institute, the University of Tokyo)

A Volcanic eruption is a hazardous phenomenon that results from a sequence of coupled processes, including storage in the subsurface and ascent to the surface. The volcanic gas exsolving from the ascending magma generates bubbles, which influence both the potential energy of the magma (density) and its resistance to flow (viscosity). Bubbles can sometimes deform and/or fragment the surrounding magma, leading up to explosive eruptions that develop volcanic plumes and/or pyroclastic flows. A broad range of approaches is required to tackle these processes and better understand the factors that govern the physics of explosive eruptions. We welcome contributions from interdisciplinary approaches, including, geophysical observations of active/quiet volcanoes, geochemical measurements of eruptive products, theoretical approaches, and numerical simulations, and laboratory experiments designed to explore the fundamental processes underlying explosive volcanism.

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

[SVC31-01] Experimental constraint on redox evolution of magma during decompression

★Invited Papers

*Satoshi Okumura[1], Hidemi Ishibashi[2], Shoichi Itoh[3], Akimasa Suzumura[3], Yoshihiro Furukawa[1], Takahiro Miwa[4], Hiroyuki Kagi[5] (1.Division of Earth and Planetary Materials Science, Department of Earth Science, Graduate School of Science, Tohoku University, 2.Department of Geosciences, Fuculty of Science, Shizuoka University, 3.Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University, 4.National Research Institute for Earth Science and Disaster Resilience, 5.Geochemical Research Center, Graduate School of Science, The University of Tokyo)

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

[SVC31-02] Factors affecting the sequence of Asama volcano 1783 eruption inferred from rock texture

*Tatsuki Mizuno[1], Fukashi Maeno[1], Atsushi Yasuda[1] (1.Earthquake Research Institute, Department of Earth and Planetary Science, University of Tokyo)

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

[SVC31-03] Genesis of vesiculation in dolerite sills of the Shimokawa ophiolite in the northern Hidaka belt, Hokkaido: Genesis of trachyte in the MORB

*Kato Satomi[1], Sumio Miyashita[2] (1.Graduate School of Science and Technology, Niigata University, 2.Hokkaido Research Center of Geology)

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

[SVC31-04] Discussion time

*Yujiro Suzuki[1] (1.Earthquake Research Institute, The University of Tokyo)

Experimental constraint on redox evolution of magma during decompression

*Satoshi Okumura[1], Hidemi Ishibashi[2], Shoichi Itoh[3], Akimasa Suzumura[3], Yoshihiro Furukawa[1], Takahiro Miwa[4], Hiroyuki Kagi[5]

1. Division of Earth and Planetary Materials Science, Department of Earth Science, Graduate School of Science, Tohoku University, 2. Department of Geosciences, Fuculty of Science, Shizuoka University, 3. Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University, 4. National Research Institute for Earth Science and Disaster Resilience, 5. Geochemical Research Center, Graduate School of Science, The University of Tokyo

Redox condition of magma controls stable mineral phases and coexisting chemical species of volcanic gases; hence, its information is essential to the understanding of magmatism in the crust and volcanic eruption. A recent petrological study (Waters and Lange, 2016) demonstrated that redox condition of hydrous rhyolite is not changed during magma ascent to the surface. However, this conflicts with laboratory experiments, that is, strongly oxidation of hydrous rhyolite during decompression was observed from decompression experiments (Humphreys et al. 2015). To resolve this problem, we focused on sulfur that is a major volatile component in magma but not considered in previous studies, and experimentally investigated redox evolution of sulfur-bearing hydrous rhyolite during decompression.

We performed decompression experiments for sulfur-bearing hydrous rhyolitic glasses. The glassy samples were sealed in a gold tube and heated at 800˚C under 100 MPa in a cold-seal pressure vessel. The continuous decompressions to 10, 30 and 50 MPa were isothermally carried out with rates of 10 and 100 MPa/h. The run products were observed under SEM. Bulk sulfur contents of the samples and water and sulfur contents in glass parts of the samples were measured using EA and SIMS, respectively. To investigate redox evolution, the Fe K-edge XANES spectra of the glass parts were measured and ferric to total iron ratio (Fe^{3+}/Fe_{total}) was determined based on the calibration using standard samples on loan from the National Museum of Natural History, Smithsonian Institution. The oxygen fugacity (fO_2) was calculated from the measured Fe^{3+}/Fe_{total} value and the empirical relationship between the Fe^{3+}/Fe_{total} ratio and fO_2 (Kress and Carmichael, 1991).

Our experimental results showed that the fO_2 slightly decreases with decompression. No clear effect of decompression rate was observed. The water contents decreased with decompression and were almost consistent with equilibrium solubility. In contrast, the sulfur contents showed a slight decrease during decompression from 100 to 50 MPa and then no clear increase and decrease during additional decompression.

The results obtained were compared with the redox evolution predicted from the thermodynamic model of Burgisser et al. (2015). The model shows that magma is reduced if the existence of a pre-exsolved fluid phase is assumed, while magma is oxidized when it contains only water or no pre-exsolved fluid phases. This is because sulfur buffers the oxidation of magma through a reaction with oxygen in the fluid phase. In our experiments, pre-exsolved fluid phase existed and the experimental and theoretical redox evolutions are qualitatively consistent. Based on these results, we inferred that the redox condition of sulfur-bearing hydrous magma is not oxidized during explosive volcanism with a pre-exsolved fluid phase and closed-system degassing. In contrast, if magma contains only water or sulfur-bearing hydrous magma experiences open-system degassing, it may be oxidized. Finally, we conclude that the effects of fluid composition, pre-exsolved fluid phases, and degassing processes on redox evolution must be evaluated to

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understand redox evolution during decompression and thus to determine redox condition of magma reservoir.

Keywords: magma, redox condition, decompression, water, sulfur

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Factors affecting the sequence of Asama volcano 1783 eruption inferred from rock texture

*Tatsuki Mizuno[1], Fukashi Maeno[1], Atsushi Yasuda[1]

1. Earthquake Research Institute, Department of Earth and Planetary Science, University of Tokyo

Plinian eruption is characterized by a large, sustained column, and often changes into pyroclastic flow eruptions. Determining how the eruptive style changes is important for predicting such volcanic activity. Processes during magma ascent such as crystallization, degassing, and vesiculation are reflected in rock texture, thus analyses of rock texture are important to constrain magma ascent process. In this study, we focus on the 1783 eruption of Asama Volcano, and discuss the mechanism of eruption transition through analysis of chemical composition and observation of rock texture. In the climactic phase of 1783 eruption, Plinian column was generated and pumice-fall deposits are formed at first, then eruptive style changed to pyroclastic flow later. Pumice-fall deposits are divided into 14 layers. Upper half of deposits were formed in climactic phase. In the middle level of deposits, there are some reddish-brown silt layer which might come from pyroclastic flows before climactic phase. Each layer in the middle level contain more than 10 wt.% of juvenile lava fragments.

The 14 layers of Pumice-fall deposits and two types of pyroclastic flow deposits are chosen for measurement of density, microscopy, and chemical analysis. The average apparent densities range 0.7-0.8 g/cm^3 for fall deposits, 0.8-0.9 g/cm^3 and >1.20 g/cm^3 for pyroclastic flow deposits. Groundmass glass is heterogeneous in some cases, and SiO_2 content shows bimodal distribution around 67 wt.% and 73 wt.%. Pyroclastic flow deposits have lower SiO2 glass than pumice-fall deposits. Magma temperature (T) and water content (Cw) are estimated based on the compositions of plagioclase and glass matrix (Putirka, 2008; Waters and Lange, 2015). For pyroclastic flow deposits (67 wt.% in SiO_2), T = 1030-1090℃ and Cw = 1.6-2.0 wt.%. For pyroclastic fall deposits (73 wt % in SiO_2), T = 960-1000℃ and Cw = 1.9-2.3 wt.%. Bubble size distribution is basically bimodal, which is characterized by bubbles smaller than 100 μm that were formed just before the eruption and bubbles larger than 100 μm that were strongly affected by coalescence or formed in the magma reservoir. Bubbles smaller than 5 μm are significantly included in pumices from the pyroclastic flow deposits. The bubble number density (BND) is about 10^{14}-10^{15} (bubbles/m^3). Using the method of Toramaru (2006) and BND, SiO_2 content, water content, and temperature, decompression rates were estimated to be 4.2-12 MPa/s for fall deposits, 16-21 MPa/s for fall deposit with reddish ash, and 15-36 MPa/s for pyroclastic flow deposits, respectively. These values are significantly larger than the decompression rate estimated in assumption of steady-state ascent, suggesting that the magma ascent for the 1783 eruption cannot be explained by steady state process.

Increase of juvenile lava fragments in the deposits of pyroclastic flow phases suggests that the lava-plug was formed onto the upper conduit. In this situation, when the lava-plug was ruptured, the rapid decompression may cause bubble nucleation effectively. In the pyroclastic flow deposit, small size bubbles less than 5 μm are remarkable and they show high number density. Such pyroclasts also have low vesicularity. In the pyroclastic flow phase, bubble growth and coalescence were not promoted. This suggests that the time between bubble nucleation and magma fragmentation might be shorter due to deeper fragmentation front. Based on the observation that amount of non-juvenile fragments are not significantly changed, a significant increase of the vent radius and decrease in the exit velocity are unlikely. If the time between decompression (thus bubble nucleation) and magma fragmentation was

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shorter, the amount of gas precipitated into the gas phase will decrease and may not be easily separated from pyroclastic particles to outside without promoting coalescence of bubbles. This process will reduce the amount of gas supplied to the plume and is possible to contribute to generate pyroclastic flows.

Keywords: Asama Volcano, eruptive style, magma ascent process

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Genesis of vesiculation in dolerite sills of the Shimokawa ophiolite in the northern Hidaka belt, Hokkaido: Genesis of trachyte in the MORB

*Kato Satomi[1], Sumio Miyashita[2]

1. Graduate School of Science and Technology, Niigata University, 2. Hokkaido Research Center of Geology

Highly vesiculated dolerite sills are found in three places in the Shimokawa ophiolite. Dolerites which intruded into soft sediments are considerably vesiculated up to 10 % (Miyashita, 1999). Highly vesiculated dolerite sill 1 has different texture and vesiculation texture between the margin part and inside part. There are few researches dealing with texture and vesiculation texture. In this presentation, we clarified texture and vesiculation texture and examined a process of vesiculation in the dolerite sill. We present new finding of Ab-Kfs veins and aggregates. Based of the geological and chemical features of the Ab-Kfs veins and aggregate, we examined the formation process.

The Shimokawa ophiolite is exposed in the northern part of central Hokkaido. Serpentinized harzburgite and gabbro occur at the lowest part. The lower part of the main body consists of alternation of dolerite and sediments, the upper part consists of pillow lava, and the middle part shows intermediate features between the upper and lower parts. Dolerites show MORB features (Miyashita and Watanabe, 1988).

Highly vesiculated dolerite sill 1 about 22 to 24 m thick occurs at the lowest horizon in the highly vesiculated dolerite sills. Dolerite is composed plagioclase, clinopyroxene and opaque minerals. The marginal part of the sill shows hyalo-ophitic textures, inside part show dolerite texture, and the most upper part shows fine-grained dolerite texture. Vesicles are irregular shape, about 1 mm^2 size, filled with chlorite and quartz. We measured vesicularities of 22 samples. The marginal part within 50 cm from the contact is not vesiculated. Vesicularities increase as much as 10 vol % upward until about 18 m from the lower contact. But dolerites containing Ab-Kfs veins show high vesicularity. Plagioclase number densities (PND) show a systematic variation. The margin shows a high value (40 number/mm^2) and inside shows low values (4-6 number/mm^2), implying that the margin is fine-grained and inside is coarse-grained. The PND of basalt containing the Ab-Kfs vein is higher than the surrounding rocks (15 number/mm^2), indicating fine-grained than the surrounding basalts. Above facts suggest that the Ab-Kfs veins were formed before the solidification of the sills.

The Ab-Kfs vein and aggregates are found from 8 locations in the highly vesiculated dolerite sill 1. In the marginal part of the sill the Ab-Kfs aggregates appearing intergranular crystals, show irregular shape and $<100\,\mu m^2$ size. The Ab-Kfs veins are >2 mm width and thicker than later calcite veins. The border of the Ab-Kfs vein is not straight and waves. It is noted that the Ab-Kfs veins do not cut primary igneous crystals. The Ab-Kfs veins and aggregates are mostly composed of albite and K-feldspar. The bulk composition of the veins estimated from averaged analyses from 44 spot measured by SEM-EDS exhibits a trachytic composition (IUGS igneous rock classification). The bulk compositions are also estimated from color mapping and mineral analyses by EPMA-WDS of the vein and shows again similar trachytic composition. The Ab-Kfs veins have irregular shaped vesicles of 3 mm^2 size which are filled with chlorite and quartz. It’s difficult that trachyte melts were produced by fractional crystallization of MORB magma. Trachyte melts are brought from outside the dolerite sill.

The Shimokawa ophiolite generally shows poor vesiculation. Dolerite sill 1 shows high vesiculation except for the chilled margin. PND analyses show a systematic variation. The margin shows a fine-grained and

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inside shows coarse-grained. Texture made by crystallization after magma intrudes. The chilled margin is not vesiculated, but inside of the sill is vesiculated > 5 %. We found 2 type of Ab-Kfs aggregates one is vein in the inside parts, the other is aggregates in the chilled margin. Composition of the Ab-Kfs vein is trachytic. Here we show trachytic melts is interstitial melt brought from outside the MORB magma. Surrounding dolerites of the Ab-Kfs veins are highly vesiculated. Therefore, the Ab-Kfs veins release volatile components into magma. The factor of the high vesiculation in the dolerite sill 1 is multiple.

[1]Miyashita and Watanabe, 1988. [2]Miyashita, 1999.

Keywords: Hokkaito Hidaka belt, dorelite sill, Shimokawa ophiolite, vesiculation

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Discussion time

*Yujiro Suzuki[1]

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Poster presenters can give a flash talk within 3 minutes.

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

Sat. Jun 5, 2021 3:30 PM - 5:00 PM JST | Sat. Jun 5, 2021 6:30 AM - 8:00 AM UTC | Ch.25 Zoom Room 25

[S-VC31] Dynamics of volcanic eruptions and their physical and chemical processes

convener:Yujiro Suzuki(Earthquake Research Institute, The University of Tokyo), Atsuko Namiki(Graduate School of Environmental Studies, Nagoya University), Masatoshi Ohashi(Earthquake Research Institute, the University of Tokyo), Chairperson:Atsuko Namiki(Graduate School of Environmental Studies, Nagoya University), Masatoshi Ohashi(Earthquake Research Institute, the University of Tokyo)

A Volcanic eruption is a hazardous phenomenon that results from a sequence of coupled processes, including storage in the subsurface and ascent to the surface. The volcanic gas exsolving from the ascending magma generates bubbles, which influence both the potential energy of the magma (density) and its resistance to flow (viscosity). Bubbles can sometimes deform and/or fragment the surrounding magma, leading up to explosive eruptions that develop volcanic plumes and/or pyroclastic flows. A broad range of approaches is required to tackle these processes and better understand the factors that govern the physics of explosive eruptions. We welcome contributions from interdisciplinary approaches, including, geophysical observations of active/quiet volcanoes, geochemical measurements of eruptive products, theoretical approaches, and numerical simulations, and laboratory experiments designed to explore the fundamental processes underlying explosive volcanism.

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

[SVC31-05] The run-out distance of large-scale pyroclastic density currents in magmatic and phreatomagmatic eruptions: Numerical simulations of a two-layer depth-averaged model

*Hiroyuki A. Shimizu[1], Takehiro Koyaguchi[2], Yujiro J. Suzuki[2] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Earthquake Research Institute, The University of Tokyo)

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

[SVC31-06] Effects of the dynamics of conduit flow with a plug on pre-eruptive crustal deformation

*Tomofumi Kozono[1], Chihiro Matsuno[2] (1.Department of Geophysics, Graduate School of Science, Tohoku University, 2.IDAJ Co., LTD.)

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

[SVC31-07] Volcanic glow fluctuation prior to vulcanian eruptions at Showa Crater, Sakurajima volcano, Japan

*Dan Muramatsu[1], Koki Aizawa[2], Akihiko Yokoo[3], Masato Iguchi[4] (1.Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2.Institute of Seismology and Volcanology, Faculty of Science, Kyushu University, 3.Aso Volcanological Laboratory, Institute for Geothermal Sciences, Kyoto University, 4.Sakurajima Volcano Research Center, Disaster Prevention Reserach Institute, Kyoto University)

4:15 PM - 4:45 PM JST | 7:15 AM - 7:45 AM UTC

[SVC31-08] Discussion time

*Atsuko Namiki[1] (1.Graduate School of Environmental Studies, Nagoya University)

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

[SVC31-09] Discussion

The run-out distance of large-scale pyroclastic density currents in magmatic and phreatomagmatic eruptions: Numerical simulations of a two-layer depth-averaged model

*Hiroyuki A. Shimizu[1], Takehiro Koyaguchi[2], Yujiro J. Suzuki[2]

1. National Research Institute for Earth Science and Disaster Resilience, 2. Earthquake Research Institute, The University of Tokyo

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 PDCs (i.e., the extent of PDC deposits) and the eruption conditions (e.g., the magma discharge rate and the mass fraction of external surface water mixed with the magma) is desired to mitigate volcanic hazard associated with explosive eruptions. In particular, the effect of the surface-water mass fraction is a key issue, because it closely relates to the eruption style (i.e., magmatic and phreatomagmatic eruptions). This study aims to clarify the effect of surface water on the run-out distance of large-scale PDCs on the basis of numerical simulations of PDC dynamics.

PDC is a gravity current with strong stratification of particle concentrations; its run-out distance is determined by lift-off of the upper dilute current (particle concentrations <~1 vol.%) or deposition of the lower dense current (~10-50 vol.%). In order to reproduce this basic property, we have developed a two-layer depth-averaged model. This model can evaluate the effect of the temperature decrease due to surface water on the PDC dynamics through the suppression of the thermal expansion of the entrained air in the dilute current (e.g., Shimizu et al., 2019, JpGU Meeting, SVC37-09). In addition, this study considers the phase change between water vapor and liquid water and the latent heat associated with the phase change on the basis of the fact that the temperature of PDCs can become less than 100℃ by a large amount of surface water. We assume that a homogeneous mixture consisting of magma and surface water is steadily supplied during time >0 from the source vent and it spreads as a two-layer PDC radially from the source along the horizontal ground surface. We performed a parametric study for various mass fractions of surface water at the source (i.e., (mass of surface water)/(mass of magma and surface water)=0-0.5).

The numerical results show that as the dilute current spreads from the source, its flow 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 the front position and the source position is referred to as r_U). Particles settling from the base of the dilute current form a thin dense current, which also spreads radially. When the radial mass flux of the dense current at the front is balanced with the basal deposition rate, the dense current stops forward propagation and converges to a steady state (the distance between the front position and the source position is referred to as r_L). The results of the parametric study show that the relative magnitude between r_U and r_L depends on the surface-water mass fraction at the source; r_U is shorter than r_L when the surface-water mass fraction is small (<~0.2), whereas r_U is longer than r_L when the surface-water mass fraction is large (>~0.2). This variation comes from the fact that the lift-off distance of the dilute current (i.e., r_U) significantly increases as the surface-water mass fraction at the source increases. The increase in r_U results from the delay of

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lift-off caused by two factors: (1) the suppression of the thermal expansion of the entrained air and (2) the increase in flow density due to the condensation of water vapor. The results for large surface-water mass fractions (i.e., $r_U > r_L$) 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, Magmatic eruption, Phreatomagmatic eruption, Ignimbrite

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Effects of the dynamics of conduit flow with a plug on pre-eruptive crustal deformation

*Tomofumi Kozono[1], Chihiro Matsuno[2]

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Pre-eruptive crustal deformation is one of the key observations for eruption precursors, and it is caused by complex magma dynamics in volcanic conduit and magma chamber. In particular, the magma flow in the conduit (i.e., the conduit flow) shows wide variations in pressure, velocity, and magma viscosity during magma ascent, which may lead to a drastic crustal deformation. Most previous studies for conduit flow modeling have mainly focused on eruption phases such as effusive and explosive eruptions and a transition process between them. In this study, for the sake of modeling a pre-eruptive process in the conduit, we developed a 1-dimensional conduit flow model in which a formation of a solid plug beneath the vent is considered. By combining this model with a model for an elastic deformation of crust surrounding the conduit-chamber system, we investigated how the conduit flow dynamics affect the pre-eruptive crustal deformation which can be geodetically measured such as by tiltmeters and strainmeters.

The conduit flow model is based on Kozono and Koyaguchi (2012) and Wong et al. (2017), in which the magma ascent velocity is described by the sum of the velocity of viscous flow and that of the solid plug. In the viscous flow, essential processes controlling magma dynamics such as equilibrium vesiculation, vertical and lateral gas escapes, crystallization kinetics, and magma viscosity change are considered. The solid plug frictionally slips on the conduit wall, following rate-dependent friction law. The transition from the viscous flow to the solid plug is assumed to occur when the frictional plug velocity is greater than the viscous flow velocity. In the crustal deformation model, the elastic modulus surrounding the conduit-chamber system is set in the 2-dimensional axisymmetric domain, and we calculate the surface displacement caused by the normal and shear stresses acting on the conduit wall and the normal stress on the chamber wall which are obtained from the conduit flow model.

In the analysis of the conduit flow, we found that the solid plug is formed beneath the vent for a low magma flow rate. When the magma influx to the magma chamber reaches a critical value, the conduit-chamber system becomes unstable, leading to abrupt transition of the conduit flow accompanied by drastic increases in the magma flow rate, the magma porosity, and the overpressure inside the conduit. During the transition, the thickness of the plug decreases, and finally, the plug diminishes. This transition can be treated as a pre-eruptive process in the conduit. The analysis of the crustal deformation revealed that the increases in the overpressure and the magma ascent velocity beneath the plug cause near-field displacements just before the eruption, leading to observable tilt and strain changes. We also found that our results qualitatively agree with tilt and strain changes observed before the Vulcanian eruptions at Sakurajima volcano, suggesting that the conduit flow-plug dynamics play a key role in excitation of the pre-eruptive crustal deformation.

Keywords: Conduit flow, Crustal deformation, Numerical model, Pre-eruptive process

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Volcanic glow fluctuation prior to vulcanian eruptions at Showa Crater, Sakurajima volcano, Japan

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Introduction

A volcanic glow is occasionally observed at active volcanoes, which is interpreted that radiative visible light from red-hot bodies (e.g., magma) is reflected by fumarolic gas or clouds above the crater. At Showa Crater of Sakurajima volcano, the glow sometimes appears before vulcanian eruptions. Aizawa et al. (2013, JpGU) reported that the glow intensity increases from at ~1 s before the onset of the explosion and which synchronizes with the infrasound preceding phase (Yokoo et al., 2009). In this study, we re-analyze these glow events and discuss their implications for triggering processes of vulcanian eruptions.

Methods

We analyzed visible light video recordings (30 fps) and infrasound data observed at Kurokami station (Kyoto Univ.) for 36 events from 2011 to 2012. For video recordings, we calculated R-value averaged over a rectangular range (30×60 pixels) set above the crater for each frame to quantify glow intensity. For infrasound, we shifted the waveforms to their origin times based on the estimated travel times and then compared them with the time-series change of R-value.

Results

In addition to the correspondence of glow increase and infrasound preceding phase that reported by Aizawa et al. (2013, JpGU), we found 13 events in which a gradual increase in glow intensity began 2-33 seconds before the infrasound onset. The glow gradually intensifies from a few seconds to several tens of seconds before the eruption (we call stage Ⅰ), and then increases rapidly with the onset of infrasound preceding phase (stage Ⅱ), leading to an explosion.

Discussion

Since it is thought that the lava dome (caprock) caps the crater bottom before vulcanian eruptions, thermal radiations from the exposed high-temperature body (red-hot portion) due to crack formations on the dome surface may cause the glow. In this case, based on the theory of thermal radiation, there are two possible reasons for glow intensity increase: (a) temperature increase in the red-hot portion and (b) expansion of the red-hot portion without temperature increase. Thus, we calculated G/R ratio (green light / red light) based on a methodology of color ratio pyrometry as an indicator of temperature change. Consequently, we suggest that the glow intensity increased by the mechanism (b) in stage Ⅰ and (a) in stage Ⅱ. Therefore, stage Ⅰ may reflect, e.g., the widening of cracks due to the expansion of the lava dome and accompanying expansion of the red-hot portion, and stage Ⅱ correspond to a rapid temperature increase due to an opening of crack which reaches a gas pocket beneath the caprock.

Keywords: Vulcanian eruption, Volcanic glow, Sakurajima volcano

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Discussion time

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Poster presenters can give a flash talk within 3 minutes.

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

[S-VC31] Dynamics of volcanic eruptions and their physical and chemical processes

convener:Yujiro Suzuki(Earthquake Research Institute, The University of Tokyo), Atsuko Namiki(Graduate School of Environmental Studies, Nagoya University), Masatoshi Ohashi(Earthquake Research Institute, the University of Tokyo), Chairperson:Atsuko Namiki(Graduate School of Environmental Studies, Nagoya University), Masatoshi Ohashi(Earthquake Research Institute, the University of Tokyo)

Sat. Jun 5, 2021 3:30 PM - 5:00 PM Ch.25 (Zoom Room 25)

A Volcanic eruption is a hazardous phenomenon that results from a sequence of coupled processes, including storage in the subsurface and ascent to the surface. The volcanic gas exsolving from the ascending magma generates bubbles, which influence both the potential energy of the magma (density) and its resistance to flow (viscosity). Bubbles can sometimes deform and/or fragment the surrounding magma, leading up to explosive eruptions that develop volcanic plumes and/or pyroclastic flows. A broad range of approaches is required to tackle these processes and better understand the factors that govern the physics of explosive eruptions. We welcome contributions from interdisciplinary approaches, including, geophysical observations of active/quiet volcanoes, geochemical measurements of eruptive products, theoretical approaches, and numerical simulations, and laboratory experiments designed to explore the fundamental processes underlying explosive volcanism.

4:45 PM - 5:00 PM

[SVC31-09]Discussion

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[J] Oral | S (Solid Earth Sciences)：S-GC Geochemistry

Sat. Jun 5, 2021 1:45 PM - 3:15 PM JST | Sat. Jun 5, 2021 4:45 AM - 6:15 AM UTC | Ch.24 Zoom Room 24

[S-GC33] Solid Earth Geochemistry, Cosmochemistry

convener:Gen Shimoda(Geological Survey of Japan, AIST), Katsuhiko Suzuki(Submarine Resources Research Center, Japan Agency for Marine-Earth Science and Technology), Katsuyuki Yamashita(Graduate School of Natural Science and Technology, Okayama University), Akira Ishikawa(Department of Earth and Planetary Sciences, Tokyo Institute of Technology), Chairperson:Katsuhiko Suzuki(Submarine Resources Research Center, Japan Agency for Marine-Earth Science and Technology), Katsuyuki Yamashita(Graduate School of Natural Science and Technology, Okayama University), Akira Ishikawa(Department of Earth and Planetary Sciences, Tokyo Institute of Technology), Gen Shimoda(Geological Survey of Japan, AIST)

Solid Earth Geochemistry, Cosmochemistry" session aims at evaluating processes during the 4.6 billion years of the solar system and the Earth. Any approaches to this issue is welcomed, including, geochemistry, geophysics, geology, mineralogy and petrology.

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

[SGC33-01] Highly siderophile elements in Earth's oldest rocks from Acasta Gniess Complex, Canada: an impact melt origin or not?

*Akira Ishikawa[1,2], Keiko Koshida, Katsuhiko Suzuki[2], Tetsuya Yokoyama[1], Tsuyoshi Komiya[3] (1.Department of Earth and Planetary Sciences, Tokyo Institute of Technology, 2.Submarine Resources Research Center, Japan Agency for Marine-Earth Science and Technology, 3.Graduate School of Arts and Sciences, The University of Tokyo)

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

[SGC33-02] Estimation of highly siderophile element abundances in the primitive mantle from the perspective of the pyrolite model

*Tetsu Kogiso[1], Akira Ishikawa[2], Norikatsu Akizawa[3] (1.Kyoto University, 2.Tokyo Institute of Technology, 3.The University of Tokyo)

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

[SGC33-03] Chromium and titanium stable isotope measurements for volcanic rocks derived from deep mantle

*Yuki Hibiya[1], Tsuyoshi Iizuka[2], Katsuhiko Suzuki[1], Shigekazu Yoneda[3] (1.Submarine Resources Research Center, Japan Agency for Marine-Earth Science and Technology, 2.The University of Tokyo, 3.National Museum of Nature and Science)

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

[SGC33-04] $^{182}W/^{184}W$ of the komatiites from Dharwar and Singhbhum cratons, India: implications for the early evolution of the mantle

*Katsuhiko Suzuki[1,5], Madhusoodhan Satish-Kumar[2], Trisrota Chaudhuri[3], M. Jayananda[4] (1.Submarine Resources Research Center, Japan Agency for Marine-Earth Science and Technology, 2.Department of Geology, Faculty of Science, Niigata University, 3.Department of Geology, University of Calcutta, 4.Centre Earth and Space Sciences, University of Hyderabad, 5.Department of Earth Sciences, Graduate School of Science, Tohoku University)

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

[SGC33-05] The magma generation process of the North Sredinny Range, Kamchatka – Insights from highly siderophile elements and Re-Os isotope system

Yuri Mitsude[1], *Tatsuji Nishizawa[2], Hitomi Nakamura[3], Tatiana Churikova[4], Boris Gordeychik[5], Akira Ishikawa[6], Hikaru Iwamori[1] (1.Earthquake Research Institute, The University of Tokyo, 2.Volcanic Fluid Research Center, School of Science, Tokyo Institute of Technology, 3.Institute of Earthquake and Volcano

Geology, Geological Survey of Japan, AIST, 4.Institute of Volcanology and Seismology, Far East Branch, RAS, 5.Institute of Experimental Mineralogy, RAS, 6.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

[SGC33-06] The characteristics of highly siderophile elements in the high-Mg andesite and basalts and its implications for the origin of the Quaternary arc magmatism in the forearc region, Kamchatka

*Tatsuji Nishizawa[1], Yuri Mitsude[2], Hitomi Nakamura[3], Tatiana Churikova[4], Boris Gordeychik[5], Akira Ishikawa[6], Hikaru Iwamori[2] (1.Volcanic Fluid Research Center, School of Science, Tokyo Institute of Technology, 2.Earthquake Research Institute, The University of Tokyo, 3.Institute of Earthquake and Volcano Geology, Geological Survey of Japan, AIST, 4.Institute of Volcanology and Seismology, Far East Branch, RAS, 5.Institute of Experimental Mineralogy, RAS, 6.Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology)

Highly siderophile elements in Earth's oldest rocks from Acasta Gniess Complex, Canada: an impact melt origin or not?

*Akira Ishikawa[1,2], Keiko Koshida, Katsuhiko Suzuki[2], Tetsuya Yokoyama[1], Tsuyoshi Komiya[3]

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The first billion years' history of the Earth is veiled in mystery due to the dearth of Hadean and earliest Archean rocks. Although this might be a natural outcome given the high efficiency of overprinting and reworking processes caused by plate tectonics, an important question of when plate subduction started on Earth still remains obscure. Alternatively, it has been proposed that the crust preservation was delayed by a barrage of asteroid impacts that caused global-scale melting and continuous resurfacing of Earth after a period referred to as "late heavy bombardment" on the Moon (~4.1-3.9 Ga).
A recent petrogenetic modelling suggests that the Earth's oldest evolved rocks, the 4.02 Ga Idiwhaa tonalitic gneisses of the Acasta Gneiss Complex [1], represent the predominant felsic crust at that time, which has been generated by impact melting of Hadean mafic crust [2]. We test this hypothesis by investigating abundances of highly siderophile elements (HSEs) and Re-Os isotope systematics for the Idiwhaa tonalitic gneisses collected from previously located outcrops and a newly identified exposure as a southern extension of the same unit. These tracers are considered to be sensitive for involvement of extraterrestrial components and relatively immune to secondary alteration.
Although quadruplicate measurements for each sample showed significant variations indicative of isotope and elemental heterogeneity inherent in studied samples, the preservation of Hadean HSE signatures in the Idiwhaa tonalites are supported by whole-rock Re-Os isotope data; extremely radiogenic ^{187}Os (>94% of total Os) provides a weighted mean ^{187}Re-^{187}Os model age ~4.0 Ga consistent with the U-Pb ages of zircon. Regarding HSE abundances, the Idiwhaa tonalites display strongly fractionated HSE patterns. Concentrations of common Os, Ir and Ru are low with chondrite-normalizing values ranging from 10^{-5} to 10^{-6} level. These data show no contribution of the meteoritic components to the generation of Idiwhaa tonalites, and lend no support to the hypothesis of impact melt origin.
[1] J. R. Reimink et al., Earth's earliest evolved crust generated in an Iceland-like setting. *Nature Geosci.* 7, 529–533 (2014).
[2] T. E. Johnson et al., An impact melt origin for Earth's oldest known evolved rocks. *Nature Geosci. 11*, 795–799 (2018).

Keywords: Highly siderophile elements, Re-Os isotopes, Acasta Gneiss Complex

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Estimation of highly siderophile element abundances in the primitive mantle from the perspective of the pyrolite model

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Highly siderophile elements (HSE: Ru, Rh, Pd, Re, Os, Ir, Pt and Au) are strongly concentrated in the metallic core in the Earth, and therefore their abundances in the silicate mantle are quite low (~ μg/g). Just because of the low abundances, HSE in the mantle are the key index for deciphering chemical processes involving metallic phases, such as the core-mantle segregation and subsequent core-mantle chemical interactions during the Earth's history. In particular, HSE abundances in the mantle at the time of core-mantle segregation, that is, the HSE abundances in the primitive mantle (PM), are one of the crucial constraints to know the initial condition of the chemical evolution of the mantle.
The HSE abundances in the primitive mantle (HSE_{PM} hereafter) have been estimated based on HSE concentrations of fertile peridotites, which are rich in "melt components" such as Al_2O_3, because fertile peridotites are thought to retain their pristine compositions. However, recent studies (e.g., [1]) have revealed that most of the fertile peridotites were formed by addition of basaltic melt to refractory peridotites (= refertilization). Therefore, more precise estimation of the HSE_{PM} can be done by calculation of supposed mixture of refractory peridotites (harzburgites) and refertilizing agents with basaltic composition. This calculation is just identical to the "pyrolite model" of Ringwood (e.g., [2]), which was proposed for estimating the major element composition of the primitive mantle. In fact, the major element composition of the pyrolite has widely been accepted as the representative of the Earth's mantle. This would be due to the facts that compositions of natural harzburgites are rather homogeneous and that major element compositions of the refertilizing agents (coincidentally?) resemble those of supposed melts extracted from the primitive mantle. On the other hand, HSE compositions of natural harzburgites are very variable (up to 2 orders of magnitude), which makes it difficult to select the composition of harzburgite to be used for the "pyrolitic" estimation of HSE_{PM}. Despite such difficulty, we can estimate the pyrolitic HSE abundances using compositions of the harzburgites that were not remarkably affected by secondary processes if we can properly select suitable harzburgite samples based on detailed petrography. Our preliminary estimation of the pyrolitic HSE abundances demonstrates non-chondritic relative ratios with significant depletion of Pd and Pt. This is contrary to the conventional view that the HSE_{PM} is chondritic.
[1] Le Roux V., Bodinier J.-L., Tommasi A., Alard O., Dautria J.-M., Vauchez A., Riches A.J.V. 2007. The Lherz spinel lherzolite: Refertilized rather than pristine mantle. *Earth Planet. Sci. Lett.*, 259, 599-612.
[2] Ringwood T.E. 1962. A model for the upper mantle. *J. Geophys. Res.* 67, 57-866.

Keywords: primitive mantle, highly siderophile element, platinum group element, early Earth

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Chromium and titanium stable isotope measurements for volcanic rocks derived from deep mantle

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Introduction: Recent studies have shown that the primordial signatures (e.g., those characterized by nebular $^{20}Ne/^{22}Ne$ and D/H ratio; [1, 2]) of the Earth-forming materials are preserved in the deep mantle and that they are chemically and isotopically distinct from those of the ambient upper mantle. However, it is still unclear exactly which type of planetary materials those primordial signatures correspond to, and when those materials were accreted to proto-Earth. To address these issues, we use the nucleosynthetic ^{54}Cr and ^{50}Ti anomalies, which provide information about the genetic relationship between the planetary materials especially when the two systems are combined [3]. In addition, we use the stable ^{53}Cr, a decay product of a short-lived radionuclide ^{53}Mn, which provides chronological information about the first ~20 Ma of solar system history. Attention is focused on the basalts from the Ontong Java plateau (OJP) and Samoan ocean islands (OIBs), and komatiites from the Singhbhum Craton, because these are suggested to record the Archean to modern plume-dominated environments [4-6].

Results & Discussion: We prepared OJP drill core samples provided by the Ocean Drilling Program (ODP Leg 192), basalts from the Samoan Island of Tutuila, and komatiites from the Singhbhum Craton, Eastern India. The chemical separation and purification of Cr and Ti from the samples were made following the procedure described by [7]. The recovery rates of both Cr and Ti were 90–100% for all samples. We have measured Cr and Ti stable isotope compositions of the purified samples using Thermo Fisher Scientific TRITON Plus TIMS and Neptune Plus MC-ICP-MS, respectively. The Ti isotope analyses yielded no resolvable $^{46, 48, 50}Ti$ excesses or deficits for all samples. On the other hand, the Cr isotope analyses yielded $\varepsilon^{53}Cr = 0.02 \pm 0.10$ ~ 0.12 ± 0.07 (2σ), $\varepsilon^{54}Cr = 0.10 \pm 0.12$ ~ 0.25 ± 0.07 (2σ) for the OJP basalts, $\varepsilon^{53}Cr = 0.01 \pm 0.02$ ~ 0.03 ± 0.09, $\varepsilon^{54}Cr = -0.02 \pm 0.08$ ~ 0.16 ± 0.16 for the Samoan basalts, $\varepsilon^{53}Cr = -0.04 \pm 0.08$ ~ 0.13 ± 0.10, $\varepsilon^{54}Cr = 0.02 \pm 0.07$ ~ 0.21 ± 0.05 for the Singhbhum komatiites. The resolved ^{53}Cr and ^{54}Cr excesses in some sources potentially reflect the survival of carbonaceous chondrite-like (characterized by ^{53}Cr and ^{54}Cr excesses) materials from mixing by mantle convection over geological history. However, the exponential-law corrected $\varepsilon^{53}Cr$ and $\varepsilon^{54}Cr$ of respective samples are slightly correlated with a slope of ~1–4.8. Similarly, we found the residual correlation between $\varepsilon^{53}Cr$ and $\varepsilon^{54}Cr$ for the Cr standards calculated relative to the mean of all 463 measurements over a period of two years, yielding a slope of ~1.3 (R ~ 0.84). Although the slope ~1.3 is significantly shallower than that of the residual linear mass fractionation correlation line (slope ~2) in [8-10], it is indistinguishable from the slope obtained recently for the terrestrial basalts and peridotites by [11]. We are in the process of exploring the reason for the positive correlation observed between ^{53}Cr and ^{54}Cr.

[1] Williams and Mukhopadhyay (2019) *Nature* **565** 78–81, [2] Hallis et al. (2015) *Science* **350** 795–797, [3] Warren (2011) *EPSL* **311** 93–100, [4] Rizo et al. (2016) *Science* **352** 809–812, [5] Jackson et al. (2014) *Nature* **514** 355–358, [6] Chaudhuri et al. (2017) *Precambrian Res.* **298** 385–402, [7] Hibiya et al. (2019) *GGR* **43** 133–145, [8] Lugmair and Shukolyukov (1998) *GCA* **62** 2863–2886, [9] Trinquier et al. (2006) *EPSL* **241** 780–788, [10] Qin et al. (2010) *GCA* **74**1122–1145, [11] Mougel et al. (2018) *EPSL* **481** 1–8.

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Keywords: chromium, titanium, komatiites, LIPs, OIBs, deep mantle

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$^{182}W/^{184}W$ of the komatiites from Dharwar and Singhbhum cratons, India: implications for the early evolution of the mantle

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Since Hf and W are lithophile and siderophile elements, Hf is likely to have remained in the silicate melt phase and W was preferentially partitioned to the metallic melt phase during the formation of the Earth's core. Such Hf-W fractionation is thought to have occurred before the disappearance of currently distinct ^{182}Hf, and the values of $\mu^{182}W$ (deviations from W standard in ppm) have been reported to show negative deviations from the present-day mantle value ($\mu^{182}W$ =0) in ocean island basalts such as Hawaii and Samoa (e.g., Mundl et al., 2017; Takamasa et al., 2020). In contrast, most rocks originated at depths and older than 2.5 Ga show relatively uniform $\mu^{182}W$ values of +10 to +20 (e.g., Willbold et al., 2011, Touboul et al., 2014, Liu et al., 2016, Mundl et al., 2018, Tusch et al., 2019). On the other hand, some komatiites, such as Schapenburg and Komati (both formed at 3.5 Ga), yield negative or have values near 0, respectively (Touboul et al., 2012, Puchtel et al., 2018). In addition, Mei et al. (2019) reported $\mu^{182}W$ values near 0 for 3.0 Ga Anshan komatiite. Therefore, it is still highly debated on when and how the mantle has reached the present state.

In this study, we analyzed the W isotopes of 3.3 Ga Singhbhum and Dharwar komatiites from India to determine the W isotopic variations in the mantle during the period from 3.5 Ga to 3.0 Ga. The chemical separation of W was carried out using a method modified from Takamasa et al. (2020), and isotope analysis was performed by MC-ICP-MS (Thermofisher Scientific, NEPUTUNE Plus). The $\mu^{182}W$ values ranged from -0.5 to +5.6 (n=3) and from -1.4 to +5.0 (n=4) for komatiites from the Singhbhum and Dharwar cratons, respectively. These values are also much smaller than the range of uniform $\mu^{182}W$ values (from +10 to +15) for older rocks above 2.5 Ga, as discussed above. This result suggests that between 3.5 and 3.0 Ga, the primitive mantle with positive $\mu^{182}W$ values may have been already sufficiently mixed with extraterrestrial materials such as Late Veneer with negative $\mu^{182}W$ values that some domains of the mantle had the $\mu^{182}W$ values of the present-day mantle. In other words, mantle convection may have been active as early as 3.5 Ga.

Keywords: early evolution of mantle, W isotope, komatiite

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The magma generation process of the North Sredinny Range, Kamchatka –Insights from highly siderophile elements and Re-Os isotope system

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The subduction zone is a relatively "cold place" on Earth. Observational and experimental studies in petrology, geochemistry, and geophysics suggest that magma is generated associated with the circulation of H_2O-rich fluids. A standard quantitative model has also been proposed that incorporates the following processes; generation and migration of the fluid released from the subducted plate, transportation into the mantle wedge, the melting point depression of rock, and melting to supply magma to the volcanoes. Within this framework, the structure and processes of the subducted side (i.e., arc side), such as the composition and temperature of the mantle wedge, have been extensively studied to understand the formation of arc lava. In addition to these studies, researches on the ocean area have progressed in recent years, and are being developed from the viewpoint that the material and thermal structure of the subducting ocean plate, that is, the condition of the "subducting side" has a great influence on geological processes on the arc.

For studying such a subduction zone-scale material cycle, the elemental concentrations and isotopic ratios of the island arc lava are useful as a tracer of the subducted material. In this study, we focused on highly siderophile elements (HSE) and Re-Os isotope systems, which are considered to be indicators of subduction substances and melting degree owing to the large variation in elemental partitioning of the HSE between melt/fluid and solid.

Kamchatka is one of the largest volcanic arcs in the world that has unique tectonic settings such as being adjacent to the triple junction of the plates, the significant along-arc variation of both arc magmatism and the subducting plate, and subduction of the prominent seamount chain. It is a suitable place for studying how the variable subduction conditions affects the arc magmatism. We studied North Sredinny Range (N-SR) area, which is located at the northernmost part of the long volcanic chain on the backarc side of Kamchatka and is located further north of the subducted Pacific Plate. We analyzed 30 Quaternary lava samples from the N-SR region for HSE and Re-Os isotopic ratios and discuss the volcanic processes in this region.

The Os concentrations in the N-SR lavas range from 0.0001 to 0.0814 ppb and $^{187}Os/^{188}Os$ ratios range from 0.1276 to 0.8421. The FeO*/MgO of N-SR lavas suggests fractional crystallization from a relatively undifferentiated lava. A positive correlation between Os, Ir, Ru concentrations and FeO*/MgO, and a model calculation of fractional crystallization show that the fractional crystallization of phenocryst minerals such as olivine has removed highly compatible elements including Os from the lavas. The correlation between 1/Os and $^{187}Os/^{188}Os$ ratio shows a linear relationship with different slopes for the individual sub-areas within the studied area, suggesting that each sub-area has undergone a different amount of crustal assimilation during the AFC process in the N-SR area. In addition, the Os concentration and $^{187}Os/^{188}Os$ in the mantle source were estimated from element and isotope correlations, and the fluid contribution to the source mantle estimated independently from other trace element data show that a seamount subducted in the past could exist under the N-SR area and may contribute to the generation of

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magma.

Keywords: Kamchatka, Highly Siderophile Elements (HSE), Os isotope, Assimilation and Fractional Crystallization (AFC), Arc magmatism

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The characteristics of highly siderophile elements in the high-Mg andesite and basalts and its implications for the origin of the Quaternary arc magmatism in the forearc region, Kamchatka

*Tatsuji Nishizawa[1], Yuri Mitsude[2], Hitomi Nakamura[3], Tatiana Churikova[4], Boris Gordeychik[5], Akira Ishikawa[6], Hikaru Iwamori[2]

1. Volcanic Fluid Research Center, School of Science, Tokyo Institute of Technology, 2. Earthquake Research Institute, The University of Tokyo, 3. Institute of Earthquake and Volcano Geology, Geological Survey of Japan, AIST, 4. Institute of Volcanology and Seismology, Far East Branch, RAS, 5. Institute of Experimental Mineralogy, RAS, 6. Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology

Kamchatka is a massive volcanic arc that corresponds to the subduction of the northern part of the Pacific Plate (PAP), which forms three sub-parallel volcanic belts; the Eastern Volcanic Front (EVF), the Central Kamchatka Depression (CKD), and the Sredinny Range. The Emperor Seamount Chain connected to the Hawaiian hot spot is subducting along with the PAP beneath the central part of Kamchatka. The subducting dip decreases sharply from 50˚ to 35˚ at the northern edge of the PAP slab, which causes the volcanic front from to bend from the EVF to the CKD at 55.5˚N. On the other hand, in the northestern extension of the EVF corresponding to the forearc region, there are Quaternary monogenetic cones dated at <1 Ma, the East Cone volcanic group (EC). The 16 fresh EC lavas sampled from 8 cones could be categorized into 5 rock types, including high-Mg andesite (HMA) and basalt (B). The EC lavas are primitive with low FeO*/MgO (<~1) and show typical arc-signatures such as positive Pb spikes. Based on the petrological and geochemical characteristics of EC lavas, the previous study suggests that the thermal and geochemical contributions from the subducted seamount chain have caused the temporal evolution of local arc magmatism in EC with a wide compositional range in the forearc region. For example, HMA including ultra-high-Ni olivine was derived from pyroxenite veins formed by the metasomatism of the mantle peridotite caused by silica-enriched fluids derived from the subducted seamount. On the other hand, the primitive B was generated by flux melting of the mantle peridotite source caused by silica-depleted slab fluids due to the previous metasomatism (Nishizawa et al., 2017).
In order to further elucidate the genesis of EC lavas, we focused on the highly siderophile elements (HSE) that are strongly partitioned into metal or sulfide phases. Therefore, HSE concentration in lavas could provide important information about melting and fractional processes. In this study, we analyzed the bulk-rock concentrations of Re and the platinum-group elements (PGE) including Ru, Pd, Os, Ir, and Pt. As results, the depleted mantle (DM; Salters & Stracke, 2004)-normalized HSE spidergram for EC lavas are different in each rock-type or cone, but all EC lavas are relatively depleted in iridium-PGE (I-PGE; Os, Ir, and Ru) compared to the platinum-PGE (P-PGE; Pt, Pd) and Re, which are common in volcanic rocks such as MORB and arc lavas (e.g. Gannoun, 2016). Especially, HMA and the primitive B show almost the same pattern and concentration of P-PGE and Re, but the concentration of I-PGE is in contrast. In the I-PGE concentration of EC lavas, HMA shows the lowest concentration, while the primitive B shows the highest concentration. HMA seems to have been generated by I-PGE “nugget” fractionation from the primitive B melt. In other words, the factors that determine P-PGE and Re concentration of the melts are the almost same while the factors that determine I-PGE concentration in the melts are different between HMA and the primitive B, which is an important feature of the genesis of EC lavas.
To elucidate the factors that determined the HSE concentration in the EC lavas, we performed forward calculations of primitive melt assuming the four different melting conditions: 1. bulk rock batch melting model, 2. sulfide melt entrainment model, 3. sulfide melt partitioning model, 4. sulfide melting model. These results suggest that the differences in HSE concentration between HMA and the primitive B cannot

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be explained by a simple difference in the degree of partial melting. In addition, in any case, it is difficult to reproduce the HSE concentration of the EC lavas without assuming the sulfide phase that is the main host of HSE in the mantle rocks.

Keywords: Kamchatka, Highly Siderophile Elements (HSE), Arc magmatism, High-Mg andesite, Seamount

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

Sat. Jun 5, 2021 9:00 AM - 10:30 AM JST | Sat. Jun 5, 2021 12:00 AM - 1:30 AM UTC | Ch.22 Zoom Room 22

[S-TT36] Synthetic Aperture Radar and its application

convener:Yohei Kinoshita(University of Tsukuba), Takahiro Abe(Graduate School of Bioresources, Mie University), Shoko Kobayashi(Tamagawa University), Yuji Himematsu(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Takahiro Abe(Graduate School of Bioresources, Mie University), Yohei Kinoshita(University of Tsukuba)

ALOS-2 and Sentinel-1, which have highly enhanced capacity compared to previous SAR satellites, were launched in 2014, and their utilization has been widely expanding as data have accumulated for approximately six 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, under the situation of next-generation advanced and/or constellated SAR satellite plans by both public agencies (e.g. ALOS-4 and NISAR) and 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 invite various kinds of research and application results with regard to SAR, sharing our knowledge and having a discussion for the advancement of the SAR utilization.

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

[STT36-01] Automatic error-term estimation approach for improving the accuracy of InSAR time-series analysis - Example on the Arima-Takatsuki Fault Zone, Japan

*Yo Fukushima[1] (1.International Research Institute of Disaster Science, Tohoku University)

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

[STT36-02] Correlation between surface displacement and groundwater level displacement in the periods before and after the 2018 Northern Osaka earthquake

*Yutaro Shigemitsu[1], Kazuya Ishitsuka[1], Weiren Lin[1] (1.Kyoto University Graduate School of Engineering)

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

[STT36-03] Landslide and its displacement along the Marsyangdi River, Nepal detected by differential interferometric SAR

*Seiya Usami[1], Hiroshi, P. Sato[2], Hiroshi YAGI[3] (1.Grad student, Graduate School of Science and Technology, Nihon University, 2.College of Humanities and Science, Nihon University, 3.Faculty of Art, Science and Education, Yamagata University)

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

[STT36-04] Road blockage detection due to landslides using Sentinel-1 intensity images

*Keisho Ito[1], Yohei Kinoshita[1] (1.Tsukuba University)

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

[STT36-05] Short-term glacier velocity changes in the Southern Patagonian Ice Field detected by the Sentinel-1 satellite

*Yuya Ito[1], Masato Furuya[2] (1.Graduate School of Science, Hokkaido University, 2.Department of Earth and Planetary Hokkaido University)

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

[STT36-06] Discussion of the colour map for SAR interferograms

*Morishita Yu[1] (1.Geospatial Information Authority of Japan)

Automatic error-term estimation approach for improving the accuracy of InSAR time-series analysis - Example on the Arima-Takatsuki Fault Zone, Japan

*Yo Fukushima[1]

1. International Research Institute of Disaster Science, Tohoku University

InSAR time-series (InSAR-TS) analysis enables us to obtain the time-series of line-of-sight (LOS) displacements over a wide area by using a number of SAR images repeatedly acquired on the area. Among the factors affecting the accuracy of the InSAR-TS analysis, I focus on three factors that may severely limit the detection of small signals. Firstly, it is often the case that the selection of the reference point (determining the offset in each interferogram) is problematic. Wrong selection largely deteriorates the accuracy of the displacement time-series, and there are cases where the whole scene cannot be assumed to be stable. Secondly, interferograms often contain ramp-type artifact that originate from inaccuracy in the orbit data or ionospheric disturbance. Correction for this type of noise is often difficult, especially when one attempts to obtain the displacements of long wavelengths. Thirdly, the altitude-correlated phase delay in the troposphere is often the most significant noise source in interferograms. Although many studies using weather models have been conducted to mitigate this kind of noise, simple regression of the phase change with respect to the altitude is often the most effective method. This kind of regression approach, however, can sometimes over-correct the true deformation signals.

Fukushima et al. (2019, Earth, Planets and Space) proposed an InSAR-TS analysis method to simultaneously solve for the displacement time-series and the error terms mentioned above (plus the error in the digital elevation model), and succeeded in obtaining clear signals caused by fault creep. In the proposed method, the unwrapped phase in interferograms is assumed to be composed of a linear combination of the LOS displacement, offset, planar ramp, altitude-correlated phase, and error in the used digital elevation model. A set of unwrapped small-baseline interferograms is then inverted to simultaneously obtain the displacement time-series and the parameters describing the error terms under the minimum norm condition on the displacement time-series.

In this study, the method was applied to the ALOS-2 data acquired around the Arima-Takatsuki Fault Zone located on the margin of the Osaka Plain in western Honshu, Japan. The data consisted of 26 images acquired between March 2015 and August 2019 from a descending orbit along Path 21 and Frame 2910. Some of the original interferograms contained severe noise such as a phase ramp equivalent to approximately 25 cm of LOS displacements. The average velocity field obtained by applying the method captured the relative range decrease (negative LOS change rate) of the southern side with respect to the northern side of the fault zone with a localized signal of up to approximately 1 mm/year around (latitude, longitude) = (34.79, 135.38), which are consistent with the results of an InSAR-TS analysis of Sentinel-1 data (Morishita, 2021, PEPS). Given the fact that the Sentinel-1 dataset had much favorable conditions (much larger number of data (133 images for the descending dataset) and much smaller ionospheric noise), the consistency in the average velocity field suggests the effectiveness of the noise correction method.

Keywords: InSAR, Arima-Takatsuki Fault Zone

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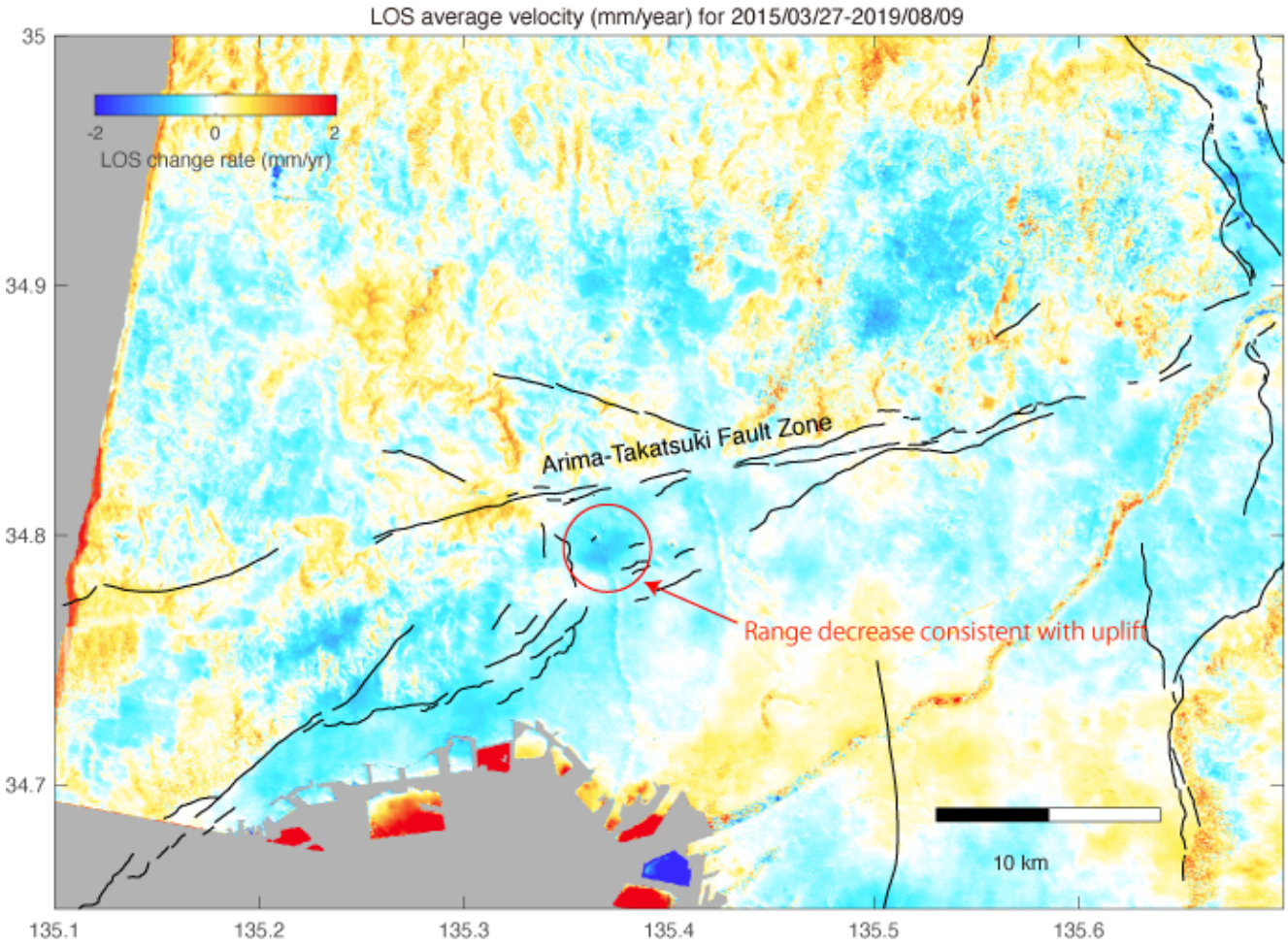

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Correlation between surface displacement and groundwater level displacement in the periods before and after the 2018 Northern Osaka earthquake

*Yutaro Shigemitsu[1], Kazuya Ishitsuka[1], Weiren Lin[1]

1. Kyoto University Graduate School of Engineering

It is known that displacement of groundwater level sometimes occurs around an epicenter or in a wide area immediately after an earthquake. For example, in the Kumamoto earthquake in 2016, some areas of the groundwater level increased due to the inflow of groundwater stored at the foot of the mountain. On the other hand, other area of the groundwater level decreased due to the groundwater flowing into the fracture area in the deep underground. It is widely known that displacement of ground surface is caused by such displacement of groundwater level. Land subsidence due to the lowering of the groundwater level is generally recognized and a model for it has been developed. However, in some areas, rising ground surface due to rising groundwater level has been observed as a phenomenon, but its model is not fully understood. It is important to examine which parameters contribute to rising ground surface when the groundwater level rises, such as speed and acceleration of the groundwater level.
In the periods before and after the Osaka Northern earthquake on June 18, 2018, the rises of the groundwater level have been observed at several groundwater wells in the Hanshin area, Japan. Therefore, the ground uplift due to the rise of the groundwater level may have occurred. In this study, we first estimated the amount of long-term change in ground surface displacement in the Hanshin area in the periods before and after the 2018 Osaka Northern Earthquake, and then discussed the correlation between surface displacements and groundwater levels. Finally, we discuss a simple model for uplift of the ground surface due to rising groundwater levels. PSInSAR analysis was used to estimate surface displacements because it can calculate displacements over a wide area. By combining the surface displacement from the PSInSAR analysis with the groundwater level displacement data, It will be possible to discuss changes in displacement of groundwater level and ground surface due to earthquakes, the magnitude of seasonal displacement of groundwater level and ground surface, and changes in two-dimensional displacement of groundwater level. The satellite data was obtained from the European Space Agency's Sentinel-1 northward orbit for the period April 2015 to April 25, 2019. For the groundwater level data, we used the groundwater level stations of the hydrological water quality database operated by the Ministry of Land, Infrastructure, Transport and Tourism, the groundwater level stations operated by the National Institute of Advanced Industrial Science and Technology, and the groundwater level stations operated by Osaka City.
As results of PSInSAR analysis, surface displacements in the direction of satellite line-of-sight shortening were observed in the vicinity of Takarazuka City and the eastern part of the Osaka Plain in the period before and after the earthquake. The direction of these displacements is westward or uplift direction in terms of actual displacements. These results are consistent with the groundwater level displacement at the groundwater level point near Takarazuka City because the groundwater level rose in the periods before and after the earthquake. On the other hand, in each observation point of groundwater level in the eastern part of the Osaka Plain, the displacement trend of groundwater level depends on the location. Specifically, some observation points showed seasonal changes in groundwater level due to increases and decreases in precipitation, while others showed no seasonal changes. This indicates that displacement of groundwater level and ground surface cannot be modeled simply, and that it is necessary to study the geological structure and aquifer characteristics of each site.

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Acknowledgments:The groundwater level data for Osaka City was provided by the Environmental Management Division, Environmental Management Department, Osaka City Environment Bureau. We would like to express our gratitude to them.

Keywords: the 2018 Northern Osaka earthquake, groundwater level displacement, surface displacement, PSInSAR analysis, satellite Sentinel-1, Osaka Plane

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Landslide and its displacement along the Marsyangdi River, Nepal detected by differential interferometric SAR

*Seiya Usami[1], Hiroshi, P. Sato[2], Hiroshi YAGI[3]

1. Grad student, Graduate School of Science and Technology, Nihon University, 2. College of Humanities and Science, Nihon University, 3. Faculty of Art, Science and Education, Yamagata University

Nepal has the areas prone to be affected by landslides in the world due to the steep topography and complex geological structure caused by plate collision. However, due to the highly undulating topography, on-site monitoring of landslide displacement is difficult, and the number of observation cases is limited. In this study, we attempted to monitor landslide displacement using D-InSAR and to elucidate the characteristics of landslide displacement along the Marsyangdi River, which was considered to be a high risk area of landslides in the previous studies.
A total of 17 ALOS-2 data observed from November 20, 2014 to August 6, 2020 was used in this study, and RINC0.41 software developed by Ozawa et al. (2016) was used for D-InSAR analysis. The D-InSAR images were projected onto a map using ArcGISpro for topographic interpretation and displacement analysis (Fig. 1).
Two landslides were interpreted on the right bank of the Marsyangdi River (28˚21'56 "N, 84˚23'25 "E; 28˚21'4 "N, 84˚23'17 "E). These sites (Fig. 2) are located about 1.5 km north of the Main Central Thrust (MCT), where a large landslide feature are identified and gneiss is distributed. The resulting displacement analysis using multi-temporal D-InSAR images showed that the displacement continued from September 15, 2015 to December 26, 2019 at the shortest. The maximum displacement was calculated from the D-InSAR image of October 18, 2018 - March 21, 2019 and it was compared with the precipitation. The results showed that the rate of displacement did not increase during the rainy season, but rather accelerated immediately after the rainy season (Fig. 3). In addition, we confirmed that top of the landslide body is located on the knick line on the slope, and that the lower part of the landslide body was displaced just after the displacement of the upper part (Fig. 1).
It is inferred that the geology fractured by the MCT is involved in this movement. The relationship with precipitation suggests that there is a temporal gap between landslide displacement and high precipitation. Since the top of the landslide body is located on the knick line, the topography associated with the down cutting after the last glacial period may contribute to the landslide behavior, and this point will be discussed in detail in the future.

Acknowledgement
This study was supported by KAKEN 19H01368, and data used in this study were provided by PIXEL (PALSAR Interferometry Consortium to Study our Evolving Land surface) under a cooperative research (2021-B-03) contract with ERI, Univ. of Tokyo. AW3D data (https://www.aw3d.jp/) were used for producing shaded relief map.

References:
Ozawa, T., Fujita, E., and Ueda, H. (2016): Crustal deformation associated with the 2016 Kumamoto Earthquake and its effect on the magma system of Aso volcano. Earth, Planets and Spase, 68: 16.
Yagi H, Sato G, Sato HP, Higaki D, Dangol V, Amatya SC, Slope deformation caused Jure landslide 2014 along Sun Koshi in lesser Himalaya and effect of Gorkha earthquake 2015, In Vilímek V, Wang F, Strom A, Sassa K, Bobrowsky PT, Takara K (eds.), Understanding and Reducing Landslide Disaster Risk, 5, 65-72, Springer, 2020.

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Keywords: D-InSAR, ALOS-2, Landslide

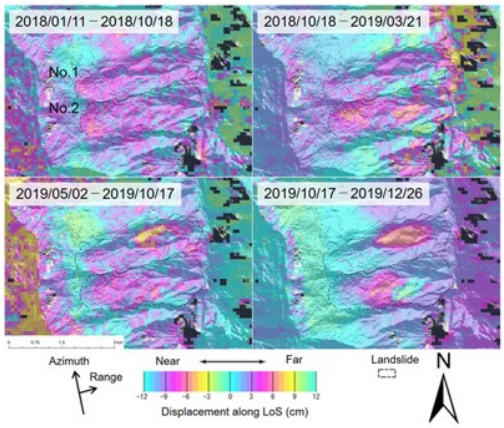

Fig.1 ALOS-2 D-InSAR along Marsyangdi river.
The dashed delineate Landslide areas.

Fig. 2 Local photo of Marsyangdi river.
Orange arrow shows the direction of flow.
(Photographed by Yagi, H.)

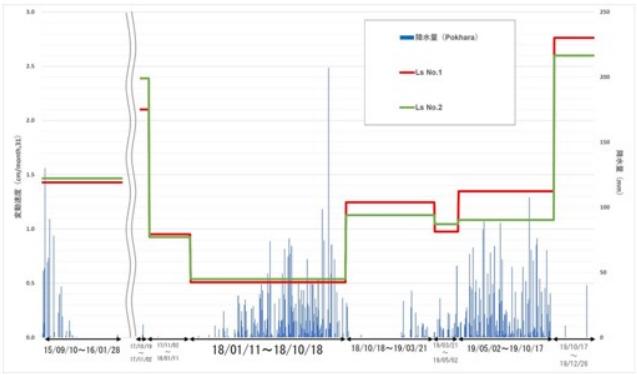

Fig. 3 Comparison of precipitation and displacement velocity.
The red and green line shows displacement velocity of No.1 and No.2 site, respectively.
The blue bars indicate precipitation of Pokhara.

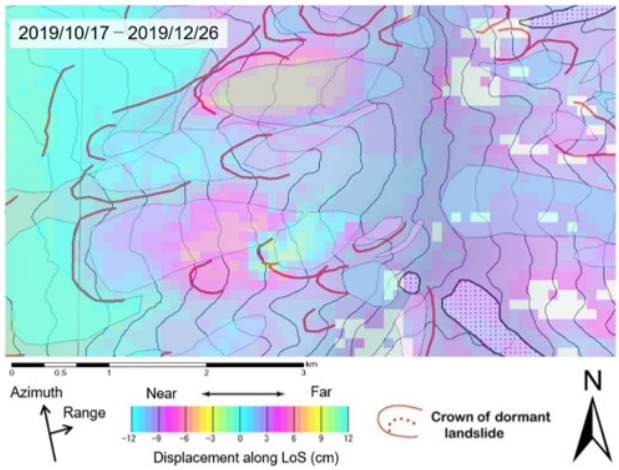

Fig. 4 Overlaying of landslide map and ALOS-2 D-InSAR.
Landslide map is based on Yagi et al.(2020)

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Road blockage detection due to landslides using Sentinel-1 intensity images

*Keisho Ito[1], Yohei Kinoshita[1]

1. Tsukuba University

When natural disasters such as earthquakes and heavy rains occur, roads may be blocked due to rapid landslides. These road blockages can cause isolation of the community and delay of rescue and evacuation, leading to serious damage in both human and economics. Therefore, it is necessary to detect disaster-affected areas quickly after the disaster occurrence. The satellite synthetic aperture radar (SAR) has the ability to get information about affected areas by observing the ground surface over wide area regardless of time of day and the existence of clouds. This study proposed a new method to detect landslides and road blockages using Sentinel-1 intensity images.

This study used backscatter intensity difference between the time-averaged images in the pre-disaster stage and a single intensity image immediately after the disaster occurrence to detect anomalous signals associated with landslides. We analyzed several past landslides and found that these landslides caused large increase of backscatter intensity after the sediment collapse. Based on the above analysis, we set the threshold of the anomaly detection as 4dB intensity increase and created a landslide detection method using the decision tree technique composed of several kinds of thresholds with regard to radar intensity and topographical information such as the hill slope. The landslide detection in our proposed method was performed for square areas with several hundred meters on a side, because there were a lot of small noises in the raw-resolution image and the detailed shape and size of each landslides is not so important in practical use for administrations and municipalities. Then, we detected road blockage areas based on the information of detected landslides and an empirical model to estimate the mass flow length due to landslides. The detection accuracy of the proposed method was evaluated on two cases, the 2018 Hokkaido Eastern Iburi Earthquake and the 2017 heavy rain event in Northern Kyushu.
In the case of 2018 Hokkaido Eastern Iburi Earthquake, our proposed method could detect part of landslides, most of which were relatively large-size landslides. The accuracy of landslide detection for square areas of 400 meters on a side was 2.7% for the false detection rate and 85.2% for the undetected rate. Similarly, nearly half of the roadblock areas were detected by the proposed method. On the other hand, there were many false landslide detections in 2017 heavy rain event in Northern Kyushu, possibly due to sudden surface change of scatter characteristics due to the strong rainfall. The failure of the landslide detection also led to many failures in the road blockage detection. However, the proposed method might capture the areal concentration of landslides, which may showed a potential to roughly detect the damaged area under a heavy rainfall situation.

Keywords: SAR, Landslide, Road blockage, Sentinel-1, Intensity image

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Short-term glacier velocity changes in the Southern Patagonian Ice Field detected by the Sentinel-1 satellite

*Yuya Ito[1], Masato Furuya[2]

1. Graduate School of Science, Hokkaido University, 2. Department of Earth and Planetary Hokkaido University

The glaciers of the Southern Patagonian Ice Field are the second largest group of glaciers in the Southern Hemisphere after Antarctica. Like the glaciers and ice sheet in Northern Hemisphere, they are retreating and losing their mass. Although the flow rate of glaciers in the Southern Patagonian Ice Field is known to change on a semi-annual to multi-year time-scale, their changes in flow rate within a year are uncertain. In order to investigate the detailed changes in the flow velocity, we obtained radar images acquired by the Sentinel-1B satellite with a recurrent period of 12 days between 2019 and 2020, and estimated the flow velocity at the relatively larger six glaciers using the pixel offset method on the assumption of parallel flow approximation. Of the six glaciers (Occidental Glacier, Pio XI Glacier, Asia Glacier, Tyndall Glacier, Viedma Glacier, O'Higgins Glacier), four (Pio XI Glacier, Asia Glacier, Viedma Glacier, O'Higgins Glacier) exhibit winter speed-up signals (Abe and Furuya, 2015), accelerating in winter and decelerating in summer. Pio XI Glacier, Asia Glacier, and Viedma Glacier showed significant changes in their downstream areas and accelerated by about 450%, 20%, and 30%, respectively, in winter. O'Higgins Glacier showed significant changes in the upstream, accelerating by 30% in winter. However, unlike the winter speed-up glaciers reported by Abe and Furuya (2015), the four glaciers except Pio XI glacier have not been known as surge-type glaciers. Moreover, it is not clear if any portion of those glaciers indicate so-called spring/summer speed-up signals like a number of mountain glaciers in Northern Hemisphere. We will extend the analysis period to confirm if the inferred short-term velocity changes are persistent every year.

Keywords: The Southern Patagonian Ice Field, Flow rate

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Discussion of the colour map for SAR interferograms

*Morishita Yu[1]

1. Geospatial Information Authority of Japan

The accurate visualization of numerical data is essential in science communication. Crameri et al. (2020) reported that unscientific colour maps which have uneven colour gradients visually distort data and can lead to misinterpretation and that scientifically derived colour maps should be used to accurately represent data. Rainbow-like colour maps, including widely used jet, is one of the unscientific colour maps. Perceptual uniformity can be quantitatively evaluated by metrics such as L (lightness), a (red-green correlative), b (yellow-blue correlative), and ΔE (incremental lightness difference) (Figure). The Scientific Colour Maps (Crameri, 2018) based on these metrics are perceptually uniform and do not visually distort data.

SAR interferometry is a technique to measure surface deformation by calculating phase differences between two or more SAR images acquired at different times at the same location. Since the phase is measured only modulo 2π, the phase difference in a SAR interferogram becomes also wrapped, cyclic data. A cyclic colour map is suitable to visualize the interferogram containing wrapped phase differences because a non-cyclic colour map generates false boundaries between $-\pi$ and π. A rainbow colour map that GAMMA software developed by the GAMMA REMOTE SENSING normally uses has been the most commonly used so far (Figure). Other software packages such as GSISAR developed by GSI and ISCE developed by NASA have also used the GAMMA-style rainbow colour map. The Headquarters for Earthquake Research Promotion (2011) introduced the GAMMA-style as the standard colour map for the wrapped SAR interferogram. The GAMMA-style has been a de facto standard for more than 20 years.

However, the GAMMA-style is not a scientific colour map based on the metrics above. I present the theoretical background of the scientific colour maps and discuss the issues in the GAMMA-style rainbow colour map and potentially alternative colour maps.

References

Crameri, F. (2018). Scientific colour maps. Zenodo. http://doi.org/10.5281/zenodo.1243862

Crameri, F., Shephard, G.E. & Heron, P.J. (2020). The misuse of colour in science communication. Nat Commun 11, 5444. https://doi.org/10.1038/s41467-020-19160-7

The Headquarters for Earthquake Research Promotion (2011). The observation technique of crustal deformation associated with seismic activities by Synthetic Aperture Radar (Appendix). https://www.jishin.go.jp/main/eisei/eisei_furoku.pdf

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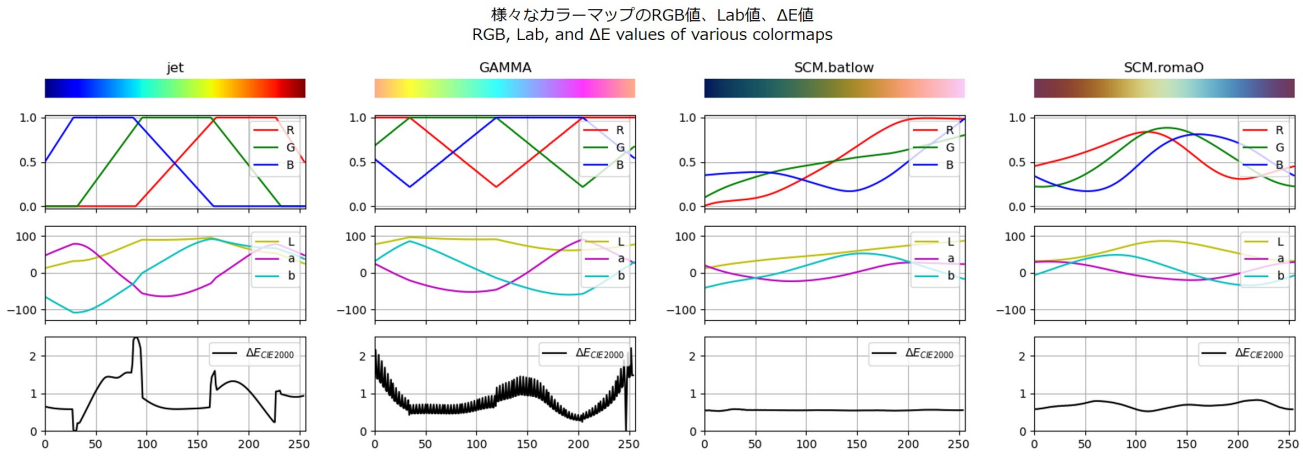
Keywords: InSAR, color map, scientific visualization



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

Sat. Jun 5, 2021 10:45 AM - 12:15 PM JST | Sat. Jun 5, 2021 1:45 AM - 3:15 AM UTC | Ch.22 Zoom Room 22

[S-TT36] Synthetic Aperture Radar and its application

convener:Yohei Kinoshita(University of Tsukuba), Takahiro Abe(Graduate School of Bioresources, Mie University), Shoko Kobayashi(Tamagawa University), Yuji Himematsu(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Masatsugu otsuki(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Yuji Himematsu(National Research Institute for Earth Science and Disaster Resilience)

ALOS-2 and Sentinel-1, which have highly enhanced capacity compared to previous SAR satellites, were launched in 2014, and their utilization has been widely expanding as data have accumulated for approximately six 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, under the situation of next-generation advanced and/or constellated SAR satellite plans by both public agencies (e.g. ALOS-4 and NISAR) and 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 invite various kinds of 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

[STT36-07] Examination of extraction method of topographical change due to eruption of Nishinoshima using time series SAR

*Daiki Inano[1], Masanobu Shimada[2] (1.Tokyo Denki University, graduate school of science and engineering ,division of architectural, civil and environmental engineering, 2.Tokyo Denki University, division of architectural, civil and environmental engineering)

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

[STT36-08] Tropospheric Dispersive Phase Anomalies during Heavy Rain Detected by L-band InSAR and Their Interpretation

Naufal Setiawan[1], *Masato Furuya[1] (1.Department of Earth and Planetary Sciences Hokkaido University)

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

[STT36-09] Error level evaluation of L-Band InSAR Water Vapor Observation by Comparison with GNSS Observations

*Keita Matsuzawa[1], Yohei Kinoshita[1] (1.University of Tsukuba)

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

[STT36-10] **Comparison of atmospheric delay correction methods in InSAR: Case study in Japan**

*Sardila Nurulhikmah Sailellah[1], Yo Fukushima[2] (1.Geophysics Department, Graduate School of Science Tohoku University, 2.International Research Institute of Disaster Science, Tohoku University)

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

[STT36-11] Development of ground-based radar interferometer for volcano deformation monitoring

*Taku Ozawa[1], Yuji Himematsu[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

[STT36-12] Small SAR satellite development and solution services
★Invited Papers

*Shuji Fujimaru[1] (1.Synspective Inc.)

Examination of extraction method of topographical change due to eruption of Nishinoshima using time series SAR

*Daiki Inano[1], Masanobu Shimada[2]

1. Tokyo Denki University, graduate school of science and engineering ,division of architectural, civil and environmental engineering, 2. Tokyo Denki University, division of architectural, civil and environmental engineering

The SAR image is subjected to two processes, synthetic aperture technology and pulse compression technology, to form a grid-like mesh on the ground surface, and the intensity of reflected waves is measured for each pixel. The reflected wave also differs greatly depending on the object. Therefore, in order to classify the land area and the sea area from the images observed by SAR, we consider the definition of the land area and the sea area. The land area is a place where the altitude is 0 m or more, and the backscattered signal in the land area is generally larger than that in the sea area. On the other hand, the sea area is an altitude of 0 m, and the reflected signal is generally small. Since the signal in the land area is larger than that in the sea area, it looks bright in the amplitude image.

In this study, we study Nishinoshima, an uninhabited volcanic island in the Ogasawara Islands of Japan, using time-series SAR data, focusing on temporal changes and area changes in topography associated with eruptions.In addition, the accuracy of the results obtained by these methods will be evaluated. Among the topographical changes, three methods were implemented for the area. The data used is time-series data of 23 scenes observed by JAXA's ALOS-2 / PALSAR-2 for 6 years from September 29, 2014.

The first is the threshold method. Determine one optimal threshold as a whole. The area is calculated by counting the number of pixels above the threshold value as the number of pixels on land. On the other hand, as the island expands, the brightness changes depending on the location due to the effects of ash fall. Therefore, the image is divided into four parts, threshold values are set in each area, and the land area is calculated. Therefore, the image is divided into four parts, threshold values are set in each area, and the land area is calculated. All of them are added together to calculate the total land area.

The second is the automation method. This method uses image analysis software called ImageJ to automatically determine the threshold. As a result, an image in which the land is white and the sea is black is created, and the area is calculated.

The third is the edge detection method. By multiplying the original image by the convolution matrix in the vertical and horizontal directions and adding the obtained pixel values, a differential weighted image with emphasized boundaries is created. By multiplying the original image by the convolution matrix in the vertical and horizontal directions and adding the obtained pixel values, a differential emphasis image with emphasized boundaries is created. This is an image with an increased backscattering coefficient on land. Therefore, even in the image where the backscattering coefficient of a part of the land is lowered due to the accumulation of volcanic ash, the backscattering coefficient of the sea is larger than the backscattering coefficient of the land as a whole, and the backscattering coefficient of the coastal area changes slightly can be extracted.

As a result, with respect to the local data of the Japan Coast Guard and the Japan Meteorological Agency, the relative error of each method is -2.79% for the threshold method, -12.63% for the threshold method

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when the island is divided into four, and -10.94% for the automation method,the edge detection method resulted in -5.56%. At this point, the threshold method is considered to be the most effective for extracting the area of the island, and the edge detection method may also be an effective means depending on the treatment of sea noise.

Keywords: time series SAR, Nishinoshima

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Tropospheric Dispersive Phase Anomalies during Heavy Rain Detected by L-band InSAR and Their Interpretation

Naufal Setiawan[1], *Masato Furuya[1]

1. Department of Earth and Planetary Sciences Hokkaido University

The split-spectrum method (SSM) can largely isolate and correct for the ionospheric contribution in the L-band interferometric synthetic aperture radar (InSAR). The standard SSM is performed on the assumption of only the first-order ionospheric dispersive effect, which is proportional to the total electron content (TEC). It is also known that during extreme atmospheric events, either originated from the ionosphere or in the troposphere, other dispersive effects do exist and potentially provide new insights into the dynamics of the atmosphere, but there have been few detection reports of such signals by InSAR. We apply L-band InSAR into heavy rain cases and examine the applicability and limitation of the standard SSM. Since no events such as earthquakes to cause surface deformation took place, the non-dispersive component is apparently attributable to the large amount of water vapor associated with heavy rain, whereas there are spotty anomalies in the dispersive component that are closely correlated with the heavy rain area. The ionosonde and Global Navigation Satellite System (GNSS) rate of total electron content index (ROTI) map both show little anomalies during the heavy rain, which suggests few ionospheric disturbances. Therefore, we interpret that the spotty anomalies in the dispersive component of the standard SSM during heavy rain are originated not in the ionosphere but the troposphere. While we can consider two physical mechanisms, one is runaway electron avalanche and the other is the dispersive effect due to rain, comparison with the observations from the ground-based lightning detection network and rain gauge data, we conclude that the rain dispersive effect is spatiotemporally favorable. We further propose a formulation to examine if another dispersive phase than the first-order TEC effect is present and apply it to the heavy rain cases as well as two extreme ionospheric sporadic-E events. Our formulation successfully isolates the presence of another dispersive phase during heavy rain that is in positive correlation with the local rain rate. In comparison with other dispersive phases during Sporadic-E episodes, the dispersive heavy rain phases seem to have the same order of magnitude with the ionospheric higher-order effects.

Keywords: heavy rain, non-dispersive medium, dispersive medium, interferometric synthetic aperture radar, split-spectrum method

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Error level evaluation of L-Band InSAR Water Vapor Observation by Comparison with GNSS Observations

*Keita Matsuzawa[1], Yohei Kinoshita[1]

1. University of Tsukuba

Interferometric synthetic aperture radar (InSAR) can measure not only the surface deformation, but also the information of troposphere at the high spatial resolution This is caused by the propagation delay effect similar to the GNSS (Global Navigation Satellite System), which is approximately proportional to the zenith total delay (ZTD) or the precipitable water vapor (PWV). Previous researches have evaluated the precision of InSAR PWV observation using C-band SAR by comparing with GNSS (Tang et al. 2016, Mateus et al. 2020). In general, each satellite SAR sensor has a single frequency band. Most of all SAR satellites mainly use three types of frequency bands such as X-band, C-band, and L-band. The precision of meteorological observation data is necessary to calculate more accurate initial condition when observations are assimilated in weather forecasting. It is necessary to evaluate the precision of water vapor observation using InSAR data in each frequency band because each band has different characteristics in coherence and sensitivity to the ionosphere.

In this work, we evaluated the error level of water vapor observation by L-band InSAR. At first, we calculated the distribution of the zenith total delay difference (ΔZTD) from the InSAR data by the projection from the slant path delay using the simple trigonometric function. The overall offset of InSAR ΔZTD was corrected by the ΔZTD obtained from GNSS observations in the scene. Then, we computed the standard deviation of the residuals between the InSAR ΔZTD and the GNSS ΔZTD. The ΔZTD was then converted to the ΔPWV with a constant coefficient. Finally, we calculated the standard deviation of InSAR-derived PWV at a single epoch using the law of error propagation. Here we assumed that the noise level of water vapor observations on each SAR acquisition was at the same level, and the absolute error level of the GNSS ZTD was set to 16.1 mm that was obtained by a previous research (Boccolari et al. 2002). We used the GNSS Earth Observation Network System (GEONET) data processed with the 5-minutes PPP analysis by the Nevada Geodetic Laboratory at University of Nevada, Reno.

In the InSAR processing, we adopted the Split-Spectrum Method for compensating the differential ionospheric path delay in L-band interferograms. SAR data used were observed by the ALOS-2/PALSAR-2 stripmap mode. The data were collected over four areas in Japan: southern Ibaraki, western Tokyo and Kanagawa, Osaka, and southern Kyushu, spanning from 2014 to 2020. The multilook processing resulted in reduction of the decorrelation noise with sacrificing the spatial resolution to 100×100 m.

Our results showed that the overall distribution of residuals was unbiased and the standard deviation were 8.64 mm in ΔZTD. Estimated standard deviations from the residuals were different in each region, and tended to be larger for the data observed during the rainy season (from June to September). We evaluated the precision of the PWV measurement by L-band InSAR as 2.83 mm, indicating the precision of the L-band InSAR PWV observation is as good as other PWV measurements like C-band InSAR, GNSS, radiometer and weather satellites. By the time of the presentation, we will perform the time series analysis to evaluate the precision of the InSAR PWV measurement for each SAR acquisition days.

Keywords: InSAR, ALOS2, water vapor, error propagation

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Comparison of atmospheric delay correction methods in InSAR: Case study in Japan

*Sardila Nurulhikmah Sailellah[1], Yo Fukushima[2]

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Interferometric synthetic aperture radar (InSAR) is widely used to measure surface displacements using the phase differences of two acquisition dates. Various Earth phenomena have been studied using InSAR such as volcanic activity, landslides, earthquakes and variations in groundwater levels. The delay of the microwave in the atmosphere is a major source of error in InSAR measurements. In the tropospheric layer, temperature, pressure, and relative humidity vary spatially and temporally, creating tropospheric delay masking out the surface displacement signals. Previous studies suggested methods to reduce the atmospheric noise by calculating the delay using atmospheric data and models. In this study, we compared the results of atmospheric delay calculation obtained by the RINC software (Ozawa et al., 2016) and GACOS (Yu, et al., 2017). The former directly integrates the delay along the propagation path using the atmospheric refractivity model of Thayer (1974) and the Meso-Scale Model (MSM) of Japan Meteorological Agency. The latter uses the atmospheric refractivity model of Berrada-Baby et al. (1988) combined with a decomposition model of the stratified and turbulent components, applied on the European Centre for Medium-Range Weather Forecasts (ECMWF) model and optionally the delay obtained from GNSS.

We calculated the delay on the timing of nine ALOS-2 acquisitions in the Tohoku region and fifteen ALOS-2 acquisitions in the Osaka region in Japan. We found that the amount of tropospheric delay tended to be larger for GACOS compared to RINC (Fig.1). To investigate the reason, we calculated the delay by applying the two refractivity models of Berrada-Baby et al. (1988) and Thayer (1974) on identical MSM data sets, and confirmed that the former systematically gives larger delay compared to the latter. For the topography-correlated stratified delay, some differences between the RINC and GACOS results were observed in the Tohoku region, whereas the topography-correlated delay was consistent in the Osaka region. As for the turbulent (topography-uncorrelated) component, the difference between the RINC and GACOS results was larger than 20 cm for half of the cases (12 out of 24), suggesting the difficulty in accurately estimating the turbulent contributions.

We applied the delay correction calculated by the both methods on the ALOS-2 interferograms processed for the two regions. The mean standard deviation of the LOS displacements did not reduce after applying the correction of RINC and GACOS, suggesting that the ionospheric delay contribution is dominated and thus indicating the importance of the ionospheric correction.

Keywords: InSAR, Atmospheric delay, Tropospheric delay

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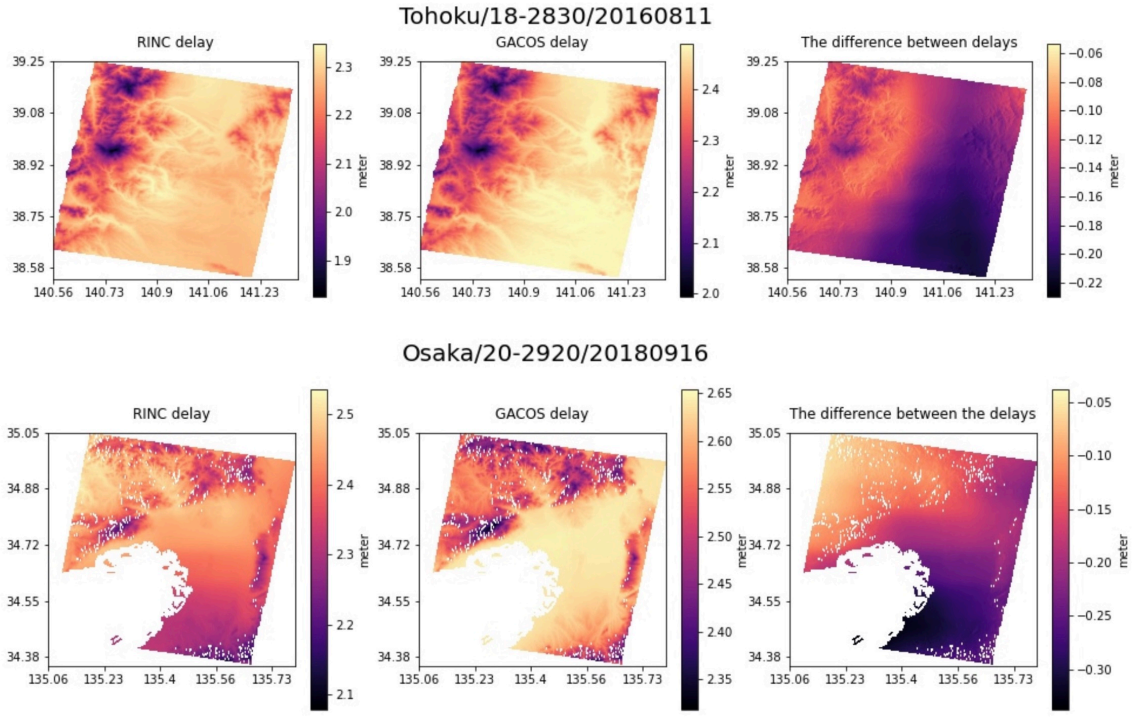

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Development of ground-based radar interferometer for volcano deformation monitoring

*Taku Ozawa[1], Yuji Himematsu[1]

1. National Research Institute for Earth Science and Disaster Resilience

SAR interferometry using spaceborne SAR has been used as one of the general tools for detecting volcanic deformation. It is effective because spatially detailed deformation is obtained without ground observations. If volcano deformation can be detected with higher temporal resolution during active volcanic activity, it is expected to lead to a more detailed understanding of the volcanic activity mechanism. However, it has a disadvantage that the temporal resolution is limited to the satellite recurrence period. Therefore, we are researching on the use of ground-based radar interferometers that can illuminate radar wave from the ground and investigate crustal movements frequently for volcanic observation.

We have installed LiSA mobile k09 (synthetic aperture radar type) and GAMMA GPRI2 (real aperture radar type) using Ku-band radar waves at the Asama volcano and are continuing their operations for 5 years. After the start of operation, a very small eruption occurred at the Asama volcano, but no significant crustal movement was detected. On the other hand, atmospheric disturbances are prominent, and phase changes that exceed one cycle in a few minutes are often detected by real aperture radar. In such situation, processing of the synthetic aperture radar often fails. Its solution is difficult and this problem is one of the disadvantages of ground-based synthetic aperture radar.

We are also developing a portable synthetic aperture radar which can be used in a campaign observation during the time that volcanic activity increases. This synthetic aperture radar can select observation methods moving the antenna on the rail (GBSAR type), by vehicle-mounted (Car-borne type), and by hand (Man-borne type). Regarding the GBSAR and the Car-borne types, it has been confirmed that appropriate coherence can be obtained by repeat-pass observations. In the future, we will improve this sensor through experiment measurements in volcanoes and attempt to detect crustal deformation.

Keywords: SAR, crustal deformation, voilcano

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Small SAR satellite development and solution services

*Shuji Fujimaru[1]

1. Synspective Inc.

1. Company Introduction

Synspective is world’ s only company having capability both development of own small SAR satellite constellation and providing solutions with its data and analytics. We create the Learning World where people can expand their capabilities and make tangible progress with new data and technologies.

We believe that there are three important pillars: the creation of new data by satellites, the analysis of data by data science and machine learning, and the development of human resources who will lead the learning world.

2. Small SAR Satellite

2-1. About SAR satellites

Synspective has developed and is operating a small SAR satellite that weighs 100 kg class.SAR (Synthetic Aperture Radar) satellites use microwaves to observe the shape of terrain and structures. Microwaves have a long wavelength and can transmit through clouds, making it possible to observe the earth's surface beneath clouds. Also, microwave observation is possible both during the day and at night because it actively emits radio waves. Particularly in Asia, where the rainy season is long and cloudy, it is often difficult to observe with optical satellites, and the demand for SAR satellites that can observe.

2-2. Differences from conventional satellite

The weight of our small SAR satellite "StriX" is 100 kg, which is about 1/10 of a conventional large SAR satellite. In terms of cost, the total cost of development and launch is about 1/20 of that of a conventional large SAR satellite.It will be possible to produce a number of SAR satellites at a lower cost by reducing their size and weight while maintaining performance similar to that of conventional large SAR satellites.

2-3. Results

On December 15, 2020, our first demonstration vehicle "StriX-α" was launched by Rocket Lab's Electron rocket from the launch site in Mahia Peninsula, New Zealand. It was successfully injected into its scheduled orbit (sun-synchronous orbit, 500 km altitude).
On February 16, 2021, we successfully acquired images from the first small SAR satellite (100kg class) in Japan.

2-4. Future development

In 2021, we plan to launch the second demonstration satellite, StriX-β, with the goal of demonstrating in orbit InSAR (Interferometric SAR), an analysis technology unique to SAR that detects millimeter-scale variations in the earth's surface. We aim to build a constellation of 6 satellites by 2023 and 30 satellites by the late 2020s.

3. SAR data utilization

As an example of the use of SAR data, we will observe an area that is in the midst of being damaged by a typhoon. It is possible to know where areas are submerged, which roads are blocked due to flooding, and the overall extent of damage after the typhoon passes. The data can be expected to be utilized by the

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insurance and financial industries, as well as the government, which need to quickly assess the damage situation based on primary information when a flood occurs.

Another example is the use of SAR satellite data for infrastructure development and urban development, taking advantage of its wide area. At the planning stage of infrastructure and urban development, it is possible to obtain information on topography and land use, which can be used to determine where to install infrastructure. At the construction stage, the data can be used to obtain objective information on the progress of construction and the condition of materials at the site. Also, as the satellite orbits the earth, it is possible to observe construction sites in thousands of locations around the world. For subsequent maintenance, the satellite can also be used for time-series observation and analysis of ground deformation, which can be used for early detection of unexpected stresses and deformations in dams and distortions in large-scale structures such as ports and runways.

Recently, on February 13, a magnitude 7.1 earthquake occurred in Fukushima and Miyagi. Many people may have remembered the Tohoku earthquake and tsunami, however, there is a possibility that our solutions can be effectively used for disaster response in the occasion of such a disaster.

Synspective has already released the "Flood Damage Assessment" solution for assessing flood damage (flooded area, flooded depth, damaged roads, damaged buildings) for disaster response as a solution service. Also, we provide the "Land Displacement Monitoring" solution that detects and displays a time series of changes in the land surface in millimeters over a wide area.

Keywords: SAR, Small satellite

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

Sat. Jun 5, 2021 9:00 AM - 10:30 AM JST | Sat. Jun 5, 2021 12:00 AM - 1:30 AM UTC | Ch.21 Zoom Room 21

[S-TT38] 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), Ryoichiro Agata(Japan Agency for Marine-Earth Science and Technology), Chairperson:Takane Hori(R&D Center for Earthquake and Tsunami, Japan Agency for Marine-Earth Science and Technology), Ryoichiro Agata(Japan Agency for Marine-Earth Science and Technology)

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.

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

[STT38-01] On large-scale numerical simulation of earthquake generation, wave propagation and soil amplification aiming for comprehensive earthquake damage estimation

Takane Hori[1], Tsuyoshi Ichimura[2,3,4], Kohei Fujita[2,3], *Ryoichiro Agata[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Earthquake Research Institute, 3.Riken Center for Computational Science, 4.Riken Center for Advance Intelligence Project)

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

[STT38-02] Large-scale earthquake simulation with supercomputing and data-learning

★Invited Papers

*Tsuyoshi Ichimura[1] (1.the University of Tokyo)

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

[STT38-03] Comparison of E-wave FEM and GMS in Calculation of Long-Period Ground Motion in 3D Heterogeneous Underground Structures

*Ryoichiro Agata[1], Yoshihisa Hiyoshi[1], Sayako Hirobe[1], Takahiro Maeda[2], Asako Iwaki[2], Kohei Fujita[3,4], Hiroyuki Fujiwara[2], Tsuyoshi Ichimura[3,4,5], Takane Hori[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.National Research Institute for Earth Science and Disaster Resilience, 3.Earthquake Research Institute, 4.Riken Center for Computational Science, 5.Riken Center for Advance Intelligence Project)

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

[STT38-04] Three-dimensional thermal structure modeling in the Alaska subduction zone

*Kaya Iwamoto[1], Nobuaki Suenaga[2], Shoichi Yoshioka[2,1] (1.Department of Planetology, Graduate School of Science, Kobe University, 2. Research Center for Urban Safety and Security, Kobe University,)

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

[STT38-05] Sensitivity analysis with large-scale 3D finite element crust structure model for seafloor geodetic constraints on coseismic slip and interseismic slip-deficit distributions

*Sota Murakami[1], Tsuyoshi Ichimura[1], Kohei Fujita[1], Takane Hori[2], Yusaku Ohta[3] (1.Earthquake Research Institute, The University of Tokyo, 2.R&D Center for Earthquake and Tsunami, Japan Agency for Marine-

Earth Science and Technology, 3.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University)

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

[STT38-06] Discussion

On large-scale numerical simulation of earthquake generation, wave propagation and soil amplification aiming for comprehensive earthquake damage estimation

Takane Hori[1], Tsuyoshi Ichimura[2,3,4], Kohei Fujita[2,3], *Ryoichiro Agata[1]

1. Japan Agency for Marine-Earth Science and Technology, 2. Earthquake Research Institute, 3. Riken Center for Computational Science, 4. Riken Center for Advance Intelligence Project

The operation of the supercomputer "Fugaku" has started in FY2020. The Ministry of Education, Culture, Sports, Science and Technology of Japan (MEXT) has established “Program for Promoting Researches on the Supercomputer Fugaku” (FY2020-2022). "Large-scale numerical simulation of earthquake generation, wave propagation and soil amplification," which the authors have applied for the project, has been adopted as one of the subjects. In this task, we have been developing finite element (FE) analysis methods targeting earthquake generation, wave propagation and soil amplification, which can make the most of the computational performance of “Fugaku”. “E-wave FEM” and “STRIKE” are programs for seismic wave propagation and soil amplification analysis that combine an implicit time integration scheme, unstructured tetrahedral quadratic elements, and an iterative solver using a high-performance preconditioner. By using these applications, seismic wave propagation and soil amplification analysis in complex ground can be performed accurately, stably, and rapidly.

In this project, we aim to lay a foundation for using numerical simulations with computational applications that utilize high-performance computation in policy making and practice uses. First, there is a need for more sophisticated methods in the evaluation of long-period ground motions in the national damage estimation. E-wave FEM, which meets this need, has been included in the committee's investigation for application to the national damage estimation. This project aims for ensuring the accuracy of the method based on calculations that can only be done at “Fugaku”, and then to actually use the method in the national damage estimation. Using “Fugaku”, we improved the program by using the most advanced technology of computational science and computer science to bring out the performance of “Fugaku” in the FE analyses (Ichimura et al., SC20, 2020). In addition, by comparing the numerical solutions of E-wave FEM and a finite difference method conventionally used in the national damage estimation through benchmark tests, we summarized the merits of adopting E-wave FEM as a tool for damage estimation. Then, preparations are made for the implementation of seismic wave propagation analysis using E-wave FEM in the national damage estimation. We also developed a platform for constructions and civil engineering companies to use a system that can perform calculations equivalent to those applied in the government. In order to provide the tools that is easy to use, we developed a computing environment, including manuals, pre-post processing computers, and tools. In addition, tutorials on calculations using E-wave FEM were held for companies participating in this project. We have already received feedback on the functions implemented in the tool set, and we will improve the environment based on the feedback. As for STRIKE, we are preparing for conducting soil amplification analyses at “Fugaku” based on the needs of each company, aiming for application to more practically relevant problems.

In this project, we have developed a large-scale simulation program for elastic and viscoelastic crustal deformation, E-cycle FEM, using a FE analysis solver that is essentially the same as E-wave FEM. Main applications of this program is to estimate the initial water level of tsunamis and the spatio-temporal evolution of fault slips in the Nankai Trough. In this project we mainly target to obtaining reference

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solutions based on elastic and viscoelastic crustal deformation calculations that can only be done at Fugaku, such as those in 3D heterogeneous structures in a large area or very detailed structures in a limited area. Such a reference solution will be important for creating Green's functions with high accuracy, which can be provided to those applications mentioned above.

Keywords: High-performance computing, Finite element method, Supercomputer "Fugaku", Seismic wave propagation analysis, Nonlinear soil amplification, Crustal deformation

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Large-scale earthquake simulation with supercomputing and data-learning

*Tsuyoshi Ichimura[1]

1. the University of Tokyo

Advanced observations have been carried out and various observation data have been accumulated. In order to make the best use of such valuable observation data, technological innovation is required to improve the analysis capability. Although seismic phenomena are diverse and have different length scales and resolutions, from the viewpoint of mathematical problems, many behaviors of seismic phenomena can be modeled as static/dynamic, nonlinear/linear responses of solids. Although the "constitutive laws" and "senses" differ depending on the target phenomenon, many phenomena can be attributed to these forward and inverse analysis problems, and the advancement of analysis methods that can solve such problems will play a major role in improving analysis capabilities. Since the above is a mathematical problem in which stress-free boundary conditions and geometry have a strong influence on the solution, the finite element method based on unstructured elements is one of the suitable methods, but it will be a large-scale problem due to the large size of the target problem and the high resolution required to ensure the reliability (convergence) of the solution. Therefore, it is necessary to develop a new method to solve the problem by efficiently synchronizing a large number of computer nodes, while solving the bottleneck caused by the fact that the core kernel of the finite element method is the random memory access dominant type, which is incompatible with modern computer architecture. In this talk, we present a large-scale earthquake simulation method that combines supercomputing and data-learning and show application examples on a supercomputer (e.g., Fugaku), which demonstrate the effectiveness of approaches of combining supercomputing and data-learning.

Keywords: large-scale simulation , supercomputing and data-learning, finite element method

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Comparison of E-wave FEM and GMS in Calculation of Long-Period Ground Motion in 3D Heterogeneous Underground Structures

*Ryoichiro Agata[1], Yoshihisa Hiyoshi[1], Sayako Hirobe[1], Takahiro Maeda[2], Asako Iwaki[2], Kohei Fujita[3,4], Hiroyuki Fujiwara[2], Tsuyoshi Ichimura[3,4,5], Takane Hori[1]

1. Japan Agency for Marine-Earth Science and Technology, 2. National Research Institute for Earth Science and Disaster Resilience, 3. Earthquake Research Institute, 4. Riken Center for Computational Science, 5. Riken Center for Advance Intelligence Project

Estimation of long-period seismic motions and strong ground motions caused by large subduction zone earthquakes, which are anticipated to occur in the future, is important for advancing measures for earthquake damage in urban areas. For this purpose, it is necessary to calculate seismic ground motions in complex subsurface structures for appropriately set source fault models using numerical methods such as the finite difference method (FDM) and the finite element method (FEM). The advantage of using FDM in such calculations is that discretization using structural grids makes it relatively easy to generate a computational model, to decompose the model domain for parallel computation, and to achieve high computation performance due to efficient memory access. GMS (Aoi & Fujiwara 1999, Aoi & Fujiwara 1998, Aoi et al. 2004), a 3D FDM calculation program using a discontinuous grid, has been packaged and is widely used. Since FEM can handle computation models with unstructured elements, it is suitable for handling complex topography, seismic wave velocity structure, and various source fault models flexibly in seismic ground motion analyses. In combination with an implicit time integration scheme, it is easy to achieve more stable numerical calculations. On the other hand, it has been considered difficult to solve large-scale problems at high speed because of the inefficient memory access when dealing with unstructured elements, and the necessity of solving a large linear equation at every time step when using an implicit time integration scheme. On the other hand, recent development in the field of high-performance computing has led to the development of E-wave FEM (e.g., Ichimura et al. 2014), an implicit FEM simulation program that overcomes the above problems. Seismic ground motion analyses using supercomputers can be performed rapidly for large-scale problems of 10^{10} degrees of freedom or larger. Preparations are now underway to apply E-wave FEM to damage estimations conducted by the government (Agata et al., JpGU-AGU Joint Meeting, 2020). Although comparisons between FEM and FDM in seismic ground motion analyses have been performed already (e.g., Yoshimura et al. 2011, 2012, 2013), it is important to clarify how to use E-wave FEM and widely-used FDM programs such as GMS properly in damage estimations in national agencies, summarizing the differences in the basic features, calculation accuracy, calculation cost, and so on. In this study, long-period earthquake ground motions in 3D heterogeneous velocity structures are calculated using E-wave FEM and GMS, and the results and computational costs are compared and discussed.

We simulated the earthquake near Awaji Island (Mj 6.3) that occurred on April 13, 2013 by using E-wave FEM. Targeting seismic ground motions up to 0.35 Hz, we set up a 3D heterogeneous velocity structure without topography consisting of 33 layers with uniform seismic wave velocity in the region of 900 km, 748 km, and 50 km in the east-west, north-south, and vertical direction, respectively, based on J-SHIS database of NIED. The computational models for the velocity structure were constructed to satisfy the discretization conditions usually used in each program, i.e., at least five elements for E-wave FEM per wavelength for S-wave velocity, respectively. Seismic ground motions for 60 seconds were calculated with a time step size of 0.01 seconds. The resources required to obtain the numerical solution were about 22 minutes using 128 computation nodes of the Oakforest-PACS at The University of Tokyo for the E-wave

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FEM. In the conference, we will compare the results and those obtained by using GMS and also show the results of the numerical solution by changing the mesh size, grid size and other settings. In addition, calculations for a larger target domain will be also discussed.

Keywords: High-performance computing, Seismic ground motion analysis, Finite element method, Finite difference method, Long-period ground motion

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Three-dimensional thermal structure modeling in the Alaska subduction zone

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1. Department of Planetology, Graduate School of Science, Kobe University, 2. Research Center for Urban Safety and Security, Kobe University,

In the Alaska subduction zone, megathrust earthquakes such as the 1964 Alaska earthquake (Mw 9.2), and slow earthquakes such as slow slip events and tectonic tremors have occurred near the plate boundary.
In this region, the Pacific plate is subducting beneath the North American plate, and recent studies have revealed that the Yakutat terrane is subducting at the eastern edge of the Pacific plate. The Yakutat terrane has a significantly different tectonic setting from that of the Pacific plate, and is characterized by the occurrence of tectonic tremors, the absence of volcanoes, and the remarkable thicknesses of the marine sedimentary layer and the oceanic crust.

In this study, we constructed a three-dimensional thermomechanical model associated with the simultaneous subduction of the Yakutat terrane and the Pacific plate to identify the thermal conditions of the region where such interplate seismic events take place in the Alaska subduction zone.
In this numerical simulation, the subduction history of the plate was considered, referring to the plate rotation model, and the subduction velocities were given independently for the Yakutat terrane and the Pacific plate. We also assigned the thicknesses of the marine sedimentary layer and the oceanic crust separately for both regions. In addition, we introduced a low-viscosity layer at the plate boundary below the mantle wedge, which allows for lower temperatures in the forearc region.
Under these conditions, we solved the time-dependent problem of the temperature and mantle flow velocity fields from millions of years ago to the present, using the finite-difference method.
The present temperature field obtained from the numerical simulation was compared with the Curie-point depth distribution and heat flow observations, and we attempted to construct a model in which the residuals between the observed and calculated values can be minimized.

In the future, based on the thermal structure obtained from the numerical simulations, we plan to investigate the relationship between interplate seismic events and dehydration, using phase diagrams of hydrous minerals in the marine sedimentary layer and the oceanic crust.

Keywords: temperature, three-dimensional modeling, numerical simulation, Alaska, subduction zone

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Sensitivity analysis with large-scale 3D finite element crust structure model for seafloor geodetic constraints on coseismic slip and interseismic slip-deficit distributions

*Sota Murakami[1], Tsuyoshi Ichimura[1], Kohei Fujita[1], Takane Hori[2], Yusaku Ohta[3]

1. Earthquake Research Institute, The University of Tokyo, 2. R&D Center for Earthquake and Tsunami, Japan Agency for Marine-Earth Science and Technology, 3. Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University

Estimating the coseismic slip distribution and interseismic slip-deficit distribution play an important role in understanding the mechanism of massive earthquakes and predicting the resulting damage. It is useful to observe the crustal deformation not only in the land area, but also directly above the seismogenic zone. Therefore, improvements in terms of measurement precision and increase in the number of observation points have been proposed in various forms of seafloor observation. However, there is a room for developing a quantitative evaluation method of the estimation accuracy in cases where new crustal deformation observation points are available or when the precision of the observation methods have been improved. In this study, we proposed a method for quantitatively evaluating the improvement in the estimation accuracy of the coseismic slip distribution and the interseismic slip-deficit distribution in cases where new crustal deformation observation points are available or where the precision of the observation methods have been improved. We will present application examples based on large-scale finite element analysis using high-fidelity 3D crust structure and show the usefulness of the proposed method.

Keywords: seafloor observation, inversion of fault slip, sensitivity analysis, crustal deformation, finite element analysis

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

[S-TT38] 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), Ryoichiro Agata(Japan Agency for Marine-Earth Science and Technology), Chairperson:Takane Hori(R&D Center for Earthquake and Tsunami, Japan Agency for Marine-Earth Science and Technology), Ryoichiro Agata(Japan Agency for Marine-Earth Science and Technology)

Sat. Jun 5, 2021 9:00 AM - 10:30 AM Ch.21 (Zoom Room 21)

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.

10:15 AM - 10:30 AM

[STT38-06]Discussion

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Sat. Jun 5, 2021 9:00 AM - 10:30 AM JST | Sat. Jun 5, 2021 12:00 AM - 1:30 AM UTC | Ch.19 Zoom Room 19

[S-CG45] Ocean Floor Geoscience

convener:Kyoko Okino(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Yukari Kido(Japan Agency for Marine-Earth Science and Technology), Asuka Yamaguchi(Atomosphere and Ocean Research Institute, The University of Tokyo)

Most of Earth's volcanism and much of its tectonic activity occur on and beneath the s eafloor. Various phenomena on the seafloor are closely linked to plate tectonics, Earth s tructure and dynamics, and also related to Earth's environments through the hydrosphe re and atmosphere. Seafloor rocks and sediments record Earth's evolution and heat an d material fluxes on the Earth. Ocean Floor Geoscience session covers a broad range of research on seafloor such as mid-ocean ridge process, subduction dynamics, arc magm atism, hot spot and LIPs, crustal movement and structure etc. Every field of researches and every approaches 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

[SCG45-01] JAMSTEC Contribution to the NIPPON FOUNDATION-GEBCO SEABED2030 Project

*Yukari Kido[1], Mitsuko Hidaka[1], Daisuke Matsuoka[1], Tatsu Kuwatani[1], Junji Kaneko[1], Takafumi Kasaya[1], Yoichi Ishikawa[1], Eiichi Kikawa[1] (1.Japan Agency for Marine-Earth Science and Technology)

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

[SCG45-02] The new tectonic model between the Madagascar Ridge and the Del Cano Rise in the southern Indian Ocean

*Taichi Sato[1], Yoshifumi Nogi[2], Hiroshi Sato[3], Masakazu Fujii[2] (1.National Institute of Advanced Industrial Science and Technology, 2.National Institute of Polar Research, 3.Senshu University)

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

[SCG45-03] Sedimentation process at the South Shetland Trench in the Antarctic Ocean

*Asuka Yamaguchi[1] (1.Atomosphere and Ocean Research Institute, The University of Tokyo)

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

[SCG45-04] Highly refractory dunite formation in Gibbs Island and Bruce Bank, and its role in the evolution of the circum-Antarctic continent

*Norikatsu Akizawa[1], Asuka Yamaguchi[1], Chihiro Ohshima[1], Kenichiro Tani[2], Akira Ishikawa[3], Ryo Fujita[3], SUNG HI CHOI[4] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.National Museum of Nature and Science, 3.Tokyo Institute of Technology, 4.Chungnam National University)

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

[SCG45-05] Magmatic evolutions erupted on the Cretaceous seamount province, western Pacific Plate

*Naoto Hirano[1], Hirochika Sumino[2], Taisei Morishita[3] (1.Center for Northeast Asian Studies, Tohoku University, 2.Graduate School of Arts and Sciences, The University of Tokyo, 3.Hydrographic and Oceanographic Department, Japan Coast Guard)

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

[SCG45-06] Pre-stack depth imaging and pore-fluid pressure estimation along the Nankai Trough subduction zone off the Kii Peninsula, SW Japan

*YU FAN[1], Ehsan Jamali Hondori[1], Jin-Oh Park[1] (1.The University of Tokyo)

JAMSTEC Contribution to the NIPPON FOUNDATION-GEBCO SEABED2030 Project

*Yukari Kido[1], Mitsuko Hidaka[1], Daisuke Matsuoka[1], Tatsu Kuwatani[1], Junji Kaneko[1], Takafumi Kasaya[1], Yoichi Ishikawa[1], Eiichi Kikawa[1]

1. Japan Agency for Marine-Earth Science and Technology

In October 2019, a new research program called “Mathematical Seafloor Geomorphology” was launched in the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) to establish collaborations between various research fields. One of the major objectives of this program is to contribute to the “Nippon Foundation - General Bathymetric Chart of the Oceans (GEBCO) Seabed 2030 Project.” Efforts are also ongoing to establish a new method for creating high-resolution seafloor bathymetry using machine learning technology.
This is a joint enterprise, being led by an oceanography committee formed by the International Hydrographic Organization (IHO), GEBCO, and the United Nations Educational, Scientific and Cultural Organization Intergovernmental Oceanographic Commission (UNESCO-IOC). GEBCO standardizes the creation of bathymetry maps to fill bathymetric gaps in the world’s oceans. Funded by the Nippon Foundation, the Nippon Foundation - GEBCO Seabed2030 Project started in 2017. In January 2021, UNESCO also started the “UN Decade of Ocean Science for Sustainable Development (2021-2030, hereafter the UN Decade),” and has since collaborated with and supported the “Seabed2030” project. The Hydrographic and Oceanographic Department of the Japan Coast Guard is a formal desk for a coordination engine of Japanese seabed bathymetry data. JAMSTEC is sharing information with the Japan Oceanographic Data Center (JODC), is collecting bathymetry data using six research vessels, and is cooperating with GEBCO’s grid making process. A database site, called “DARWIN,” is being used to display the collected data and provide the bathymetry data obtained so far. Due to the different projection mappings being used by DARWIN and the National Oceanic and Atmospheric Administration (NOAA)/IHO Data Center for Digital Bathymetry (DCDB), this program was corrected and revised in July. The displays of the NOAA/IHO DCDB and DARWIN are jointly integrated and provide bathymetry data globally. A method for generating super-high-resolution topographic data and analyzing gaps where no investigations have yet been conducted has also successfully been developed using mechanical learning. Herein, we would like to outline the current state of bathymetry data collection, introduce a timeline for 2030, and highlight the crowd-sourced development achieved by outreach activities discussions that were held during the GEBCO week Map the Gaps symposium that was performed in January, 2021. We would like to hold your attention to collaborate for data collection, and to ensure complete seafloor mapping.

Keywords: GEBCO project, Seabed2030 project, seafloor bathymetry

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The new tectonic model between the Madagascar Ridge and the Del Cano Rise in the southern Indian Ocean

*Taichi Sato[1], Yoshifumi Nogi[2], Hiroshi Sato[3], Masakazu Fujii[2]

1. National Institute of Advanced Industrial Science and Technology, 2. National Institute of Polar Research, 3. Senshu University

The Indian Ocean is among the best locations worldwide to understand the supercontinent fragmentation process because the seafloor spreading history following the breakup of Gondwana has mostly remained. Focusing on the south Indian Ocean, the seafloor is dominated by the Southwest Indian Ridge (SWIR), and several aseismic ridges and hotspots are emplaced. Several aseismic ridges have been recognized as oceanic large igneous provinces. Many studies have already presented seafloor-spreading models of the Indian Ocean; however, previously reported magnetic survey lines are sparse and not adequately aligned to detect the seafloor spreading direction. Therefore, the detailed spreading history, including these aseismic ridges, is still an open question.

Based on our newly obtained magnetic data (total and vector magnetic field data) as well as using an open dataset of magnetic data, we re-interpreted seafloor ages in the SWIR segments between the Discovery II and Gallieni fracture zones. The Madagascar Ridge, Del Cano Rise, Crozet plateau, and Conrad rise are emplaced on both off-axis areas. The identified oldest isochron was Chron 31o (71.4 Ma). Before Chron 21y (45.7 Ma), the spreading rate was ultraslow (18–19 km/Ma). Following Chron 21y, the spreading rate was changed to slow (~25 km/Ma). The spreading direction was changed from N10°W to N05°E around Chron 21. The segmentation pattern at Chron 30 (66.5 ~ 68.4 Ma) differs from the present SWIR. The reorganization had occurred around Chron 24 (52.6 ~ 57.1 Ma) and then changed into the present pattern around Chron 21. Revised seafloor ages suggest that the southern Madagascar Ridge and the Del Cano Rise had once formed a single bathymetric high at least before Chron 30. These two rises have thick crusts and have been recognized as formed by excess volcanism on or near the spreading axis of SWIR, or Marion hotspot-SWIR interaction; however, isochrons and linear magnetic anomalies implying the seafloor spreading process do not observe on the two rises. Therefore, we propose that excess volcanism related to seafloor spreading is not the only factor for their gravity anomaly and thick crust, the other factor, such as continental fragments, most likely contributes to the formation of the rises.

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Sedimentation process at the South Shetland Trench in the Antarctic Ocean

*Asuka Yamaguchi[1]

1. Atomosphere and Ocean Research Institute, The University of Tokyo

Sediments incoming subduction zones affect mechanics of plate boundary fault and mass balance in subduction zones. The nature and distribution of sediments incoming trenches such as Nankai Trough, Japan Trench, Cascade, Costa Rica, Barbados, Hikurangi, Sumatra, etc. were elucidated by ocean drilling. On the other hand, the nature of sediments in trenches around the Arctic and Antarctic region are not well-understood, though the existence of abundant Iceberg-Rafted Debris (IBRD) and biogenic opal derived from diatom is speculated. In this study we report preliminary result of characteristics of surface sediments sampled from the South Shetland Trench in the Antarctic Ocean to reveal sedimentation process in a trench in the polar regions.
The South Shetland Trench in the northwest of Antarctic Peninsula is the boundary between the former Phoenix Plate and Antarctic Plate. Although active back-arc spreading is on-going at the Bransfield Strait located in between the South Shetland Islands and the Antarctic Peninsula, forearc seismicity is inactive. 9 piston cores were sampled from the Antarctic and Atlantic Ocean during R/V Hakuho-maru KH-19-6 cruise (Dec. 2019-Jan. 2020), and 4 cores (PC02, PC03, PC04, PC5) were sampled from around the South Shetland Trench. Sample localities include bottom of the trench (PC02 and PC04), landward trench slope (PC03) and seaward trench slope (PC05). All the cores were shipped to Kochi Core Center and X-CT analysis was conducted prior to splitting. Visual core description, MSCL and ITRAX analyses were performed by using split core.
PC02 and PC04 are characterized by turbidite layers which contain fine sands at the bottom. At least 28 and 10 turbidite layers were found in PC02 and PC04, respectively. Sand layers are enriched in Ca and Sr. Mud layers sandwiched in between sand layers show gradual color change, from brown at the lower part to olive gray at the upper part, which would correspond to turbidite mud and hemipelagic mud, respectively. ^{14}C ages of total organic carbon (TOC) in hemipelagic mud of PC02 range from 19076-18826 to 9684-9531 cal BP, suggesting ~0.4 m/1 ky of hemipelagic sedimentation rate and ~300 years of turbidite recurrence interval. PC03 includes poorly sorted subangular gravel, and is interpreted as diamicton or channel deposit. PC05 contains inclined and disrupted sand and silt layers in bluish gray mud matrix, which are characteristic in slump deposit. IBRD are rare in all the cores.
Preliminary analyses of four cores suggest sediments were transported to the South Shetland Trench by gravity flow from both landward and seaward sides. On the other hand, IBRD are not common in the bottom of the trench, reflecting that icebergs mainly drift towards eastern side of the Antarctic Peninsula.

Keywords: the Antarctic Ocean, the South Shetland Trench, Hakuho-maru

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Highly refractory dunite formation in Gibbs Island and Bruce Bank, and its role in the evolution of the circum-Antarctic continent

*Norikatsu Akizawa[1], Asuka Yamaguchi[1], Chihiro Ohshima[1], Kenichiro Tani[2], Akira Ishikawa[3], Ryo Fujita[3], SUNG HI CHOI[4]

1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. National Museum of Nature and Science, 3. Tokyo Institute of Technology, 4. Chungnam National University

The continental margin is of profound importance as it records continental growth by steady-state accretion of orogenic magmas and following rifting. Intense mantle melting due to hydrous fluid input is expected to simultaneously stimulate the continental growth and lower intrinsic density of the mantle than more fertile mantle, which in turn isolate the continental lithosphere from the convective mantle. Gibbs Island (South Shetland Islands) and Bruce Bank located between South America and the Antarctic Peninsula, are tectonic windows into the Earth’ s interior in the circum-Antarctic region. To investigate the continental growth of Antarctica, we present geochemical data of 8 dunites from Gibbs Island and 1 dunite from Bruce Bank, including Re-Os isotope and highly siderophile element compositions.

The dunites are severely suffered from serpentinization of antigorite + brucite or lizardite (loss on ignition = LOI ranging from 3 to 34 wt%), but contain primary euhedral to subhedral chromian spinels with or without spherical olivine inclusions. The chromian spinels rarely form lens-shaped aggregates. A dunite from Gibbs Island contains fresh olivine grains filling a fracture of chromian spinel with low LOI (3 wt%), indicating a deserpentinization origin from serpentinized dunite. The dunites show highly depleted bulk major-element composition: Mg/Si = 1.4–1.6 and Al/Si = 0.004–0.01 for the dunites from Gibbs Island, and Mg/Si = 0.66 and Al/Si = 0.008 for the dunite from Bruce Bank. The positive correlation in Re/Ir and LOI space corroborates Re input during latest serpentinization process. The $^{187}Os/^{188}Os$ of the dunites vary significantly (0.1188–0.1445).

Phanerozoic Re-depletion (melt-depletion) ages of ca. <470 Ma are recorded in the dunites, except for a dunite from Gibbs Island with Proterozoic Re-depletion age of ca. 1.2 Ga. Since there exists serpentinization-related perturbation of Re, they provide minimum time estimates for melt depletion events. The early Paleozoic magmatism is inferred to have occurred during Ross orogeny in response to plate convergence along the margin of the eastern Gondwana, whereas the Mesoproterozoic Re-depletion age is consistent with the Re-depletion ages of mantle xenoliths and Nd model ages of granites and orthogneisses in Marie Byrd Land, West Antarctica. The petrographic characteristics of the chromian spinels with highly depleted nature of the dunites corroborate peridotite-melt reaction and subsequent melt mixing in a subduction setting. Thus, a simple interpretation of the Re-depletion ages of the dunites is that “residual” lithospheric mantle of Antarctica that experienced multiple fluid-assisted melting was incorporated into the continental outskirts during continental break-up. Widespread existence of the dunites in Gibbs Island and Bruce Bank may be attributed to pervasive removal of the continental lithospheric mantle at continental margin and possible incorporation into the oceanic convection system. This process reconciles with the existence of refractory mantle domains in the oceanic mantle lithosphere.

Keywords: highly siderophile element, subduction zone, peridotite

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Magmatic evolutions erupted on the Cretaceous seamount province, western Pacific Plate

*Naoto Hirano[1], Hirochika Sumino[2], Taisei Morishita[3]

1. Center for Northeast Asian Studies, Tohoku University, 2. Graduate School of Arts and Sciences, The University of Tokyo, 3. Hydrographic and Oceanographic Department, Japan Coast Guard

Numerous seamounts on the western part of Pacific Plate, occur within a region called the western Pacific seamount province (WPSP) that occurred during the Early to Late Cretaceous, where a group of short-lived hotspot seamount chains has formed over the present southern Pacific superplume (Koppers et al., 2003). The majority of Early Cretaceous guyots on the northern part of WPSP were instantaneously submerged as a result of a contemporaneous eustatic sea level rise during the middle Cretaceous time (e.g., Larson, 1991).

Some of the seamount chains cannot be explained using a classical hotspot hypothesis, such as that outlined for the Hawaii–Emperor seamount chain. The seamount chains do not exhibit linear age progression due to, for example, overlapping a younger hotspot (Koppers et al., 1998), coeval volcanism along pre-existing lithospheric fractures (Davis et al., 2002), or the presence of recycled material within the upper mantle immediately after a continental breakup event (Taneja et al., 2016). Moreover, it should be theoretically impossible to identify the age of seamount formation using a single radiometric age because the evolutions of seamount take a long duration of time, exemplified by present Hawaiian shield volcano (a few m.y.; Macdonald and Katsura, 1964), the Aitutaki Island along the Cook–Austral hotspot (7-8 m.y.; Jackson et al., 2020), and the Early Cretaceous Quesada seamount at Mariana Trench oceanward slope (over 10 m.y.; Hirano et al., 2002).

Newly provided Ar-Ar ages for basaltic rocks from seamount, knoll, plateau, ridge, spur, and the Minamitorishima (Marcus) Island outline the evolution of hotspot and petit-spot volcanisms in the northern part of WPSP (Hirano et al., 2019; 2021). This study first reports the Eocene ages for basaltic rocks within the WPSP, an area that has only previously yielded Cretaceous ages. The Eocene basalts from the Chuo Seamount (Ogasawara Plateau) and Minamitorishima Island are thought to reflect volcanic events that overprinted the Cretaceous volcanic edifices in this region. Although some examples of rejuvenated seamounts were previously identified during Ocean Drilling Program Leg 144, no research has yet identified rejuvenating post-Cretaceous volcanic events on pre-existing Cretaceous seamounts within the WPSP. The Minamitorishima Island, moreover, records two stages of Eocene submarine volcanic eruption that generated older pillow lavas (~40 Ma) and younger hyaloclastites of highly vesicular lava (~37 Ma), implying shield-building and rejuvenated volcanoes, respectively. The Eocene volcanic overprints of Minamitorishima mean the island represents a unique part of the northern WPSP as the majority of the Early to middle Cretaceous seamounts within this province became submerged as a result of latest Early to Late Cretaceous sea-level rise. Finally, a petit-spot volcano (younger than 3 Ma) in this region erupted at the greater distance from the trench axis which could be equally explained by a wider outer rise than that at other subduction systems.

References:
Davis et al. (2002) G-cubed, 3. DOI: 10.1029/2001GC000190
Hirano et al. (2002) Marine Geology, 189, 371-379.
Hirano et al. (2019) Deep-Sea Research Part I, 154, 103142.

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Hirano et al. (2021) Island Arc, in press. DOI: 10.1111/iar.12386
Jackson et al. (2020) Journal of Petrology, 61, egaa037.
Koppers et al. (1998) Journal of Geophysical Research, 94, 10501-10523.
Koppers et al. (2003) G-cubed, 4. DOI: 10.1029/2003GC000533
Larson (1991) Geology, 19, 963-966.
Macdonald & Katsura (1964) Journal of Petrology, 5, 82-133.
Taneja et al. (2016) Lithos, 262, 561-575.

Keywords: seamount, Pacific, alkali-basalt, petit-spot, hotspot

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Pre-stack depth imaging and pore-fluid pressure estimation along the Nankai Trough subduction zone off the Kii Peninsula, SW Japan

*YU FAN[1], Ehsan Jamali Hondori[1], Jin-Oh Park[1]

1. The University of Tokyo

Introduction

At the Nankai Trough margin, the Philippine Sea Plate is being subducted beneath the Eurasian Plate to the northwest at a convergence rate of ~4 cm/yr [Seno et al., 1993]. Historic, great megathrust earthquakes with a recurrence interval of 100-200 years [Ando, 1975] have generated strong motion and large tsunamis along the Nankai Trough subduction zone. The plate-boundary fault (i.e., decollement) is a source fault of the devastating Nankai megathrust earthquakes. While there were lots of seismic reflection studies across the Nankai Trough axis to reveal the mechanism of the Nankai megathrust earthquakes, only a few studies on pore-fluid pressure estimation were conducted. In order to figure out detailed crustal structure of the Nankai Trough subduction zone off the Kii Peninsula, southwest Japan, we carry out 2D pre-stack depth migration (PSDM) imaging by using multi-channel seismic (MCS) reflection data that were acquired by JAMSTEC. Moreover, we estimate pore-fluid pressure of the shallow underthrust sediments using the PSDM velocities and ODP/IODP drilling data.

MCS data acquisition and processing

The 2D MCS reflection data were acquired along line KI01 by R/V Kairei of the JAMSTEC in 2011. For deep-penetration seismic imaging, a large volume (~130 liters) tuned air gun array and air pressure (2000 psi) was used as the controlled sound source with 50 m shot interval and about 10 m towing depth standard. The MCS data were recorded by a 444-channel streamer with 12.5 m group spacing (~6 km maximum offset) and about 12 m towing depth standard. We tried to do pre-conditioning including air-gun bubble suppression, ghost suppression, FX deconvolution, demultiple filtering by surface-related multiple attenuation (SRMA) and parabolic radon transform (PRT). Then, we performed CDP sorting and generated seismic time sections by stacking and post-stack time migration.

Results and future work

We performed layer stripping for interval velocity model building in the depth domain by using Kirchhoff pre-stack depth migration (KPSDM), and semblance analysis for velocity QC. Currently we are improving the velocity model to obtain a model with an uncertainty of less than 5%. We will then estimate pore-fluid pressure of the shallow underthrust sediments using the PSDM velocities and drilling data.

Acknowledgments: The authors would like to thank JAMSTEC for providing the seismic reflection data. We also thank Paradigm/Emerson (http://www.pdgm.com) for providing seismic data processing software.

Keywords: Nankai Trough, Pore-fluid pressure, Multi-channel seismic

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Sat. Jun 5, 2021 10:45 AM - 12:15 PM JST | Sat. Jun 5, 2021 1:45 AM - 3:15 AM UTC | Ch.19 Zoom Room 19

[S-CG45] Ocean Floor Geoscience

convener:Kyoko Okino(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Ryuta Arai(Japan Agency for Marine-Earth Science and Technology), Masakazu Fujii(National Institute of Polar Research and SOKENDAI)

Most of Earth's volcanism and much of its tectonic activity occur on and beneath the s eafloor. Various phenomena on the seafloor are closely linked to plate tectonics, Earth s tructure and dynamics, and also related to Earth's environments through the hydrosphe re and atmosphere. Seafloor rocks and sediments record Earth's evolution and heat an d material fluxes on the Earth. Ocean Floor Geoscience session covers a broad range of research on seafloor such as mid-ocean ridge process, subduction dynamics, arc magm atism, hot spot and LIPs, crustal movement and structure etc. Every field of researches and every approaches 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

[SCG45-07] Marine and earth science surveys in the Okinawa Trough for the IODP Scientific Drilling: Hakuhomaru KH-21-3 cruise preliminary reports

*Makoto Otsubo[1], Yoshimi Kubota[2], Ayanori Misawa[1], Ken Ikehara[1], Saki Ishino[1], Masataka Kinoshita[3], Kenji Matsuzaki[4], Katsura Kameo[4], Chiori Tamura[4], Ryuta Arai[5], Tomohiro Toki[6], Yuki Mitsudome[6], Zhirong Cai[7], Keiko Takehara[8], Kodai Kato[8], Daisuke Kuwano[9], Koshiro Matsuo[10], Keita Suzuki[11], Misaki Horiuchi[11], Yohei Katayama[12], Satoshi Okumura[13] (1.Geological Survey of Japan, AIST, 2.National Museum of Nature and Science, 3.The University of Tokyo, ERI, 4.The University of Tokyo, AORI, 5.JAMSTEC, 6.University of Ryukyus, 7.Kyoto University, 8.Kochi University, 9.Chiba University, 10.Kyushu University, 11.Nippon Marine Enterprises, Ltd., 12.Marine Works Japan, Ltd., 13.MOL Marine Co., Ltd.)

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

[SCG45-08] Structure and seismicity in the southern part of the Okinawa Trough and their implications for rifting and volcanic processes

*Ryuta Arai[1], Ayanori Misawa[2], Makoto Otsubo[2], Saki Ishino[2], Masataka Kinoshita[3], KH-21-3 Shipboard Scientists (1.Japan Agency for Marine-Earth Science and Technology, 2.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 3.Earthquake Research Institute, The University of Tokyo)

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

[SCG45-09] Heat flow anomaly in the southern part of Okinawa Trough – A preliminary result from the KH-21-3 cruise-

*Masataka Kinoshita[1], Ryuta Arai[2], Chiori Tamura[3], Ayanori Misawa[4], Saki Ishino[4], Makoto Otsubo[4], Shipboard Scientists KH-21-3 (1.Earthquake Research Institute, The University of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology, 3.Atmospheric and Ocean Research Institute, the University of Tokyo, 4.National Institute of Advanced Industrial Science and Technology)

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

[SCG45-10] GNSS/Acoustic geodetic measurement at the southern end of Ryukyu Trench 2014-2020

*Akihiro Nagaya[1], Ryoya Ikuta[2], Mamoru Nakamura[3], Masataka Ando[4] (1.Undergraduate school of department of Geoscience, Shizuoka University, 2.Faculty of Science, Shizuoka University, 3.Faculty of Science, University of the Ryukyu, 4.Center for Natural Hazards of Integrated Education and Research, Shizuoka University)

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

[SCG45-11] Fluid-flow simulation for clarifying ore generation processes in the Izena Hole hydrothermal field, Okinawa Trough

*Shohei Albert Tomita[1], Katsuaki Koike[1], Tada-nori Goto[2], Katsuhiko Suzuki[3], Takafumi Kasaya[3] (1.Graduate School of Engineering, Kyoto University, 2.Graduate School of Life Science, University of Hyogo, 3.Research and Development Center for Submarine Resources, Japan Agency for Marine-Earth Science and Technology (JAMSTEC))

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

[SCG45-12] Examining the origin and depositional process of turbidites in the southern part of Okinawa Trough based on cores from Expedition KH-21-3

*Cai Zhirong[1], Hajime Naruse[1], Ken Ikehara[2], KH-21-3 Shipboard Scientists - (1.Department of Geology and Mineralogy, Graduate School of Science, Kyoto University, 2.Institute of Geology and Geoinformation, National Institute of Advanced Industrial Science and Technology)

Marine and earth science surveys in the Okinawa Trough for the IODP Scientific Drilling: Hakuhomaru KH-21-3 cruise preliminary reports

*Makoto Otsubo[1], Yoshimi Kubota[2], Ayanori Misawa[1], Ken Ikehara[1], Saki Ishino[1], Masataka Kinoshita[3], Kenji Matsuzaki[4], Katsura Kameo[4], Chiori Tamura[4], Ryuta Arai[5], Tomohiro Toki[6], Yuki Mitsudome[6], Zhirong Cai[7], Keiko Takehara[8], Kodai Kato[8], Daisuke Kuwano[9], Koshiro Matsuo[10], Keita Suzuki[11], Misaki Horiuchi[11], Yohei Katayama[12], Satoshi Okumura[13]

1. Geological Survey of Japan, AIST, 2. National Museum of Nature and Science, 3. The University of Tokyo, ERI, 4. The University of Tokyo, AORI, 5. JAMSTEC, 6. University of Ryukyus, 7. Kyoto University, 8. Kochi University, 9. Chiba University, 10. Kyushu University, 11. Nippon Marine Enterprises, Ltd., 12. Marine Works Japan, Ltd., 13. MOL Marine Co., Ltd.

We conducted a research cruise (KH-21-3 cruise) on the Okinawa Trough by R/V Hakuhomaru. In this presentation, we report the outline and preliminary results on the cruise. Two legs (Leg 1 and Leg 2) were carried out on this cruise for the IODP Scientific Drilling.

[KH-21-3 cruise Leg 1] The Okinawa Trough is a back-arc basin located on the Eurasian plate, and has been undergoing rifting since 2 Ma. Especially, the rifting in the southern part of the Okinawa Trough started about 0.1 Ma, but there are still no reports of basaltic oceanic crust. In the KH-21-3 cruise Leg 1, we find the detailed normal faults that construct the graben, the lithology and age of sediments that filled the graben, the heat flow and rocks in the knoll to understand the geohistory from Quaternary to present on the Okinawa Trough. In KH-21-3 cruise Leg 1, we conducted the seismic survey, SBP, swath bathymetry, gravity, magnetic and XCTD observations, piston coring, rock sampling by dredge, heat flow measurements and plankton sampling in the southern part of the Okinawa Trough.

[KH-21-3 cruise Leg 2] The northern part of the East China Sea has large salt fluctuations in summer, and the IODP site U1429 (Danjo Basin) is an important site for elucidating the history of changes in the Asian monsoon. However, the coring at U1429 in 2013 was blocked by a sand layer (thickness unknown) at a depth of 200 m below seafloor. Therefore, in the KH-21-3 cruise Leg 2, in order to extract the effective drilling sites, we investigate the geological structures in the southeastern part of the U1429 site. In KH-21-3 cruise Leg 2, we conducted the seismic survey, sediment sampling by piston coring, seafloor surface sediment sampling using multiple coring, SBP, swath bathymetry, gravity, magnetic and XCTD observations and plankton sampling in the Danjo Basin.

Keywords: Okinawa Trough, Scientific Drilling, Normal fault, Backarc basin, Monsoon, Paleoenvironment

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Structure and seismicity in the southern part of the Okinawa Trough and their implications for rifting and volcanic processes

*Ryuta Arai[1], Ayanori Misawa[2], Makoto Otsubo[2], Saki Ishino[2], Masataka Kinoshita[3], KH-21-3 Shipboard Scientists

1. Japan Agency for Marine-Earth Science and Technology, 2. Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 3. Earthquake Research Institute, The University of Tokyo

The Okinawa Trough is an active rift zone behind the Ryukyu subduction zone and provides a great research field to study the deformation and evolution of the lithosphere in a back-arc setting. The southern part of the Okinawa Trough exhibits the highest rifting rate and the deepest seafloor depth (>2,000 m) in the basin. Consistently, recent seismic surveys show that significant crustal stretching occurs beneath the rift axis marked by the linear bathymetric depression (Yaeyama Rift) and suggest that the southern part of the Okinawa Trough is thought to be at a transitional stage from continental rifting to seafloor spreading (e.g., Arai et al., 2017). Another important feature here is that off-axis volcanic features are in close proximity to on-axis magmatic intrusions. From the viewpoint of seismicity, large earthquakes (with a magnitude greater than 5) frequently occur around the rift axes. These earthquakes mostly accompany rapid increase in seismicity rate (swarm activity), implying sudden changes in stress regime probably induced by large-scale dike intrusion. Although these tectonic and volcanic processes are expected to closely interact each other, their relative roles in controlling the overall back-arc rifting process are poorly understood.

Aiming at better understanding the tectonic and volcanic processes associated with the continental back-arc rifting, we conducted integrated marine geophysical and geological surveys in the southern part of the Okinawa Trough using the research vessel *Hakuhomaru* in January 2021 (KH-21-3). During the cruise, we acquired high-resolution multichannel seismic reflection data along the 5 rift-parallel (SW-NE direction) lines and 4 rift-perpendicular (NW-SE direction lines using two GI guns with a total volume of 710 cu.in. and a 1200-m-long, 48-channel streamer cable. The study area covers the Yaeyama Rift and the potential submarine volcano located further south, providing three-dimensional structural constraints on both on-axis and off-axis magmatic intrusions at shallow depths. In this presentation, we discuss the structure and rifting processes in the southern part of the Okinawa Trough based on the newly obtained seismic reflection images and seismic activity.

Keywords: Okinawa Trough, Back-arc rifting, Submarine volcano

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Heat flow anomaly in the southern part of Okinawa Trough –A preliminary result from the KH-21-3 cruise-

*Masataka Kinoshita[1], Ryuta Arai[2], Chiori Tamura[3], Ayanori Misawa[4], Saki Ishino[4], Makoto Otsubo[4], Shipboard Scientists KH-21-3

1. Earthquake Research Institute, The University of Tokyo, 2. Japan Agency for Marine-Earth Science and Technology, 3. Atmospheric and Ocean Research Institute, the University of Tokyo, 4. National Institute of Advanced Industrial Science and Technology

The southern part of Okinawa Trough, located between Ryukyu Islands and the East China Sea, has been extending since ~10 Ma. In its middle is a central graben, called the Yaeyama Rift (YR), bounded by a series of E-W trending normal faults. Previous seismic refraction surveys reveal a thick (~15 km) crust, indicating that the southern Okinawa Trough is in a continental rifting stage having extension/subsidence.

One of the key observations to test this hypothesis is the heat flow. However, so far very little data exist here, except for some very low heat low within YR. During the KH-21-3 cruise Leg 1, 17 new heat flow data were obtained as well as seismic reflection survey, piston coring, bathymetry and dredge sampling in the southern part of Okinawa Trough (Figure).

Obtained temperature vs. depth profiles are all linear, supporting a thermal conduction dominant near the surface. Thermal conductivity values, measured on piston core samples, are generally close to 1 $Wm^{-1}K^{-1}$, typical of surface marine sediments.

Preliminary heat flow values vary greatly from < 40 mWm-2 to 120mWm-2, suggesting local-scale excursions ongoing at the sites. Low heat flow in the southern slope of YR can either be due to rapid sedimentation or to the recharge od seawater in the hydrothermal system.

At site HF2, we conducted 8 measurements. It is located between the Ishigaki Knoll and the Yaeyama Knoll, where a bathymetric swell and subseafloor ‘melt lens’ are identified by Arai et al. (2016 JGR), called the ‘magmatic uplift’. Through the multi-narrow bathymetric survey we identified two seamount aligned E-W with their height ~100 m. HF2 measurements were made along E-W line running in the northern rim of the western seamount. Surprisingly the heat flow increases eastward. The eastern most point is located between two seamounts, and has the highest value 120 mWm^{-2}. The seismic reflection profiles show anomalous reflection beneath the seamounts, implying the relation with the magmatic uplift by Arai et al.

The purpose of this leg is to get new data for the IODP drilling proposal. As such, it is necessary to show the regional heat flow in the south Okinawa Trough. Because of large scatter in heat flow, so far we cannot show the regional heat flow in this area. The southern most site shows 70mWm-2 (PC4), but this site may also be disturbed by the turbidites supplied from south. However, the finding of twin seamounts and heat flow anomaly should give us a new insight on the evolution of Okinawa Trough.

Keywords: Okinawa Trough, Heat flow, IODP

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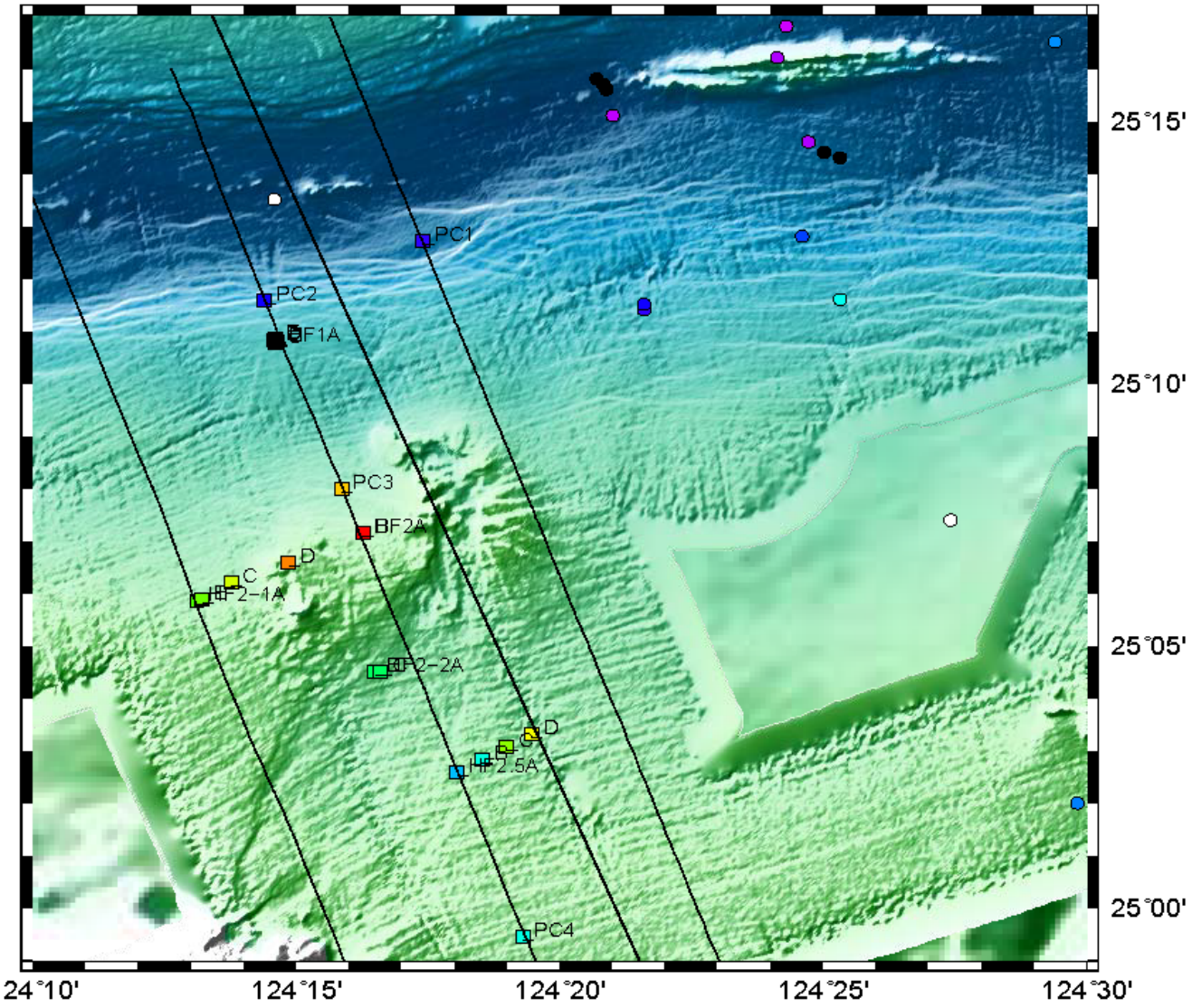

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GNSS/Acoustic geodetic measurement at the southern end of Ryukyu Trench 2014-2020

*Akihiro Nagaya[1], Ryoya Ikuta[2], Mamoru Nakamura[3], Masataka Ando[4]

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We present the results of six years of GNSS/acoustic measurement conducted from October 2014 to September 2020 in the forearc basin of the Yaeyama Islands, the southernmost part of the Ryukyu Trench.

To the south of the Yaeyama Islands, the Philippine Sea Plate is subducting under the Eurasian Plate (Yangtze Plate) at a rate of about 8 cm/yr along the Ryukyu Trench. Behind the Yaeyama Islands, the Okinawa Trough back arc basin is opening at a rate of about 4-5 cm/yr. As a result, the convergence rate between the Yaeyama Islands and the Philippine Sea Plate is fast at about 12-13 cm/yr. The Ryukyu subduction zone beneath the Yaeyama Islands is an extensional plate boundary where back-arc opening occurs, and it has been thought that the interplate coupling is weak and does not capable of huge earthquakes (Scholz and Campos, 2012, JGR).

However, there are several old legends of tsunamis in Miyakojima and Ishigakijima islands, and it is known that the Yaeyama earthquake of April 24, 1771 caused a devastating tsunami in these islands (Nakamura, 2009, GRL).

Nakamura (2009, GRL) conducted a numerical simulation of the tsunami based on the Tsunami inundation data by Nakata and Kawana (1995), and estimated the Yaeyama earthquake as a tsunamigenic earthquake of Mw 8.0 that occurred in the Ryukyu Trench. In addition, trenching of tsunami deposits in Ishigaki Island estimated that the Yaeyama earthquake was a massive earthquake with severe strong ground motion, and that tsunamis of approximately the same size as the 1771 earthquake occurred four times in the past 2000 years at intervals of about 600 years (Ando et al., 2018, Tectonophysics). In order to estimate the presence or absence of the inter-plate coupling around the tsunami fault area estimated by Nakamura (2009, GRL), seafloor transponders were deployed in the forearc region at a depth of about 3300 m, about 40 km off the south coast of Hateruma Island, by Shizuoka University and the University of the Ryukyus in October 2014. In this study, we estimated the motion of the transponders over a period of six years from the observation data taken seven times in total from October 2014 to September 2020.

The position of the transponders was estimated using the method of Ikuta et al. (2008, JGR) using kinematic GPS, ship attitude, two-way travel time of acoustic ranging, and XCTD data. To estimate the kinematic GPS positions, we used Interferometry Trajectory (IT), a long baseline analysis software developed by NASA/GSFC in six of the seven campaigns expect for the campaign in 2014. In 2014 campaign, the results of the IT analysis showed a large discrepancy between the astronomical tide and the GPS antenna height change. We reanalyzed the kinematic GPS for the 2014 campaign only using RTKLIB (Takasu, 2006). For the estimation of the three transponders positions, we introduced the assumption that the sound velocity structure changes smoothly with time and that the geometries of them do not change through all campaigns. And we estimated the positions of the three transponders for all campaigns simultaneously by penalized least squares method.

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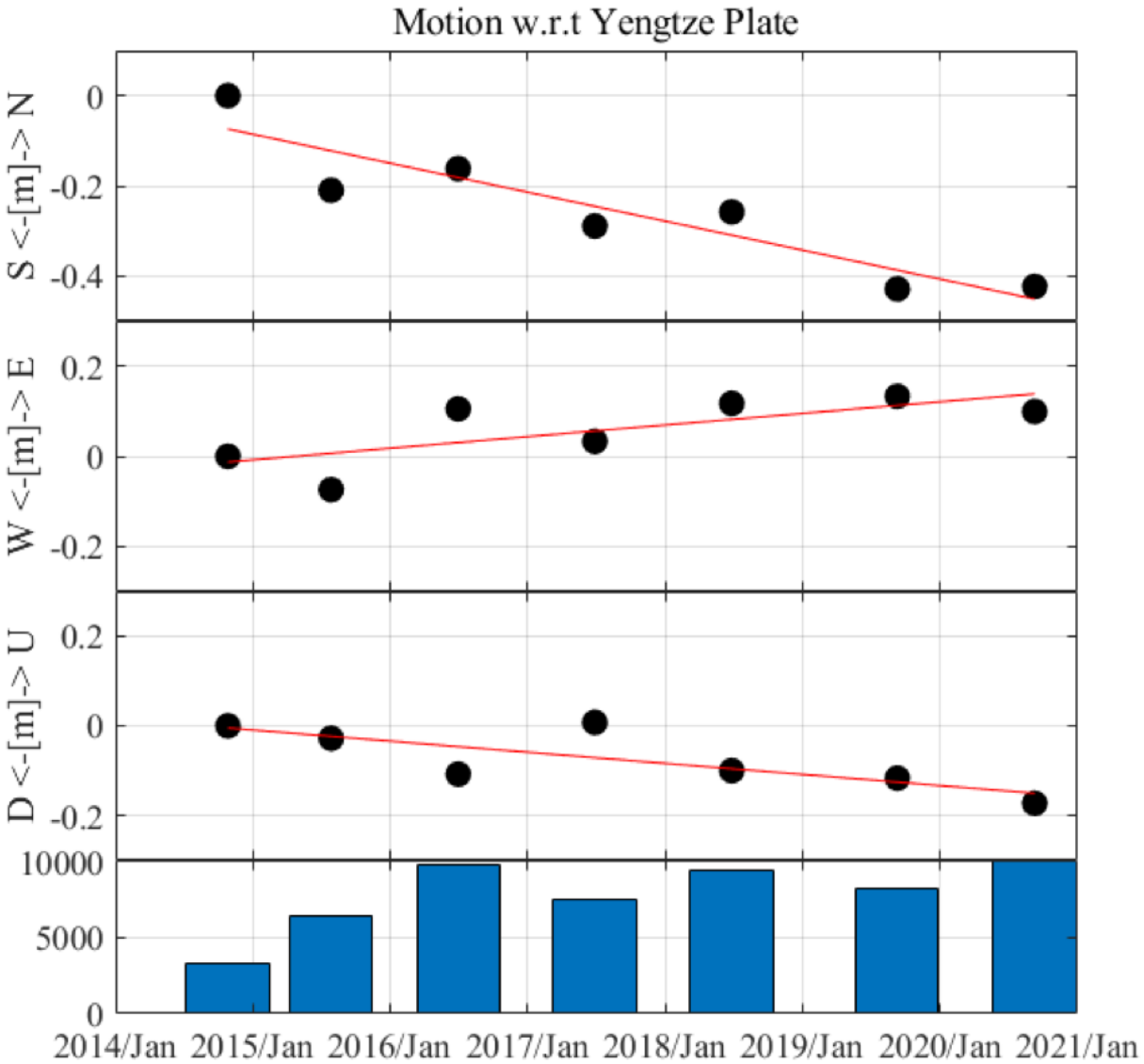
As a result, the average velocity vectors calculated from the positions of the transponders for all campaigns were estimated to be 64.2±11.2 mm/yr in the south direction, 25.8±9.8 mm/yr in the east direction, and 24.8±8.0 mm/yr in the subsidence direction relative to the Eurasian plate. The rms of the residuals between the predicted and actual transponders positions for each campaign at the calculated velocities were 54.3 mm north-south, 47.8 mm east-west, and 39.0 mm up-down; before the reanalysis of the 2014 GNSS data by RTKLIB, these were 61.0 mm, 66.4 mm, and 40.7 mm, respectively. It can be seen that the improvement of GNSS data in 2014 affected the analysis results.
In this presentation, based on the above results, we discuss the extent of inter-plate coupling at this southernmost tip of the Ryukyu Trench.

Keywords: Yaeyama Tsunami, Ryukyu Trench, GNSS/Acoustic measurement, Seafloor crustal deformation, Inter-plate coupling



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Fluid-flow simulation for clarifying ore generation processes in the Izena Hole hydrothermal field, Okinawa Trough

*Shohei Albert Tomita[1], Katsuaki Koike[1], Tada-nori Goto[2], Katsuhiko Suzuki[3], Takafumi Kasaya[3]

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Seafloor hydrothermal deposits have a high potentiality for new metal resources. An understanding of the genesis of the deposits is indispensable to exploring the deposits. In the previous study, we conducted a hydrothermal flow simulation for the Iheya North hydrothermal field, Okinawa Trough and clarified that a formation of the cap layer induced the lateral flow and boiling of the hydrothermal fluids, which caused the metallic mineral deposition below the seafloor (Tomita et al., 2020). In this study, we aim to verify the applicability of the Iheya North mineral precipitation model to other seafloor hydrothermal deposits by selecting the Izena Hole hydrothermal field, Okinawa Trough as a case study field and a hydrothermal flow simulation using TOUGH2.

The field observations such as the drilling data, seismic survey, and heat flux measurement were used to construct a proper three-dimensional numerical model that contains two hydrothermal sites, Jade and Hakurei sites. In the simulation, the seafloor was set as the top boundary where the temperature and pressure were fixed at 4 ℃ and hydrostatic conditions, respectively. The physical properties of rocks were set by the data of seafloor drillings, and the permeabilities (hereinafter, *k*) of the five elements were adjusted with trial-and-error approaches so that the heat flux and temperature differences would be acceptably small with consideration of heat balance. To clarify the general fluid flow pattern and the temperature and pressure distributions, the model domain was simply divided into five geologic elements, conduit (high *k*), fault (high *k*), volcanic basement (medium *k*), cap layer (low *k*), and sediment (low *k*), by excluding geological and hydrological heterogeneities. The conduits were set vertically from the bottom to seafloor at the middle area common to Jade and Hakurei sites. The hydrothermal fluid of 360 ˚C was injected from the conduit bottoms, and the hydrothermal fluid was set to discharge from the conduit surfaces.

As a result of the simulation, the hydrothermal fluid ascending along the conduit was trapped by the cap layer near the surface and flowed laterally in addition to the outflow from the seafloor. The calculated heat fluxes generally corresponded with the measured values. The hydrothermal fluids that ascended along the conduit boiled under the seafloor at both the Jade and Hakurei sites due to the pressure decrease.

In the Hakurei site, a two-layer structure of exposed ore bodies on the seafloor and lower ore bodies below the seafloor were found in the northern mound around the C9027 drilling hole. We considered the origin of this two-layer structure in three stages through the simulation results and observations. In the early stage, hydrothermal fluids discharging from black smokers formed the upper seafloor massive sulfide (SMS) deposits on the seafloor. In the middle stage, cap layers (anhydrite and clay minerals) formed below the seafloor, which induced the lateral flow and boiling under the cap layers. The presence of cap layer below the seafloor was confirmed by the drilling data. After formation of the cap layers, liquid-dominated hydrothermal fluids rich in metals flow laterally below the cap layers, forming the lower SMS deposits at tens of meters depth below the seafloor. In the late stage, the center of hydrothermal activity shifted from

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the northern mound to the Dragon chimney, because the pore spaces were filled with mineral precipitation and then *k* was largely decreased at the mound.

In conclusion, this study clarified that the Iheya North mineralization model could be applied to the Izena Hole.

Reference
Tomita, S. A., Koike, K., Goto, T., & Suzuki, K. (2020). Numerical simulation-based clarification of a fluid-flow system in a seafloor hydrothermal vent area in the middle Okinawa Trough. Geophysical Research Letters, 47, e2020GL088681. https://doi.org/10.1029/2020GL088681

Keywords: hydrothermal flow simulation, TOUGH2, temperature, boiling, seafloor massive sulfide deposit, cap layer

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Examining the origin and depositional process of turbidites in the southern part of Okinawa Trough based on cores from Expedition KH-21-3

*Cai Zhirong[1], Hajime Naruse[1], Ken Ikehara[2], KH-21-3 Shipboard Scientists -

1. Department of Geology and Mineralogy, Graduate School of Science, Kyoto University, 2. Institute of Geology and Geoinformation, National Institute of Advanced Industrial Science and Technology

Okinawa Trough is an actively rifting back-arc basin and an important area for examining the tectonic history of the Ryukyu subduction zone. Past studies showed that the main sources of sediment deposition in the southern part of Okinawa Trough were Taiwan and the East China Sea continental shelf. The main process of sediment transportation to the Okinawa Trough was turbidity currents in addition to hemipelagic sediment transport. Estimating sediment flux from Taiwan as well as local sediment input from volcanic arcs into this region is important for understanding the development of the Okinawa Trough and the temporal changes in orogenic activity in Taiwan. However, the scale and source of turbidity current events related to the depositional process within the region is still unclear.

The KH-21-3 expedition surveyed the southern part of Okinawa Trough and four piston cores were obtained. Each core contained more than one turbidite unit. In order to better understand the origin and scale of turbidity current events that resulted in turbidites in the southern part of Okinawa Trough, we conducted a 2D numerical experiment of turbidity current events using a shallow water equation model that reproduced turbidites in borehole cores. This presentation will also contain a preliminary report of the characteristics of turbidites within the cores obtained from KH-21-3 and an overview of the numerical model used for simulation.

Keywords: Numerical Simulation, Turbidity Currents, Back-arc Basin

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Sat. Jun 5, 2021 1:45 PM - 3:15 PM JST | Sat. Jun 5, 2021 4:45 AM - 6:15 AM UTC | Ch.19 Zoom Room 19

[S-CG45] Ocean Floor Geoscience

convener:Kyoko Okino(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Motoyuki Kido(International Research Institute for Disaster Science, Tohoku University), Fumiaki Tomita(Japan Agency for Marine-Earth Science and Technology)

Most of Earth's volcanism and much of its tectonic activity occur on and beneath the s eafloor. Various phenomena on the seafloor are closely linked to plate tectonics, Earth s tructure and dynamics, and also related to Earth's environments through the hydrosphe re and atmosphere. Seafloor rocks and sediments record Earth's evolution and heat an d material fluxes on the Earth. Ocean Floor Geoscience session covers a broad range of research on seafloor such as mid-ocean ridge process, subduction dynamics, arc magm atism, hot spot and LIPs, crustal movement and structure etc. Every field of researches and every approaches 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

[SCG45-13] Preliminary results of ocean bottom pressure observation around Kikai submarine caldera, SW Japan

Yuko Asai[1], *Nobukazu Seama[1,2], Tomoko Hanyu[2], Tetsuo Matsuno[2,1], Hitoshi Hirose[3,1], Takuto Minami[1], Hiroko Sugioka[2,1] (1.Department of Planetology, Graduate School of Science, Kobe University, 2.Kobe Ocean Bottom Exploration Center, Kobe University, 3.Research Center for Urban Safety and Security, Kobe University)

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

[SCG45-14] Characteristic of depth dependence and annual variation of OBP time series in DONET

*Hideto Otsuka[1], Yusaku Ohta[1], Ryota Hino[1], Tatsuya Kubota[2], Daisuke Inazu[3] (1.Department of Geophysics, Graduate School of Science, Tohoku University, 2.National Research Institute for Earth Science and Disaster Resilience, 3.Department of Marine Resources and Energy, Tokyo University of Marine Science and Technology)

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

[SCG45-15] GNSS-Acoustic observations using a Wave Glider and their results

*Fumiaki Tomita[1], Takeshi Iinuma[1], Motoyuki Kido[2], Yusaku Ohta[3], Chie Honsho[3], Tatsuya Fukuda[1], Takane Hori[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.International Research Institute of Disaster Science, Tohoku University, 3.Graduate School of Science, Tohoku University)

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

[SCG45-16] Semi-realtime transmission of GNSS-A data using a Wave Glider

*Motoyuki Kido[1], Tatsuya Fukuda[2], Yusaku Ohta[3], Fumiaki Tomita[2], Chie Honsho[3], Takeshi Iinuma[2] (1.IRIDeS, Tohoku University, 2.JAMSTEC, 3.Sci. Division, Tohoku University)

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

[SCG45-17] Operation experiment of the system for seafloor crustal deformation observation system using a buoy

*Keiichi Tadokoro[1], Natsuki Kinugasa[1], Teruyuki Kato[2], Yukihiro Terada[3], Kenjiro Matsuhiro[4], Haruno Koike[4] (1.Research Center for Seismology, Volcanology and Earthquake and Volcano Research Center, Nagoya University, 2.Hot Springs Research Institute of Kanagawa Prefectural Government, 3.National Institute of Technology, Kochi College, 4.Technical Center, Nagoya University)

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

[SCG45-18] Initial results of sea trials on bathymetric survey performance of “AUV-NEXT”: aiming to acquire higher-quality bathymetric data

*MASANAO SUMIYOSHI[1], Ryosuke Nagasawa[1], Takashi Hashimoto[1], Kenji Nagahashi[2], Takao Sawa[2], Tadahiro Hyakudome[2], Takeshi Nakatani[2], Tatsuya Aso[2], Yusuke Yokota[3] (1.Hydrographic and Oceanographic Department, Japan Coast Guard, 2.JAMSTEC, 3.Institute of Industrial Science, University of Tokyo)

Preliminary results of ocean bottom pressure observation around Kikai submarine caldera, SW Japan

Yuko Asai[1], *Nobukazu Seama[1,2], Tomoko Hanyu[2], Tetsuo Matsuno[2,1], Hitoshi Hirose[3,1], Takuto Minami[1], Hiroko Sugioka[2,1]

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We perform tidal analysis of ocean bottom pressure variation, which were measured by 4 'OBEMP (Ocean Bottom Electro-Magnetometer with absolute Pressure gauge)' instruments at observation sites around Kikai submarine caldera, SW Japan. These measurements were made during periods of April/2018-Oct./2018, Nov./2018-Sept./2019, Nov./2018-March/2019, and Nov./2019-March/2020, with their water depths of 392m, 312m, 206m, and 196m, respectively. Tidal analysis of these data is performed using BAYTAP-G program (Tamura et al., 1991) to derive tidal amplitudes, factors, and phases of 14 diurnal and semidiurnal tidal groups, and these data are decomposed into three parts: 1) a tidal part, 2) a part that is correlated with the ocean bottom temperature measurement data, and 3) a nontidal part. The tidal factors are estimated at ~2 and ~ 3.5 for diurnal and semidiurnal tidal groups, respectively. Some tidal factors and phases that are well estimated with small errors indicate slight difference among the observation sites. Comparison of tidal factors and phases between our results and a global ocean tide model, NAO.99b (Matsumoto et al., 2000), also shows slight differences. These differences could be due to local loading effect on crust with relation to the existence of Kikai submarine caldera. We will perform further analysis with respect to site location difference, period dependence, and time variation to investigate possible local loading effect on crust. The result from the nontidal part indicates two characteristic features. One is a sudden increase of pressure values (~30 hPa) with in 6 hours, which occurred on August 22, 2018 at one observation site. We will investigate possible causes of the sudden pressure increase. The second one is pressure variation of 20 hPa with its period longer than a week. This variation was observed at two observation sites during Nov./2018-March/2019, which was the only duration that we made simultaneous observation at two observation sites. The similar pressure variations at two sites that are separated by 45 km in distance suggest that these variations are due to a same cause. Since pressure variation at ocean bottom corresponds to the sum of air pressure and pressure due to total mass of ocean water above observation site, we compare our pressure variation with air pressure variations observed at three Japan Meteorological Agency observation sites (Makurasaki, Tanegashima, and Yakushima) far around Kikai submarine caldera, whose data were provided by Japan Meteorological Agency. The overall air pressure variations at three sites are the same with a very small difference within ~2 hPa, suggesting air pressure variations at our ocean bottom observation sites would be the same. The comparison indicates no correlation for the period longer than a week, suggesting two things. The air pressure variations are well compensated by change in total mass of ocean water (change in ocean height level), and leads no effective variation on pressure at ocean bottom. Thus, the pressure variation of 20 hPa with its period longer than a week should be due to pressure due to total mass of ocean water above two observation sites that is probably caused by ocean current variation. We will analyze period dependence of correlation between ocean bottom pressure variations and air pressure variations. We will present all these results and possible implications from them.

Keywords: Ocean bottom pressure variation, Ocean tide, Loading effect on crust

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Characteristic of depth dependence and annual variation of OBP time series in DONET

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Ocean Bottom Pressure-gauge (OBP) is extremely important sensor to observe the continuous seafloor vertical deformation. The observed OBP data, however, contain not only the signal of crustal deformation but also the other components such as tidal-component, non-tidal oceanographic fluctuation, and sensor specific drift. Therefore, appropriate assessment of these contributions are essentially important to extract the signal of crustal deformation. Especially, the non-tidal oceanographic fluctuation is the largest noise because of its similarity in time constant to the crustal deformation. The non-tidal oceanographic model (e.g., Inazu et al., 2012) is one of the candidate to estimate its contribution. Dobashi and Inazu (2021) compared the time series of observed data with non-tidal oceanographic models in short-term time series (3-90 days) to evaluate the contribution of the non-tidal fluctuation on OBP data. In contrast, almost all previous studies did not assess the characteristics of non-tidal oceanographic component in long-term data more than several years. In this study, we investigate the long-term spatio-temporal characteristic of non-tidal oceanographic fluctuation based on the data of DONET OBP time series.

In this study, we used the 8-year continuous data between 2012 to 2019 for analyses. DONET observation network extends 200km east-west, 100km north-south, and 1-4km sea depth. Ocean tide components were removed by tide-killer filter (Hanawa and Mitsudera, 1985), and instrumental drift were approximated and removed by linear and exponential functions.

Firstly, the similarity of OBP time series of each stations was evaluated using distance and difference of sea depth between stations as indicators. We assumed a reference site, which locates in the most north-eastern part of the network, and the sea depth of the site is 2039m. We subtracted the time series of the reference site from all of the DONET sites. The standard deviation of the relative pressure time series was calculated and their dependence on station distance and sea depth difference was evaluated. The correlation coefficient with the station distance was quite small (0.15). In contrast, the correlation coefficient with the sea depth difference was 0.69. It may indicate that effective removal of the non-tidal oceanographic fluctuation is possible by selecting the reference site considering the sea depth difference rather than the distance. Secondly, we estimated the amplitude and phase of the annual component of OBP time series to evaluate the annual fluctuation based on 8-year data. Estimated amplitude and phase of the annual component also clearly show the dependency with difference of sea depth. These results suggest that the annual component is a main factor in the sea depth dependence of the non-tidal component. In the presentation, we also evaluate the temporal variation of the characteristic of the annual component.

Keywords: Marine geodesy, Ocean Bottom Pressure gauge, DONET

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GNSS-Acoustic observations using a Wave Glider and their results

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Using the GNSS-Acoustic (GNSS-A) observation technique, seafloor crustal deformation associated with an earthquake cycle has been measured [e.g., Honsho et al., 2019, JGR]. A sea-surface platform, which conducts GNSS measurement and acoustic ranging between the sea-surface and the seafloor, is essential for the GNSS-A observation; in general, a research vessel has been used. However, employment of a research vessel requires high financial and human resources, which makes frequent GNSS-A observations for many sites difficult. Then, JAMSTEC and Tohoku University have developed system for GNSS-A observations using a Wave Glider (WG) as the sea-surface platform. The WG is an unmanned surface vehicle which can move by sea-surface wave energy. We conducted a trial short-term observation using the WG at single site in July 2019, and we showed that precision of the GNSS-A measurements using the WG was comparable with that using research vessels [Iinuma et al., 2021, Frontiers in Earth Science]. Moreover, we successfully operated the WG in June–July 2020 and conducted GNSS-A observations at 14 sites [Tomita et al., 2020, GSJ Meeting]. In this study, we report outline of the GNSS-A observation using the Wave Glider in Oct. 2020 and its results. Although we also simply report the results of the observation in Nov.–Dec. 2020, this observation was conducted as urgent survey associated with activation of seismicity off northern Sanriku from early Nov. 2020; thus, its outline is reported by Hori et al. [this meeting], and its technical issues are reported by Kido et al. [this meeting].

The WG equipped GNSS-A observation instruments and Thuraya satellite communication instruments for confirming state of the obtained data. The equipped GNSS-A instruments are following: two GNSS antennas for position and attitude (heading and pitch) of the sea-surface platform, an acoustic ranging unit, an acoustic transducer, and a MEMS gyro. The Wave Glider was deployed at G24 site on Oct. 8 during the KS-20-16 cruise. After the observation for 25 days, it was recovered by a charter vessel at G13 site on Nov. 1. Although GNSS data was unavailable because of the logging system error at one site, we successfully obtained the observational data in the other sites.

We estimated horizontal displacement of the seafloor transponder array for each acoustic ping by the means of Kido et al. [2006, EPS]. The initial geometry of the transponder array was calculated by Honsho et al. [2019] using the past observational data. We then calculated average and standard deviation of the horizontal displacement during the survey for each site. We found that the temporal variations of the horizontal array position for each ping were generally large, which suggested that spatial variation in the underwater sound speed structure was complex during the observation in Oct. 2020. Although precision of the horizontal displacements in Oct. 2020 was relatively larger than the past cruises, we successfully obtained the analysis results.

Although we had conducted at least one GNSS-A observation cruise for each site per a year in the off-Tohoku region before 2016, we have hardly conducted the cruises after 2016 due to the operating cost of vessels. However, we conducted the surveys for most GNSS-A sites off Miyagi–Aomori in 2020 using the WG. Off Iwate and Aomori, the displacement rates had been small in the previous studies, and this characteristic was also confirmed in the latest results. Meanwhile, off Miyagi, large landward motions

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had been observed due to the viscoelastic relaxation of the 2011 Tohoku-oki earthquake; we found that the landward motions were still continued from the latest results, but their displacement rates were little smaller than the previous studies.

In the presentation, we will introduce outline of the observations using the WG, and we will discuss the present postseismic deformation associated with the 2011 Tohoku-oki earthquake for the horizontal components. Note that vertical motions in the whole off-Tohoku region will be discussed by Honsho et al. [this meeting].

Keywords: GNSS-Acoustic observation, Wave Glider, Seafloor geodetic observation, Crustal deformation, The 2011 Tohoku-oki earthquake

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Semi-realtime transmission of GNSS-A data using a Wave Glider

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Seafloor crustal deformation obtained by GNSS-Acoustic observation is now essential to evaluate the long-term risk for huge subduction earthquakes and to estimate the fault extent of a huge event. A network of GNSS-A sites was rapidly constructed since the 2011 Tohoku earthquake. However, the increase in the number of sites prevents frequent shipboard surveys since it takes nearly a day for a single site. To get over the situation, JAMSTEC and Tohoku Univ. jointly started automatic GNSS-A surveys using a Wave Glider (WG) capable of long-period and autonomous navigation (Iinuma et al., 2021, Frontiers in Earth Science). Obtaining data of an equivalent quality to usual postprocessing during the automatic survey, we can immediately assess a devastating earthquake, and even in an inter-seismic period, we can flexibly modify the subsequent survey plan according to the realtime data. We report the improvement in our WG system regarding the on-demand data transmission as well as automatic observation sequence.

WG to onshore communication is via Iridium Satellite system for WG navigation and Thuraya Satellite system for the payload including the GNSS-A part. When the WG arrived around a particular site and the main power is turned on from onshore, GNSS positioning is started. If the WG is found close enough to the site, GNSS and attitude data recording are automatically started. Simultaneously the acoustic unit sends wake-up and other commands to individual transponders until the commands certainly functioned. After that, it started simultaneous periodic acoustic ranging to the transponders and storing acoustic signal with a 1-minute interval. When the WG leaves the site, measurement and data recording are stopped and then the system is halted.

The GNSS-A essential data consists of GNSS antenna position, attitude of the WG, and traveltimes of acoustic signals. GNSS receiver outputs adequate precision at 10 Hz rate through realtime processing of kinematic Precise Point Positioning using the Trimble CenterPoint RTX service. Attitude is obtained 9-DOF MEMS device at 20 Hz as well as GNSS dual antenna system at 10 Hz rate. An acoustic signal is recorded for 10 sec. for every shot, in which the reply signals from all the transponder are included.

Antenna positions and attitude data at a time of transmission and predicted times of reception of acoustic signals are read from stored data for every shot. These data at arbitrary timings are interpolated with neighboring three epochs. Phase Only Correlation (POC: Honsho et al., 2021, Frontiers in Earth Science) of the acoustic signal with five wavelengths before and after the main peak is to be sent to onshore rather than traveltime, because complicated processing to detect true peak is needed due to the distortion of a signal. The introduction of the POC significantly reduces the scatter in traveltime detection. All the relevant data above are archived each time of ranging in a file of 570 bytes with gzip-compression, ready to transmit upon request, which only amounts to 34 KB per hour. Further data reduction is possible by transmitting only transducer position, however, including raw attitude data would help to recognize in case of a possible problem in the data.

In the urgent WG survey off Aomori in December 2020, we analyzed the data immediately after the transmission, which found to perform comparable quality of result with postprocessing of full data set or even shipboard survey data. We are now working on the further refinement of the WG operation

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algorithm, especially in the intelligent automatic handling against a case for unexpected behavior of seafloor transponder and in the fully automatic onshore processing immediately after reception of the WG data. In the presentation, we also introduce the detail of the system and observed data quality in individual processing steps.

Keywords: GNSS-A, Wave Glider, Realtime, Autonomous survey, Marine Geodesy

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Operation experiment of the system for seafloor crustal deformation observation system using a buoy

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The observation of seafloor crustal deformation, which combines GNSS positioning and acoustic ranging, is an indispensable tool for investigating large subduction-zone earthquakes such as the Nankai Trough earthquake. However, at present, observations are carried out using ships, and the problem is that the frequency of observations is low.

Our research group has been developed a system using buoys in order to perform continuous observation of seafloor crustal deformation. This system has been installed on a fishery buoy of Kochi Prefecture, which is moored immediately above the submarine station located 32 km off Cape Ashizuri, and has been tested for continuous observation. Observation of seafloor crustal deformation using this system started on March 28, 2018. The acoustic ranging could be carried out continuously for about 6 months, but due to power outages occurring three times, especially in winter, the power supply capacity was improved from December 2019 to March 2020 by increasing the solar panels from 5 to 8, and the amount of storage batteries was doubled; also the power supply system was separated into two systems for a 12V system and a 24V system, respectively. The acoustic ranging has been continued for about 10 months or more since March 12, 2020 after improving the power supply capacity. Therefore, it was confirmed that our system can perform the acoustic ranging measurement continuously as long as power is continuously supplied. However, the satellite communication part is insufficient quality, and acoustic ranging data transmitted to land base stations accounts for only about 60 % of the total. The GNSS positioning and attitude measurement data using a gyro are required for seafloor crustal deformation observation, as well as the acoustic ranging data, but these measurements also had problems, and the period when all data are available was only from August 2020 and January 2021. The accuracy of the seafloor positioning was about several centimeters when we used the data during this period.

Keywords: seafloor crustal deformation, moored buoy

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Initial results of sea trials on bathymetric survey performance of “AUV-NEXT”: aiming to acquire higher-quality bathymetric data

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In AUV bathymetric survey, since AUV can approach the seafloor for ocean mapping, it is possible to acquire bathymetric data with higher resolution and less noise even at the deep waters. However, in order to acquire higher-quality bathymetric data in an actual AUV bathymetric survey, it is required to establish a method for acquiring bathymetric data with sufficiently high reproducibility within the range of the bathymetric data precision. To aim at such a standardization of AUV bathymetric survey technology for acquiring high-quality bathymetric data, the JAMSTEC and JHOD conducted sea trials to verify an actual bathymetric data performance using the "AUV-NEXT".
In these sea trials, in March and November 2020, the "AUV-NEXT" dived around the Nankai Trough area (at depths of 2500-2800 m) offshore the Kii Peninsula and the Suruga Bay, and bathymetry was surveyed by using a bathymetric side scan sonar (Bathy-SSS: EdgeTech 2205AUV) installed on the AUV. After sufficient preliminary tests such as DVL calibration, which is important for AUV navigation, and patch test for correcting the mounting angle of the sonar, bathymetric data were acquired, and by confirming the reproducibility of bathymetric data to which various necessary corrections were applied, we were able to find out some important points in AUV bathymetric survey technology. As a result, higher quality bathymetric data can be acquired by using the “AUV-NEXT”. In this paper, we report the initial results of these sea trials.

Keywords: Autonomous Underwater Vehicle (AUV), “AUV-NEXT”, Bathymetric survey, Bathymetric side scan sonar (Bathy-SSS), Multibeam echosounder (MBES), Sea trials on bathymetric survey performance

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Sat. Jun 5, 2021 9:00 AM - 10:30 AM JST | Sat. Jun 5, 2021 12:00 AM - 1:30 AM UTC | Ch.20 Zoom Room 20

[S-CG46] Rheology, fracture and friction in Earth and planetary sciences

convener:Shintaro Azuma(Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology), Ichiko Shimizu(Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University), Osamu Kuwano(Japan Agency for Marine-Earth Science and Technology), Miki Tasaka(Shizuoka University), Chairperson:Shintaro Azuma(Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology), Miki Tasaka(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).

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

[SCG46-01] Low stress power-law creep of olivine

★Invited Papers

*Kosuke Yabe[1], Kenta Sueyoshi[1], Takehiko Hiraga[1] (1.Earthquake Research Institute, the University of Tokyo)

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

[SCG46-02] Vickers indentation tests on olivine: grain size and indentation size effects

*Sanae Koizumi[1], Takehiko Hiraga[1] (1.Earthquake Research Institute,The University of Tokyo)

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

[SCG46-03] Extremely slow grain growth of albitic feldspar

*Norio Shigematsu[1], Masanori Kido[1], You Zhou[2], Hideki Hyuga[2], Yuichi Yoshizawa[2] (1.Research Institute of Earthquake and Volcano Geology, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2.Multi-material Research Institute, National Institute of Advanced Industrial Science and Technology)

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

[SCG46-04] The effect of grain size and porosity on compaction localisation in high-porosity sandstones

*Elliot Rice-Birchall[1], Daniel R Faulkner[1], John D Bedford[1,2] (1.University of Liverpool, 2.Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology (JAMSTEC))

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

[SCG46-05] Deformation of simulated quartz-feldspar faults at the brittle-ductile transition zone

*Miho Furukawa[1], Berend A. Verberne[2], Jun Muto[1], Miki Takahashi[2], Hiroyuki Nagahama[1] (1.Department of Earth Sciences, Tohoku University, 2.Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology (AIST))

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

[SCG46-06] Initial results on high Pc-Pp-T rock deformation experiments under drained conditions

★Invited Papers

*Keishi Okazaki[1], Jun Muto[2] (1.Japan Agency for Marine-Earth Science and Technology, 2.Department of Earth Sciences, Tohoku University)

Low stress power-law creep of olivine

*Kosuke Yabe[1], Kenta Sueyoshi[1], Takehiko Hiraga[1]

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Strain localization plays a critical role in mantle shear zone. Some studies attributed it to grain-size-sensitive creep (i.e., diffusion creep) through grain-size reduction by dislocation creep (e.g., Warren & Hirth, 2006). Some friction experiments suggest a superplastic deformation mechanism accommodated by diffusion to play an important role even during seismic faulting (De Paola et al., 2015). Conventionally, it has widely assumed that Newtonian diffusion creep overwhelms dislocation creep at the condition of the lower stress and/or the smaller grain size. However, it is well known in material science community that power-law interface creep dominates at the lower stress and the smaller grain size than diffusion creep, which could potentially be important for the rheology of the Earth interior.
We conducted one-atmosphere uniaxial compression experiments on fine-grained (~1 μm) Fe-bearing olivine ($Mg_{1.8}Fe_{0.2}SiO_4$) aggregates that were variably doped with CaO ±Al_2O_3. We identified power-law interface-controlled creep at low stresses and grain-boundary diffusion creep at high stresses, which operate as mutually coupled, i.e., sequential processes. We established constitutive equations for interface-controlled creep and diffusion creep of undoped olivine and used the combined rate equation as a reference to examine the effect of doping on creep rates. Ca and Al were found to enhance rates of both interface-controlled creep and diffusion creep above certain temperatures, and this effect becomes significant with increasing temperature. We attribute the rate enhancements to grain-boundary-disordering promoted by grain boundary segregation of the dopants at near-solidus conditions. The enhancements are well described in relation to the sample solidus temperature and an additional activation energy relative to that of the reference creep state. Based on our established flow laws of diffusion and interface-controlled creep, we constructed deformation mechanism map and found that grain-boundary diffusion creep dominates in most of the upper mantle, while interface-controlled creep can be effective during seismic faulting in the mantle at a shallow depth.

Keywords: olivine aggregates, power law creep

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Vickers indentation tests on olivine: grain size and indentation size effects

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Vickers indentation tests on Fe-free (Mg_2SiO_4) and Fe-bearing ($Mg_{1.8}Fe_{0.2}SiO_4$) olivine single crystals and highly dense polycrystalline material with average grain sizes ranging from 170 to 890 nm were conducted. The Vickers microhardness (H_v) of the Fe-free polycrystalline material with the finest grain size is 17 GPa at a load of 0.1 N, while that of the Fe-bearing single crystal is 8 GPa at the largest load applied. Overall, H_v decreases with increasing grain size, load (indentation depth), and the presence of Fe. For each grain size, H_v is well characterized by a power law of the form $H_v/H_{0v} \propto l^{-x}$, where H_{0v} is the depth-independent value of H_v, l represents either grain size or indentation depth, and x is 0.09. Despite the small exponent value for each size effect, the nonlinear interaction of the two size effects results in large variations of H_v in our samples.
We show that our semi-empirically derived relationship as a function of grain size and indentation depth explains the H_v of both polycrystalline and single-crystal olivine at any indentation conditions. Indentation fracture toughness of the finest grained material is 0.8 MPa $m^{1/2}$, which increases slightly to 1.1 MPa $m^{1/2}$ with increasing grain size, while the toughness of the single crystals varies from 0.5 to 0.8 MPa $m^{1/2}$ depending on the crystallographic orientation of the fracture planes.

Keywords: Olivine, Vickers hardness, fracture toughness, Grain size

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Extremely slow grain growth of albitic feldspar

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Feldspar is one of the main constituent minerals of the Earth's crust. The grain growth and the mechanical behavior of plastic deformation of feldspar have well been studied for anorthite ($CaAl_2Si_2O_8$), because it is considered that this mineral controls the strength of the lower crust. However, the grain growth of albite ($NaAlSi_3O_8$) has not been studied previously. Grain growth follows the grain growth law and the rate constant was determined in the experiments.
The starting materials were prepared as follows. Albite powders for industrial use were pulverized using a HERZOG HP-MS60 automatic pulverizer at the GSJ Laboratory (GSJ-Lab.) of Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (GSJ, AIST), and fine-grained fractions less than a few hundred nm were separated by decantation. The fine-grained powders were hot pressed using a multi-purpose high temperature furnace (Fuji Dempa High Multi 10000 at AIST Chubu) at temperature of 1080 ºC and pressure of 120 MPa for 16 hours. Then the sample were cut into small pieces to perform the grain growth experiments at different conditions. Surfaces of samples were mirror polished using 1 mm diamond paste before the experiments to observe the grain boundaries by thermal or chemical etching. The grain growth experiments were performed by annealing the sample in a tube furnace (Carbolite 14/450 at AIST Tsukuba Central 7) at the atmospheric pressure and temperatures of 1030, 1050, 1065 ºC. The grain size was determined by linear intercept method after chemical etching for the initial grain size. The sample surfaces were observed in the HITACHI SU-3500 scanning electron microscope (SEM) installed at the GSJ-Lab. of GSJ, AIST.
The initial grain size is 172.9 nm. The grains grow to the grain sizes of about 282 nm after 156 hours, about 378 nm after 190 hours and about 329 nm after 64 hours at the temperatures of 1030 ºC, 1050 ºC and 1065 ºC, respectively. When the growth exponent is assumed to be 2.6, the regressions of the results yield the rate constants of 1.26×10^{-23} $m^{2.6}s^{-1}$, 2.58×10^{-23} $m^{2.6}s^{-1}$ and 5.07×10^{-23} $m^{2.6}s^{-1}$ at 1030 ºC, 1050 ºC and 1065 ºC, respectively. The Arrhenius plot for the results of the annealing experiments of albite yield the activation energy of Q=580 kJ/mol and the pre-exponent of the rate constant k_0=1.83 $m^{2.6}s^{-1}$.
The extrapolation of the grain growth curves to geological time scale indicates that it takes almost 1 century for grains to grow from 1 μm to 10 μm even at the temperature of 1050 ºC, the grain growth is extremely slow. The experiments in this study can be considered to have been under anhydrous conditions and may be different from the natural hydrous conditions. An experiment of reaction rim of albite that were formed from nepheline ($NaAlSiO_4$) and quartz (SiO_2) suggests that grain growth rate under hydrous and anhydrous conditions are not significantly different at the temperature of 1100 ºC.
The results in this study and above discussion suggest that once fine-grained feldspar with composition close to albite is formed, these feldspar grains will never grow and affect the mechanical behavior for long time. This process enables the grain-size sensitive creep of plagioclase to be important in the wide range of crustal conditions.

Keywords: Albite, Grain Growth, Crustal Rheology

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The effect of grain size and porosity on compaction localisation in high-porosity sandstones

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As sandstone reservoirs are depleted, the pore pressure reduction can sometimes result in pore collapse and the formation of compaction bands. These localised features can significantly reduce the bulk permeability of the reservoir and are therefore problematic in the hydrocarbon, groundwater, geothermal, and CO_2 sequestration industries. However, the influence that grain size, grain shape and sorting have on compaction band formation in sandstone is still poorly understood, due to the fact that finding natural sandstones with specific properties is challenging. Consequently, a method of forming synthetic sandstones has been developed, in order to produce a suite of sandstone specimens with controlled grain size and porosity characteristics. During production of the synthetic sandstones, amorphous quartz cement and sodium chloride are precipitated between sand grains as a product of the reaction between sodium silicate and hydrochloric acid. The salt can then be dissolved, resulting in synthetic sandstones that have very comparable physical properties to their natural counterparts. In this study, triaxial experiments were performed on synthetic sandstone cores with four different grain size ranges of 250-300, 425-500, 600-710 and 850-1000 microns, at three different starting porosities of 27%, 32% and 37%. The samples were each axially loaded from a point along their hydrostat corresponding to 85% of their hydrostatic yield point (P*) values. These conditions mean that yielding will occur within the shear-enhanced compaction regime, which is also where localised compaction structures typically form. All samples were taken to 5% axial strain. The microstructural results indicate that localisation of deformation within the samples did occur and was favoured by low starting porosity and small grain size. Localisation of deformation was most easily recognised by grain size reduction as a result of grain crushing. This was weakly correlated to a change in porosity but recognition of localisation was difficult to make using variations in porosity alone. Porosity reduction was not necessarily associated with a reduction in grain size. With increasing grain size and starting porosity, the deformation becomes more distributed in the samples with the highest starting porosity samples (37%) exhibiting more widely distributed grain crushing which was less intense overall. The results indicate a significant grain size and porosity influence on localisation, but also that compaction can occur via two mechanisms; one involving mostly grain rearrangement and the other primarily by grain fracturing. Consequently, the localisation of deformation is most evident in grain size reduction and is only weakly shown by porosity reduction.

Keywords: Porous rock, Sandstones, Compaction bands, Grain size, Localisation, Grain crushing

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Deformation of simulated quartz-feldspar faults at the brittle-ductile transition zone

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Continental earthquakes frequently nucleate in the brittle-ductile transition zone. Recently, experimental studies revealed that nano- or microscale deformation processes, such as amorphization (Peč et al., 2016) or intergranular dilatation (Verberne et al., 2017), may lead to nucleation of unstable slip hence runaway fault rupture. Since the continental upper crust is dominantly composed of granitoids, studying the rheological behaviors of fault rocks composed of quartz and feldspar is key for better understanding upper-crustal fault mechanics. Aiming to improve insight into the microphysical processes controlling fault slip in the continental crust, we conducted Griggs shear experiments on ~1 mm thick simulated faults composed of 50:50 wt% quartz-albite gouges. Temperatures and pressures in each experiment were varied to simulate conditions at 7, 8, 10, 13, and 18 km depths in the crust, assuming geothermal and lithostatic gradients of respectively 30℃/km and 2700 kg/m^3. The bulk shear strain rate was sequentially stepped between ~10^{-3} and ~10^{-4} /s, achieving total bulk shear strains of up to 3.5 to 5.0. Recovered sheared samples were investigated using an optical and a scanning electron microscope (SEM), energy dispersive X-ray spectroscopy (EDS) analyses in an SEM.
In general, when frictional regime dominates, shear resistance increases with increasing normal stress, whereas when flow regime dominates, shear resistance decreases with increasing temperature. Unlike this tendency, shear stresses obtained from the experiments showed positive dependences on both pressure and temperature. Since the shear resistances increased even with the increase in temperature, the mechanical data may suggest frictional regime was dominant in all experiments.
However, microstructural observations of recovered samples indicate a change in deformation style from brittle to partially plastic as the simulated depth condition increases. Specifically, backscattered electron micrographs showed that microcrack distribution changes as pressure and temperature increases. At the shallower conditions, large numbers of short cracks are observed in various directions, while at the deeper conditions, the cracks are less, and are seen to coalesce to constitute R_1- and Y- shears. Using image analysis, we characterized the deformation properties of individual grains. At the shallower conditions, the long axes of K-feldspar marker grains, present in minor amounts, are distributed randomly, whereas at the deeper conditions these are aligned along the direction of maximum tensile strain. Our interpretation is that brittle crushing and rotation are dominant under shallow conditions, with a progressively more important role for plastic flow takes towards deeper conditions. This transition is consistent with a change in autocorrelation function (ACF) of K-feldspar grains with increasing temperature and pressure.
Our results indicate that even within the range of frictional behavior, plastic deformation gradually emerges on the scale of microstructure as increasing temperature and pressure.

References

- Peč, M., H. Stünitz, R. Heilbronner, and M. Drury (2016), Semi-brittle flow of granitoid fault rocks in experiments, *J. Geophys. Res. Solid Earth*, 121, 1677-1705, doi:10.1002/2015JB012513.
- Verberne, B. A., Chen, J., Niemeijer, A. R., de Bresser, J. H., Pennock, G. M., Drury, M. R., and Spiers, C. J. (2017), Microscale cavitation as a mechanism for nucleating earthquakes at the base of the seismogenic zone, *Nat. Commun.*, 8, 1-8, doi: 10.1038/s41467-017-01843-3.

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Keywords: quartz, feldspar, gouge, Griggs shear experiment, microstructure

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Initial results on high Pc-Pp-T rock deformation experiments under drained conditions

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At subduction plate boundaries and inland active faults, most of large earthquakes (Mw >7) occur at the base of the seismogenic zone with a depth of about 10–25 km. The PT conditions of these areas corresponds to lithostatic pressures ranging 300–800 MPa and temperatures ranging 200–400 degC. In addition, seismological observations indicate that the pore fluid pressure is nearly lithostatic, meaning 300–800 MPa. The presence of high pore fluid pressure plays a key role in controlling the rock rheology, because the frictional strength of the fault is a function of the effective pressure and physico-chemical properties of fluids changes exponentially under high pressure. However, most of rock friction experiments have been conducted under pressures lower than 200 MPa. Therefore, understanding of fault rheology at the base of the seismogenic zone is limited by the extrapolations of low PT experiments and experiments using analog materials. We recently built two new solid pressure medium apparatuses at KCC/JAMSTEC and Tohoku University. They are capable of increasing the confining pressure, the pore pressure and the temperature up to 2 GPa, 1 GPa and 1200 degC, respectively. These apparatuses can reproduce the in-situ or even deeper P-Pp-T conditions of the seismogenic zone. Our preliminary experiment on San Carlos olivine deformed under the confining pressure of 1 GPa, the pore pressure of 480 MPa at the temperature of 462 degC indicates that the nominal friction coefficient was 0.42 with assuming fully undrained condition. The recovered sample showed the formation of chlorite-rich shear zone along the piston-sample boundary probably due to reaction among the sample, water and alumina piston. Serpentine and Fe-oxide were also observed in the sample matrix. This presentation will also report basic performances, calibration data of the apparatuses and further experimental results.

Keywords: Rheology, Fault, Subduction zone

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Sat. Jun 5, 2021 10:45 AM - 12:15 PM JST | Sat. Jun 5, 2021 1:45 AM - 3:15 AM UTC | Ch.20 Zoom Room 20

[S-CG46] Rheology, fracture and friction in Earth and planetary sciences

convener:Shintaro Azuma(Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology), Ichiko Shimizu(Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University), Osamu Kuwano(Japan Agency for Marine-Earth Science and Technology), Miki Tasaka(Shizuoka University), Chairperson:Ichiko Shimizu(Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University), Osamu Kuwano(Japan Agency for Marine-Earth Science and Technology)

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

[SCG46-07] Dehydration experiments of antigorite serpentinite under slab-mantle conditions

Sakurako Okude[1], *Ichiko Shimizu[1] (1.Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University)

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

[SCG46-08] Variation of stick-slip behaviors controlled by dehydration kinetics of simulated gypsum gouges

*Mikihiro Kawabata[1], Rei Shiraishi[1], Jun Muto[1], Hiroyuki Nagahama[1], Yuto Sasaki[2] (1.Department of Earth Science, Graduate School of Science and Faculty of Science, Tohoku University, 2.Earthquake Research Institute, The University of Tokyo)

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

[SCG46-09] Experimental study on drainage process of liquid film between bubbles during bubble growth

★Invited Papers

*Masatoshi Ohashi[1], Atsushi Toramaru[1], Atsuko Namiki[2] (1.Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2.Graduate School of Environmental Studies Department of Earth and Environmental Sciences)

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

[SCG46-10] Transition from viscous to inertial regime in dense frictional suspensions

*Franco Antonio Tapia[1], Olivier Pouliquen[3], Elisabeth Guazzelli[2] (1.Department of Mechanical Systems Engineering, Tokyo University of Agriculture and Technology, 2.Université de Paris, CNRS, Matière et Systèmes Complexes (MSC) UMR 7057, Paris, France, 3.Aix-Marseille Université, CNRS, IUSTI, Marseille, France)

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

[SCG46-11] Peridodic fluctation in a compressed dust-aggregate layer

*Hiroaki Katsuragi[1], Felipe Pacheco Vazquez[2], Tomomi Omura[3] (1.Department of Earth and Space Science, Osaka University, 2.BUAP, Mexico, 3.Osaka Sangyo University)

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

[SCG46-12] Elasto-plastic behavior of carbonate rocks under high strain rate deformation

★Invited Papers

*Kosuke Kurosawa[1], Hidenori Genda[2], Shintaro Azuma[3], Keishi Okazaki[4], Haruka Oono[1], Takafumi Niihara[5], Takashi Mikouchi[6], Naotaka Tomioka[4], Tatsuhiro Sakaiya[7], Tadashi Kondo[7], Masahiro KAYAMA[8], Mizuho Koike[9], Yuji Sano[10], Takuya Matsuzaki[11], Masafumi MURAYAMA[11], wataru Satake[1], Takafumi Matsui[1,12] (1.Planetary Exploration Research Center, Chiba Institute of Technology, 2.Earth–Life Science Institute, Tokyo Institute of Technology, 3.Department of Earth and Planetary Sciences, Tokyo Institute of Technology, 4.Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology, 5.Department of Systems Innovation, School of Engineering, The University of Tokyo, 6.The University Museum, The University of Tokyo, 7.Department of Earth and Space Science, Graduate School of Science, Osaka University, 8.Department of General Systems Studies, Graduate School of Arts and Sciences, The Univ. of Tokyo, 9.Department of Earth and Planetary Systems Science, Graduate School of Science, Hiroshima University, 10.Atmosphere and Ocean Research Institute, The University of Tokyo, 11.Center for Advanced Marine Core Research, Kochi University, 12.Institute of Geo-Cosmology, Chiba Institute of Technology)

Dehydration experiments of antigorite serpentinite under slab-mantle conditions

Sakurako Okude[1], *Ichiko Shimizu[1]

1. Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University

A popular hypothesis for the occurrence of double seismic zones in subducting slabs is "dehydration embrittlement" of serpentinized mantle. In the classical deformation experiments of antigorite-serpentinites conducted by Raleigh & Paterson (1965), brittle failure was observed at the temperature beyound the stability field of antigorite (> 650 ^{o}C) at the confining pressures up to 0.5 GPa. However, it is questionable if the same mechanism could be effective in subducting slabs at the depth. Here we report the results of deformation and dehydration experiments of antigorite-serpentinite, taken from the Nagasaki Metamorphic Belt, at comfining pressures up to 1.7 GPa. Using a modified Kumazawa-type solid-medium apparatus, intact serpentinite samples were axially compressed at a constant strain rate of 3.3 x 10^{-5} sec^{-1}, while laterally confined by talc assembly.

In the experimental run at 500 ^{o}C and 1.2 GPa confining pressure, the serpentinite wample was strong and show strain-hardening behavior. The final differential stress exceeded 1.8 GPa. The sample was deformed in a brittle mannar with conjugate faults. The samples deformed at 700 ^{o}C exhibited "dehydration softening" and stable creep behaviors and showed semi-brittle deformation. Forsterite and enstatite were formed along the fault zones, suggesting enhancement of dehydration reaction by fracturing and shearing. Implication of the present results to the mechanism of intermediate-depth earthquakes well be discussed.

Keywords: serpentinite, dehydration reaction, deformation experiments, intermediate-depth earthquakes

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Variation of stick-slip behaviors controlled by dehydration kinetics of simulated gypsum gouges

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In the subduction zone, the increase in pore fluid pressure causes slow slip (Katayama, 2016), slow slip accumulates stress in the asperities and accumulation of stress eventually leads to the occurrence of large earthquakes (Hasegawa et al., 2015). Because gypsum undergoes phase transition and dehydration at relatively low temperatures and pressures, it can easily reproduce the dehydration instability of hydrous minerals in the laboratory (Brantut et al., 2011). Therefore, there have been many studies on the effect of pore fluid pressure on slip events using gypsum (e.g., Leclère et al., 2016). There are also many studies on the dehydration reaction of hydrous minerals from the viewpoint of reaction kinetics (e.g., Liu et al., 2015). In order to illuminate how the dehydration kinetics controls the frictional behavior, Sasaki et al. (2016) conducted friction experiments of simulated gypsum gouges under various temperature and pressure conditions, and found the change in recurrence intervals of repeated stick-slip events with time in an experiment conducted under dehydration condition. Later by analyzing the data of Sasaki et al. (2016), Iwasaki et al. (2017) derived the time function of pore fluid pressure causing the change in the recurrence intervals assuming that gypsum underwent phase transition and dehydration during the friction experiment. However, both studies did not confirm the presence of a dehydration product (anhydrite) after experiments. In this study, we first discussed the possibility of dehydration of gypsum in the experimental conditions and then evaluated the time function of pore fluid pressure.
Sasaki et al. (2016) conducted friction experiments using gypsum gouge under the conditions of confining pressures of 10 - 200 MPa and temperatures of room temperature - 180 ˚C by gas apparatus. The data showed that the stress drops and recurrence periods of stick-slip events increased with increasing confining pressure at room temperature and 70 ˚C, while the stress drop and recurrence period decreased with time at 200 MPa and 110 ˚C (Iwasaki et al., 2017). This is presumably because the phase transition and dehydration of the gypsum created pore fluid pressure that reduced the apparent mechanical strength. Iwasaki et al. (2017) obtained a time function of pore fluid pressure by fitting the reaction kinetics using ‘Avrami's equation’ (Avrami, 1940) to temporal variation of pore fluid pressure. As for the dehydration potential of gypsum, under the condition where the stress drop varied with time, the frictional coefficient decreased with time when the pore fluid pressure was not taken into account. However, taking the pore fluid pressure into account, the frictional coefficient remained almost constant, which is consistent with the previous studies reporting the similar frictional coefficients of gypsum and anhydrate. In addition, the microstructure under the presumed dehydration condition did not show much Riedel shear planes, which may be due to the decrease in shear stress caused by the occurrence of pore fluid pressure (Leclère et al., 2016). Furthermore, we calculated the porosity of the gypsum gouge on the assumption that pore fluid pressure was generated, and the value was slightly smaller than the value known from previous studies, but it was considered that dehydration reaction occurred. This suggests that the gypsum may have undergone phase transition and dehydration during the shear deformation experiment, and then we evaluated the time function of the pore fluid pressure. The Avrami equation used for the temporal variation of pore fluid pressure includes the reaction rate k and the exponent n, which is related to the formation and growth mechanism of the material. The reaction rate k depends on the conditions of temperature, pressure, etc., and is generally harmonic when compared with the conditions of previous studies (Liu et al., 2015; Ballirano and Melis, 2009; Carbone et al., 2008). The exponent n

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indicates the formation and growth mechanism of the material. Therefore, the obtained time function of pore fluid pressure is considered to be reasonable. If the time function of the pore fluid pressure obtained from the friction experiment using gypsum can be used to estimate the time until slow slip occurs, it will contribute to the estimation of the period of stress accumulation in the asperities and to the study of the occurrence of large earthquakes caused by slow slip.

Keywords: stick-slip, subduction zone, dehydration instability, pore fluid pressure, kinetics

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Experimental study on drainage process of liquid film between bubbles during bubble growth

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Bubble coalescence has attracted attention in volcanology in recent decades because it can control volcanic eruption styles. Pre- and syn-eruptive magmas involve compressive bubbles, which reduce the effective density of magma and can be a driving force of the explosion. Thus, the explosivity of dry eruptions depends on the amount of gas in magma that exists as bubbles. The interconnected bubbles formed by coalescence can help to release the gas and prevent the magma from an explosive eruption. Bubble coalescence is divided into two stages: (1) approach stage in which the distance between bubbles shorten due to bubbles growth with maintaining the round shape, and (2) drainage stage in which the liquid film between bubbles drains out until a critical thickness. Here, we focus on the drainage stage. Previous studies investigated the timescale of drainage theoretically and experimentally under gravitational and capillary force effects (e.g., Proussevitch et al., 1993; Nguyen et al., 2013). However, the drainage by bubble growth associated with decompression is poorly understood, which must be a dominant process in a conduit. Therefore, we perform laboratory experiments and investigate if the rapid growth of bubbles accelerates or decelerates the drainage of the liquid film.

We used a Hele-Shaw cell made from two glass plates separated by 0.1 mm thick spacers. We filled the cell with silicone oil of 10 Pa・s viscosity and injected a mm-size bubble by microsyringe. By penetrating the bubble with a needle, we divided it into two nearly equal-size bubbles. We then placed the cell in a transparent acrylic container sealed by O-ring. The interior of the container was decompressed with a vacuum pump from the atmospheric pressure to 5 kPa. The decompression rate was varied by a vacuum regulator. The two bubbles gradually approached each other as the bubbles grow, and drained out the liquid film between them. The drainage process was recorded with an optical microscope and analyzed using Matlab.

The experimental results show that the growth rate of a bubble during decompression is faster than that expected from the ideal gas law. This difference can be attributed to the diffusional influx of dissolved air into bubbles. As the decompression rate increases, the bubble growth rate increases, which shortens the film rupture timescale. In the rapid decompression regime, a linear plateau border forms between two adjacent bubbles. The most striking finding in our experiments is that, under the higher decompression rate, the bubbles grow larger just before the onset of film rupture than in the case under the smaller decompression rate. The large growth rate enhances the viscous resistance in the plateau border, so that the bubble growth continues until the film thickness reaches a critical value. This finding significantly suggests that the formation of the permeable network in an eruption depends not only on the void fraction but also on the decompression rate.

Keywords: bubble coalescence, magma, laboratory experiment

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Transition from viscous to inertial regime in dense frictional suspensions

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Failure and flow of granular materials are involved in many natural disasters and industrial processes. Several peculiar phenomena such as shear rate dependence behaviour, yield stress onset, normal stress difference, etc., distinguish them dramatically from classical newtonian flows. One of the most intriguing questions, which still remain a big challenge, are jamming-unjamming process and dissipation energy rate in a dense regime. Both of them seems to be strongly ruled by microscopic nature of inter-particle interaction forces and particle coupling with interstitial fluid. While hydrodynamic interactions or lubrication forces between the particles are important in the dilute regime, they become of lesser significance when the concentration is increased, and direct particle contacts become dominant in the rheological response. Despite its have been studied extensively, none of which is clearly understood so far.

Depending on boundary condition and stress distribution, dense granular flows can shows two different regimes : (i) rate-independent quasi-static flow, for moderate shear rate deformation, partially well described by continuous viscous-plastic models, inspired by soils mechanics, and (ii) rate-dependent behaviour, in which shear a normal stresses shows a power law function of the shear rate deformation in volume imposed rheology. In this frame of work, jamming transition is presented in a classical viscous approach as a shear viscosity divergence. In order to unifies theses two regimes, a non-classical rheology is suggested, wherein normal pressure, P, is imposed on the sample instead of the volume. Thus, a non-classical-frictional approach is suggested, in which the effective friction coefficient, defined by the ratio of macroscopic shear and normal stresses, and the flowable global solid-volume fraction are meanly controlled by an empirical power-law function of the ratio of macroscopic shear rate deformation and the normal pressure (perpendicular to the gradient direction). Moreover, particle-fluid coupling rules on the algebraical effective rheological properties of granular suspension; while for low viscosity interstitial fluid, the rheology has a high influence of inertial effect, newtonian rheology become important for high viscosity regime.

We present here an experimental study of viscous-inertial transition for a dense suspension of non-colloidal rigid PMMA particles by varying systematically the interstitial fluid viscosity for a both : Pressure and Volume-imposed rheology. The effect of inter-particle interaction is also explored by changing the elastic properties of solid particles by manufacturing soft hydrogel particles suspended in a water solution of UCON oil.

Keywords: Granular, Rheology, Suspensions, Jamming, Friction

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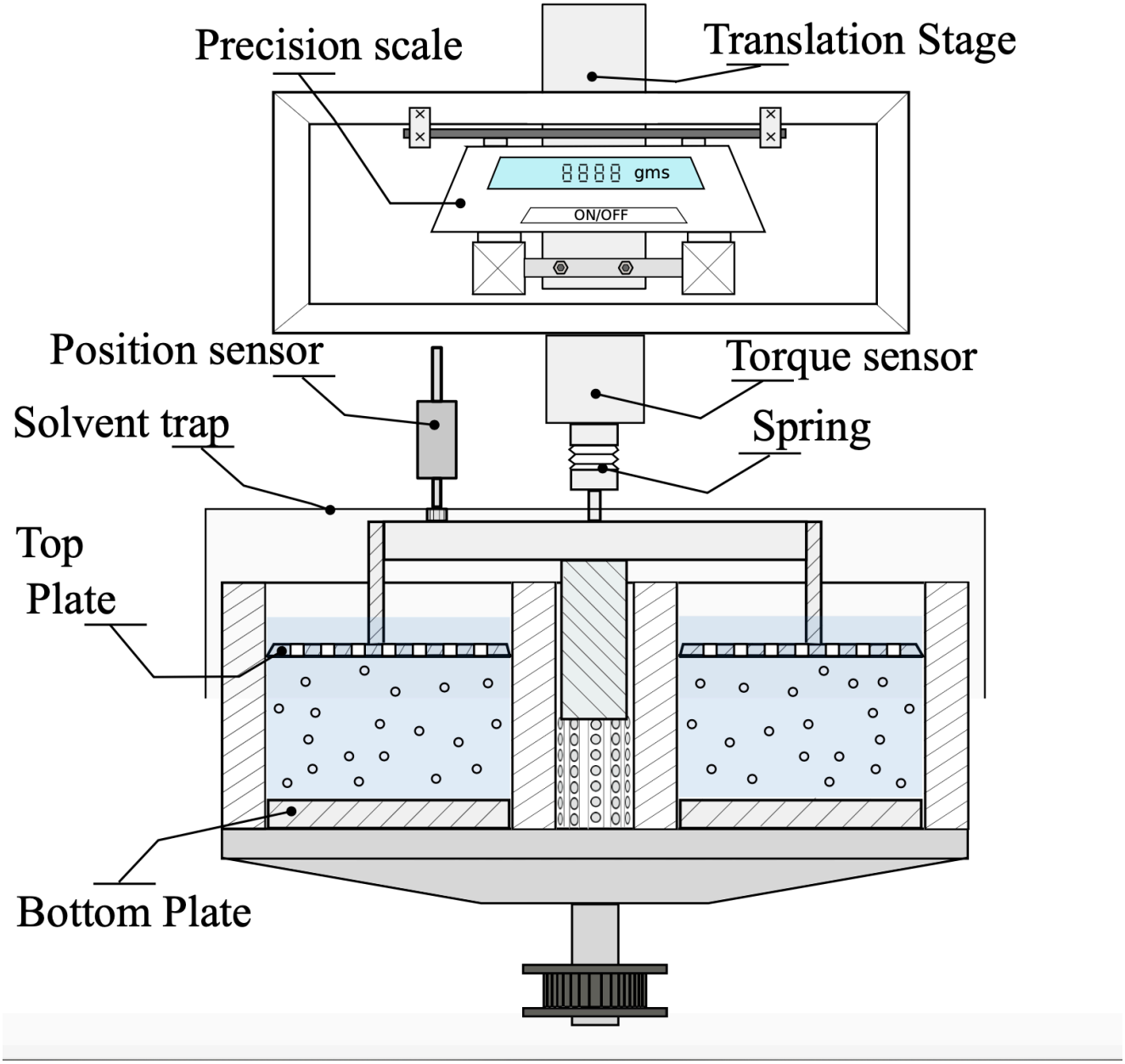

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Peridodic fluctation in a compressed dust-aggregate layer

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Granules formed by tiny powder can be found in various situations even in our everyday lives. For example, dust aggregates are considered the candidate for materials forming planetesimals. Granules of flour, sugar, salt can be easily found in a kitchen. Although the fundamental understanding on behaviors of dust aggregates is crucial to properly understand/handle them, systematic physical investigation has not been sufficiently carried out so far. Therefore, we performed a set of simple experiments. In specific, uniaxial compression test of a hierarchical granular matter was performed. The hierarchical granular matter consists of a collection of dust aggregates. Dust aggregates were formed by mixing tiny glass beads (5 micro-meter in diameter) and small amount of water. Diameter of aggregate is approximately 1 mm. Dust aggregates were poured in a cylindrical cell and uniaxially compressed by a universal testing machine (Shimadzu AGX) with a constant speed. The compression speed was varied from 0.17 to 2000 micro-meter per second (over four orders of magnitude). During the compression, the compression force was measured. The compression force gradually increased as the compression proceeds. At the same time, periodic fluctuation of the compression force was observed on the increasing compression force. To characterize the nature of periodic fluctuation, we analyzed the experimental data (fluctuation amplitude, wavelenght, etc.) and obtained an empirical form. In addition, we performed the same experiment with glass beads and compared that result with the dust-aggregate case. In this presentation, details on the analyzed result will be presented.

Keywords: dust aggregate, uniaxial compression, periodic fluctuaion

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Elasto-plastic behavior of carbonate rocks under high strain rate deformation

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Impact craters dominate the surface topography of planets/satellites/asteroids with solid surfaces and without atmospheres and hydrospheres. Most of the meteorites found on the Earth contain unique metamorphic features caused by deformation under high stress conditions. These facts are evidence that mutual collisions between planetary bodies are one of the fundamental geological processes in the solar system. In hypervelocity collisions, materials are fluidized and deformed by induced shock waves. The characteristic strain rate of celestial collisions is expressed as the ratio of the impact velocity to the projectile diameter, and it typically exceeds 1 s^-1. In the case of an impact at >10 km/s, shock pressure exceeds 100 GPa, and a temperature rise due to irreversible compression leads to the perfect fluid approximation being valid. Our understanding of impact phenomena has often been based on the perfect fluid approximation. However, the typical impact velocity in the asteroid belt where meteorite parent bodies existed is ~5 km/s, which is comparable to the sound speed of rocky materials, and the elasto-plastic response of shocked rocks during impact events could not be ignored. Recently, Kurosawa and Genda (2018), GRL, 45, 620-626, numerically showed that the degree of impact heating due to plastic deformation during low-velocity impacts (<10 km/s) can be larger than that due to irreversible compression during shock wave propagation. The accurate understanding of the rock rheology is becoming more important in planetary sciences than previously thought.

We have started multifaceted studies to explore the responses of carbonate rocks under deformation with high strain rates. The advantages of the use of carbonate rocks are: (1) the temperature and pressure dependence of yield strength can be expressed by the same empirical law pertaining to igneous rocks, (2) the volatile component (CO2) is released at a relatively low temperature, and the degree of impact heating in the shocked sample can be quantitatively evaluated by measuring the amount of CO2 generated, and (3) homogeneous samples can be obtained at low cost. In this study, Carrara marble from Italy was used as a reference material. The marble constitutes crystallographically randomly-oriented calcite crystals having 100–300 um in diameter without gaps between grains.
In this presentation, we show the importance of the flow law to accurately estimate the amount of CO2 generated from shocked marbles based on the results of numerical impact calculations incorporating a simple rheology model for Calcite [Kurosawa, Genda, Azuma, and Okazaki, Revised]. We also present the results of an on-going shock-recovery experiment with the marble. In our experiments, shocked marbles,

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which have experienced pressures of 1 - 10 GPa and strain rates of 10^5 –10^6 s-1, could be recovered for in-depth analyses.

Keywords: Celestial collisions, calcite, plastic deformation

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Sat. Jun 5, 2021 9:00 AM - 10:30 AM JST | Sat. Jun 5, 2021 12:00 AM - 1:30 AM UTC | Ch.02 Zoom Room 02

[M-IS12] Planetary Volcanology

convener:Rina Noguchi(Faculty of Science, Niigata University), Nobuo Geshi(Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Tomokatsu Morota(Department of Earth and Planetary Science, The University of Tokyo), Chairperson:Rina Noguchi(Faculty of Science, Niigata University), Nobuo Geshi(Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Tomokatsu Morota(Department of Earth and Planetary Science, The University of Tokyo)

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

[MIS12-01] Structures and formation age of lunar linear gravity anomalies constrained by impact simulations

*Gaku Nishiyama[1], Noriyuki Namiki[2], Seiji Sugita[1] (1.University of Tokyo, 2.National Astronomical Observatory of Japan)

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

[MIS12-02] Laboratory investigations of salt precipitation upon decompression and degassing of volatile-containing brines: Implication for carbonate mineral formations on Solar system icy bodies

*Masahiro Yoda[1,2], Yasuhito Sekine[2,3] (1.Department of Earth and Planetary Science, The University of Tokyo, 2.Earth-Life Science Institute of Tokyo Tech, 3.Institute of Nature and Environmental Technology, Kanazawa University)

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

[MIS12-03] Rootless cones in the southwest of Emuruangogolak Volcano, Kenya

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

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

[MIS12-04] Conditions for the formation of rootless cones on Mars and Earth

*Kei Kurita, Rina Noguchi[1] (1.ISAS/JAXA)

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

[MIS12-05] Development of an efficient geological survey method for volcanoes on extraterrestrial bodies

★Invited Papers

*Junichi Haruyama[1], Rina Noguchi[1], Nobuo Geshi[2], Motomaro Shirao[3], Keiichiro Fujimoto[1], Daigo Shoji[1] (1.Japan Aerospace Exploration Agency, 2.National Institute of Advanced Industrial Science and Technology, 3.Institute of Planetary Geology)

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

[MIS12-06] Discussion

Structures and formation age of lunar linear gravity anomalies constrained by impact simulations

*Gaku Nishiyama[1], Noriyuki Namiki[2], Seiji Sugita[1]

1. University of Tokyo, 2. National Astronomical Observatory of Japan

High-resolution lunar gravity data were acquired by NASA's GRAIL gravity mission, and positive linear gravity anomalies sometimes extending over 100 km were discovered. These gravity anomalies are interpreted as intrusions denser than the crust and indicate that the lunar surface was subject to tensile stress in the past. Since such a stress field is likely to occur during the time of lunar expansion and to affect the mechanism of intrusion formation, estimation of the formation age and shapes of the intrusions possibly constrain the ancient thermal history of the Moon. Although the depths of the intrusions have been estimated from the inversion of gravity anomalies, those depths are possibly overestimated in the conventional calculation method. On the other hand, the formation ages have been determined from the crosscutting relationship with giant basins. However, a qualitative discussion has been made only for the linear gravity anomalies near Crisium basin, and other linear gravity anomalies remain without quantitative discussion. So, we investigate two examples, Roche and Rowland craters, in this study.

In this study, we estimate the effect of crater formation directly above the underlying linear gravity anomaly using the iSALE hydrocode and attempt to constrain the depth and age of the intrusive body. First, we assume the depth and width of the intrusions that match the Bouguer gravity anomalies for various densities. Then we calculate the meteoroid collision numerically with iSALE and trace the movement of the subsurface intrusion. By comparing the simulated gravity anomalies after the crater formation with the observation, we can constrain the depth and age.

Roche crater is an example of craters above linear gravity anomalies. The linear gravity anomalies cut Roche crater in a northwest-southeast direction, and the Bouguer gravity anomalies are about 40 mGal lower inside of the crater than outside. This decrease of gravity anomalies is likely due to impact excavation, indicating that the top depth of intrusive rock is shallower than 10 km below the surface. This depth is shallower than the previous estimate of 20 km. Also, because Roche crater modified the structure of preexisting intrusion, the age of the gravity anomaly is older than the formation of Roche crater and is before Nectarian. The second example is Rowland crater. The linear gravity anomaly does not extend into the crater but stops at the rim. Our numerical simulation shows that the excavation depth of Rowland crater is too shallow to erase the linear gravity anomaly completely. Thus, this gravity anomaly is likely to have formed after Rowland crater and is younger than Nectarian. Based on the comparison between the numerical calculation and the Bouguer gravity anomaly data, we will discuss the formation age and possible structure of the linear gravity anomaly in this presentation.

Keywords: moon, gravity anomaly, impact

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Laboratory investigations of salt precipitation upon decompression and degassing of volatile-containing brines: Implication for carbonate mineral formations on Solar system icy bodies

*Masahiro Yoda[1,2], Yasuhito Sekine[2,3]

1. Department of Earth and Planetary Science, The University of Tokyo, 2. Earth-Life Science Institute of Tokyo Tech, 3. Institute of Nature and Environmental Technology, Kanazawa University

Chemical compositions of subsurface oceans on Europa, Ceres, Enceladus and other icy bodies can be constrained based on observations of non-ice materials on the surfaces. Carbonate mineral (i.e., sodium carbonate (Na_2CO_3)) is indeed found on bright spots of Ceres (*De Sanctis et al.*, 2016), suggesting the presence of carbonate-rich subsurface brine reservoirs and precipitations of the carbonate salts upon cryovolcanic activities. The mineralogical and chemical compositions of the salts would reflect not only the water chemistry of liquid reservoirs, but also eruption dynamics and degassing processes. For instance, the previous experimental studies showed that rapid freezing of brine results in formation of Na_2CO_3, compared with $NaHCO_3$ precipitation in slow freezing (e.g., *Vu et al.,* 2017; *Thomas et al.,* 2018). In addition to rapid freezing, decompression upon cryovolcanic activities could affect salt precipitations through degassing of dissolved volatiles from brine. However, no experimental studies have been conducted to investigate the effects of rapid decompression and degassing of volatile on salt precipitation.

Here, we perform laboratory experiments to investigate the effect of decompression on salt mineralization. To this end, we newly constructed an experimental system, which can simulate rapid decompression and degassing of volatile from brine. Through evacuation of gas in a vacuum chamber, volatile-containing brine evaporates and subsequently freezes. We collected salt residues after the experiments and analyzed their size and structure using SEM and mineralogical and chemical compositions using both of SEM and micro XRD. We also observed dynamics of eruption using a high-speed camera as a function of dissolved CO_2 gas in starting brines.

In the experiments, we find a clear dependence of precipitated mineralogical compositions on speed of decompression. Precipitations of Na_2CO_3 tend to be suppressed in slow decompression and ineffective degassing, resulting in precipitation of $NaHCO_3$. To form more Na_2CO_3, rapid decompression and effective degassing are favored. Together with the results of the previous studies (*Vu et al.*, 2017; *Thomas et al.*, 2018), the occurrence of Na_2CO_3 on the bright spots of Ceres implies that occurrence of explosive eruption of cryomagma with degassing and rapid freezing, rather than effusive eruption.

Keywords: Cryovolcanic activities, Salts mineralization on the icy bodies, Degassing upon decompression

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Rootless cones in the southwest of Emuruangogolak Volcano, Kenya

*Rina Noguchi[1]

1. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency

The formation condition of rootless cones (pseudocraters) is still in an enigma. In simple, they are formed by continuous explosive interactions of molten hot lava and external water. Therefore, possible rootless cones on Mars have been thought to be evidence of not only volcanic activity but also subsurface water-ice in the last 100 Ma (e.g., Greeley and Fagents, 2001). The explosive interaction (hereafter rootless eruption) does not always occur where lava meets water. For example, in the 2014-2015 Holuhraun eruption, effused lava flowed into a glacial river, but rootless eruptions that form conical mounds did not occur (Dundas et al., 2020). To constrain occurrence conditions of rootless eruptions, we have to survey the environment of rootless cone fields in detail.

Here I report a rootless cone field in the southwest of Emuruangogolak Volcano, Kenya. Emuruangogolak Volcano is a shield volcano with ~40 km extent and locates in the Great Rift Valley. This volcano is characterized by a 5 x 3.5 km summit caldera, trachytic and basaltic lava flows emanated from NNE and SSW flanks and inside of the caldera, and lateral cones/maars in the NNE-SSW trend. In the west of the volcano, a seasonal river, Suguta is located. Tiny ponds are distributed in the southwest of the volcano. In the previous report, rootless cones have been identified but never described in detail (Dunkley et al., 1993). Therefore, I described spatial distribution, bottom/crater diameters of rootless cones using high-resolution (~1 m/pixel) satellite images on Google Earth Pro.

In the Emuruangogolak rootless cone fields, 919 rootless cones were identified. They can be divided into three major localities: north, east, and west. They are split by subsequent lava flows. The lava that rootless cones are located on has been described as “Upper Basaltic Lavas” emplaced during the upper Pleistocene to recent (Dunkley et al., 1993). Since several cones are destroyed and buried by subsequent lava flows and fluvial deposits, the original amount of rootless cones in this field considered being larger than today. The bottom diameter of rootless cones in this field ranges from 3.9 m to 164.4 m, and its average is 28.2 m. For the crater diameter, it ranges from 1.4 m to 98.0 m, and 14.2 m on average. The bottom diameter to crater diameter ratio (Dcr/Dco) ranges from 0.15 to 0.75 and has 0.50 on average. In the presentation, I describe regional differences of these geomorphometry and compare them with the other rootless cone fields on Earth and Mars.

Keywords: rootless cone, Kenya, Mars, Emuruangogolak Volcano

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Conditions for the formation of rootless cones on Mars and Earth

*Kei Kurita, Rina Noguchi[1]

1. ISAS/JAXA

The rootless cone is one of the most popular and representative surface features on Mars. It has been widely recognized as a marker of lava field as well as an indicator of aqueous environment. Both are critical characteristics in the evolution of martian surface. This ubiquitus nature throws a deep enigma. RC has been considered as the product of magma-water interaction in terrestrial volcanology. Although water is ubiquitus on the Earth and a lot of occasions for lava flow to meet water are witnessed the formation of RC seems quite rare. On the other hand free water does not exist at least in the Amazonian period of Mars whereas a lot of RC were formed. This enigma indicates existence of unknown factors in the formation of RC. What is the specific condition on Mars? Motivated by this question we have conducted comparative study on microstructure of vesiculated samples between RC eruption and SC eruption. This is a second report to the precedent one,JPGU2020. This report focuses on inspection of microstructures by XCT.
Microstructural Characteristics Investigated pyroclasts were collected at Myvatn,Iceland(Noguchi et al 2016) and Miyakejima. 3D microstructure is reconstructed by the images of microfocus XCT. The spatial resolution is 5 to 8 microns. In addition we complimentarily used SEM-BI images with higher resolution. Overall characteristics of bubble size and morphology seems almost similar for pyroclasts of RC(Myvatn) and SC(Myvatn,Miyakejima) down to the scale of 50 microns. The resemblance in bubble size and morphology of RC samples at remote place(Hagi RC at Myvatn,over 40km away from the source)to those of SC is surprising. This means the external water is well mixed into the magma down to 50 micron scale.
Requirements for the formation of RC on the Earth and Mars Our microstructural investigations suggest simple water magma interaction could not explain the high degree vesiculation of rootless eruption. If free water meets high temperature magma rapid expansion of the volume induces explosion, where magma should be fragmented at the interface. This suppress further mixing of water intomagma. Well-vesiculated structure of RC samples indicates a different style of water-magma interaction. Furthermore the formation of cone of the scale of over hundreds meters requires duration of quasi-steady eruption for certain time. To maintain the eruption suppressing process to the vesiculation is necessary. In Myvatn we have proposed involvement of lake sedeiment(mud) plays an important role. If magma meets water-saturated mud this should be easily entrained into magma in small scale. Then vesiculation occurs subsequently.This scenario is consistent with the field observations. In Myvatn Rittmann(1938) describes existence of mud materials in the pyroclasts of RC. The spatial distribution of RC also semms that RC prefers the area of with deep mud sediments. We consider the viscous nature of mud delays water supply to the magma, which works as a suppressive role in vesiculation. If this scenario can explain the formation of terrestrial RC how about on Mars? In the recent period mud with free water might not be present on the surface. Recent observations by Curiosity(Ehlmann et al 2017) reports aeolian fine dust has size at the order of several tens microns and contained volatiles. This surface layer is composed with mixture of fine aeolian dust and ice particle. This should work similarly as the mud in the terrestrial RC formation.
Ehlmann et al,2017 JGR-E 122(12) 2510-43
Noguchi et al,2016 JVGR313,89-102

Keywords: rootless cone, water-magma interaction, planetary volcanology, Mars

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Development of an efficient geological survey method for volcanoes on extraterrestrial bodies

*Junichi Haruyama[1], Rina Noguchi[1], Nobuo Geshi[2], Motomaro Shirao[3], Keiichiro Fujimoto[1], Daigo Shoji[1]

1. Japan Aerospace Exploration Agency, 2. National Institute of Advanced Industrial Science and Technology, 3. Institute of Planetary Geology

Conventional outcrop surveys such as volcanic fieldwork have mainly been conducted by the expertized researchers based on tacit knowledge. Such conventional surveys have significant time limitations due to the weather changes and the accessibility limitation due to the rugged terrain, which is resulting in many problems such as losing the chance to obtain valuable data. With the remarkable advancement of unmanned aerial vehicles and autonomous robots in recent years, a large amount of data can be obtained quickly even in the outcrops where researchers' reconnaissance is usually difficult. To exploit the benefit of these advanced technologies, the establishment of new survey methods is important in terms of the scientific research fields and the industrial fields. An efficient geological survey method based on the extraction of the in-situ geological information by computational image processing has been investigated in this study. While research efforts have been made on the image segmentation and texture classification to extract the geological information, little research efforts have been made to establish the algorithm to evaluate the scientific importance metrics based on the segmentation and texture classification results to achieve a new practical geological survey method. Development of the efficient geological survey method based on such scientific importance metrics is underway in this study. It will contribute to improving the efficiency and effectiveness of the geological surveys for outcrops of volcano regions, even for extraterrestrial ones. Advantages and the features of the proposed method and the research status are presented and discussed.

Keywords: planetary volcanism, geological survey , improving efficiency, image analysis, robotics, outcrop

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[J] Oral | M (Multidisciplinary and Interdisciplinary) | M-IS Intersection

[M-IS12] Planetary Volcanology

convener:Rina Noguchi(Faculty of Science, Niigata University), Nobuo Geshi(Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Tomokatsu Morota(Department of Earth and Planetary Science, The University of Tokyo), Chairperson:Rina Noguchi(Faculty of Science, Niigata University), Nobuo Geshi(Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Tomokatsu Morota(Department of Earth and Planetary Science, The University of Tokyo)

Sat. Jun 5, 2021 9:00 AM - 10:30 AM Ch.02 (Zoom Room 02)

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.

10:15 AM - 10:30 AM

[MIS12-06]Discussion

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Sat. Jun 5, 2021 10:45 AM - 12:15 PM JST | Sat. Jun 5, 2021 1:45 AM - 3:15 AM UTC | Ch.02 Zoom Room 02

[M-IS14] Aqua planetology

convener:Yasuhito Sekine(Earth-Life Science Insitute, Tokyo Institute of Technology), Takazo Shibuya(Japan Agency for Marine-Earth Science and Technology), Hidenori Genda(Earth-Life Science Institute, Tokyo Institute of Technology), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Chairperson:Takazo Shibuya(Japan Agency for Marine-Earth Science and Technology), Yasuhito Sekine(Earth-Life Science Insitute, Tokyo Institute of Technology), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Tomohiro Usui(Japan Aerospace Exploration Agency), Hidenori Genda(Earth-Life Science Institute, Tokyo Institute of Technology)

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.

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

[MIS14-01] Internal heating of icy ocean worlds

*Shunichi Kamata[1], Kento Nakanishi[1], Kiyoshi Kuramoto[1] (1.Faculty of Science, Hokkaido University)

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

[MIS14-02] Field investigations on salt partitioning in frozen closed-basin lakes in Mongolia as terrestrial analogues of subsurface brine reservoirs on Solar System icy bodies

*Masahiro Yoda[1,2], Yasuhito Sekine[2,3], Keisuke Fukushi[3], Takuma Kitajima[4], Baasansuren Gankhurel[4], Davaadorj Davaasuren[5], Tuvshin Gerelmaa[5], Shuukhaaz Ganbat[4], Daigo Shoji[6], Yoshio Takahashi[1] (1.Department of Earth and Planetary Science, The University of Tokyo, 2.Earth-Life Science Institute of Tokyo Tech, 3.Institute of Nature and Environmental Technology, Kanazawa University, 4.Division of Earth and Environmental Sciences, Graduate School of Natural Science and Technology, 5.Department of Geography, The National University of Mongolia, 6.Institute of Space and Astronautical Science, Japan Astronautical Exploration Agency)

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

[MIS14-03] In-situ observation of gas hydrate formation as a simulation of the bottom of ice crust in icy bodies

*Atsushi Tani[1], Kenshiro Moriyama[1] (1.Department of Human Environmental Science, Graduate School of Human Development and Environment, Kobe University)

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

[MIS14-04] Evolution processes of asteroid Ryugu inferred from orbit and spin dynamics

*Masanori Kanamaru[1], Ryuki Hyodo[1], Tomohiro Usui[1], Tatsuaki Okada[1] (1.Japan Aerospace Exploration Agency)

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

[MIS14-05] Oxygen isotopic systematics of chondrules in Tagish Lake (C2) and implications of volatiles in the protoplanetary disk

*Takayuki Ushikubo[1], Makoto Kimura[2] (1.Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology, 2.National Institute of Polar Research)

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

[MIS14-06] Development of a technique for a multi-isotopic analyses of asteroid materials (small amount samples ~ 30 mg) returned by the Hayabusa2 mission

*Tetsuya Yokoyama[1], Ikshu Gautam[1], Yusuke Ohkuma[1], Tsuyoshi Iizuka[2], The Hayabusa2 initial analysis team “Isotopes and Chemistry” (1.Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology, 2.Department of Earth and Planetary Science, School of Science, The University of Tokyo)

Internal heating of icy ocean worlds

*Shunichi Kamata[1], Kento Nakanishi[1], Kiyoshi Kuramoto[1]

1. Faculty of Science, Hokkaido University

Surface temperatures of outer solar system bodies are very low (i.e., ~100 K), and the surface of the most solid bodies are covered by ice mainly composed of water. Despite its low temperature, some of such icy bodies are “aqua planets”; they possess subsurface oceans. It can be said that one of the major research subjects in Aqua planetology is to understand how such oceans are maintained.
In addition to the decay of radiogenic isotopes only slightly contained in rocks, tidal heating is considered as an important heat source maintaining subsurface ocean in satellites of giant planets. Recent theoretical studies quantifying the amount of heat produced in internal solid and liquid layers enable us to calculate the total amount as well as the spatial pattern of heating for a given internal structural model and orbital property. Nevertheless, little is known about the total amount and the spatial pattern of heating on actual satellites because of large uncertainties in their interior structures.
In this study, we calculate the total amount and the spatial pattern of tidal heating in several icy satellites, such as the Jovial icy satellite Europa, the Saturnian icy satellite Enceladus, the Neptunian satellite Triton, under a wide variety of parameter conditions using previously-reported theoretical models. We confirm that Europa and Enceladus are mainly heated by eccentricity-type, while Triton is heated by inclination-type tides, and that the total amount of heat due to the former increases while the latter decreases with increasing ocean thickness. We find that a large increase in the heating rate due to tidal resonance is unlikely to occur for Enceladus. We also find that the spatial pattern of solid tides is not sensitive to the interior structure while that of liquid tides is; the latter relatively strongly depends on the ocean thickness and the drag coefficient. This result implies that the main heating mechanism and/or the mean ocean thickness can be constrained based on the shape of the ice shell.

Keywords: Icy satellites, Tidal heating

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Field investigations on salt partitioning in frozen closed-basin lakes in Mongolia as terrestrial analogues of subsurface brine reservoirs on Solar System icy bodies

*Masahiro Yoda[1,2], Yasuhito Sekine[2,3], Keisuke Fukushi[3], Takuma Kitajima[4], Baasansuren Gankhurel[4], Davaadorj Davaasuren[5], Tuvshin Gerelmaa[5], Shuukhaaz Ganbat[4], Daigo Shoji[6], Yoshio Takahashi[1]

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Geologically-active icy bodies, e.g., Europa and Ceres, would have possessed near-surface brine reservoirs, which may be a source of salts on the surfaces (e.g., Europa’s chaos terrains and Ceres’ bright spots). Previous studies hypothesized a few processes, in which an overlying ice layer can capture salinity from a subsurface brine reservoir; however, few field investigations have been conducted for inferring the salt partitioning between ice layers and subsurface reservoirs on the icy bodies.
Here, we report results of field surveys to ice-covered, closed-basin saline lakes of Orog and Olgoy lakes in Mongolia in February 2019 and January 2020. The surface ice exhibited complex geomorphology with pressurized ridges formed by compressive force and wet cracks formed by extensional force. We collected the ice samples, including both of the contraction and wet cracks, as well as underlying lake water samples at the lakes. The salinity of ices collected from field surveys suggest that wet cracks could provide salinity to the ice layer and surface. In addition, concentrated bottom lake water, together with suspended authigenic carbonates, would be captured within the ice layer during freezing. We evaluate both of the salts partitioning and lake water chemistry in the frozen lakes using a coupled model of mass balance and low-temperature aqueous chemistry. Our model results can reproduce both the salinity in ice and major dissolved species, e.g., Na^{+}, Cl^{-}, and SO_4^{2-}, in the bottom lake water. To explain the Mg^{2+} and Ca^{2+} concentrations of in the bottom lake water metastable carbonates of amorphous magnesium carbonate and monohydrocalcite should be taken into account. We discuss the implications of the salts partitioning and water chemistry to subsurface liquid reservoirs of the icy bodies.

Keywords: Freezing brine within icy bodies, Water chemistry of frozen saline lakes, Ice-mineralization

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In-situ observation of gas hydrate formation as a simulation of the bottom of ice crust in icy bodies

*Atsushi Tani[1], Kenshiro Moriyama[1]

1. Department of Human Environmental Science, Graduate School of Human Development and Environment, Kobe University

Gas hydrates are clathrate compounds where hydrogen-bonded water cages include a guest gas molecule. Methane hydrate is one of famous gas hydrates because it is naturally found in deep-sea and permafrost sediments on the Earth. Gas hydrates would exist in icy bodies as well. One of the candidates is Pluto where the presence of subsurface ocean is suggested. Gas hydrates may exist between the ice shell and subsurface ocean and play an important role as insulator to keep warm inside. The presence of subsurface ocean is also suggested in some icy satellites like Enceladus. INMS (Ion and Neutral Mass Spectrometer) aboard the Cassini orbiter has investigated composition of the plumes there that includes H_2O (< 90 %), CH_4, CO_2, NH_3, and other various organic materials. These results could reflect the composition of the subsurface ocean and imply the presence of clathrate hydrates in the ocean. Density of gas hydrates depends on guest gas molecules. For example, methane hydrate is lighter than the water, whereas CO_2 hydrate is heavier. If CO_2 hydrate forms at the bottom of the icy shell, the average density may become large and the ice (water ice + CO_2 hydrate) may start to sink locally. If the size of each gas hydrate become small and granular gas hydrates exist in the upper part of the subsurface ocean, heat can be transferred by not only thermal conduction but also convection. This means that icy bodies may be cooled faster. To elucidate how gas hydrates form in the subsurface ocean in icy bodies, we developed the in-situ observation system of gas hydrate formation and dissociation below the ice sheet and observed gas hydrate formation.

The observation system was filled with water and set in thermostatic cooling bath. After temperature in the cell degreased enough, water ice was formed in the lower part of the cell. In this study, CF_4 gas was supplied to the cell up to 7 MPa to form CF_4 hydrate. The reason why we chose CF_4 instead of CH_4 is that CF_4 hydrate is heavier than water and should sink in the water cell even if the hydrate forms in the water.

Long period observation revealed that 1) at first, tiny hydrate particles formed in the water and drifted in the water after shaking the cell, 2) then, a few mm size of hydrate crystals formed and stuck on the ice sheet, 3) hydrate particles were embedded in the ice if formation rate of ice was faster than that of the hydrate. We expect that gas hydrate layer beneath the ice sheet in icy bodies may form after the growth of the ice sheet becomes slow and ice and gas hydrate mixed layer may be formed above the gas hydrate layer.

Keywords: icy bodies, ice crust, subsurface ocean, gas hydrate

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Evolution processes of asteroid Ryugu inferred from orbit and spin dynamics

*Masanori Kanamaru[1], Ryuki Hyodo[1], Tomohiro Usui[1], Tatsuaki Okada[1]

1. Japan Aerospace Exploration Agency

Orbital evolution of small solar system bodies supplies near-Earth asteroids from the main asteroid belt. The inward migration of small bodies is also an important source of supply of meteorites to the Earth and transport of volatile materials in the solar system. In order to interpret the results of the coming analysis of Hayabusa2's sample, it is essential to understand the dynamical evolution processes of the target asteroid, 162173 Ryugu, in terms of its orbit and spin.

As well as the gravitational effect of the major planets, the thermal recoil force also affects the dynamics of an asteroid. The thermal recoil force and torque that secularly changes its orbit and spin are known as the Yarkovsky effect and Yarkovsky-O'Keefe-Radzievskii-Paddack (YORP) effect, respectively. The direction of the Yarkovsky drift, i. e., a change of the orbital semi-major axis depends on the direction of rotation. It is required to simulate the combined effect of Yarkovsky and YORP for understanding the evolutional path of Ryugu's orbit from the source region in the inner main belt.

First, we conducted a numerical simulation of Ryugu's spin alteration caused by the YORP effect (Kanamaru et al., submitted to JGR-Planets). Given the current near-Earth orbit and three-dimensional shape of Ryugu observed by Hayabusa2, it is estimated that the rotation of the asteroid is decreasing at a rate of (-0.42 to -6.3) $\times 10^{-6}$ deg/day^2. The corresponding time scale of the spin-down is 0.58 to 8.7 million years. This "recent" spin-down is considered to be caused by a major resurfacing event on Ryugu such as the formation of the western bulge or the largest crater, Urashima. Our YORP simulation also indicates that the thermal torque has maintained the spin pole upright with respect to the orbital plane. The spin-pole stability with the retrograde rotation results in the inward migration of Ryugu by the Yarkovsky effect.

Second, we developed a N-body simulator for orbital evolution of small bodies, which incorporates the combined effect of the gravitational perturbation and above thermal force. We will present some possible paths of Ryugu's orbital evolution and its time scale from the source region in the main belt to the near-Earth orbit.

Keywords: Asteroid, 162173 Ryugu, Yarkovsky effect, YORP effect, Orbital evolution, N-body calculation

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Oxygen isotopic systematics of chondrules in Tagish Lake (C2) and implications of volatiles in the protoplanetary disk

*Takayuki Ushikubo[1], Makoto Kimura[2]

1. Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology, 2. National Institute of Polar Research

Previous studies on oxygen isotope systematics of chondrules show that individual chondrules preserve information of oxygen isotopic composition and redox state of chondrule-forming environments in the protoplanetary disk [e.g., 1, 2]. Highly MgO-rich (Mg# ≧ 96; Mg# ≡mol.% of MgO/(MgO + FeO)) and ^{16}O-rich ($\Delta^{17}O$ ~ −5‰; $\Delta^{17}O \equiv \delta^{17}O_{VSMOW} - 0.52 \times \delta^{18}O_{VSMOW}$) chondrules are abundant in CM, CO, and CV chondrites. Minor ^{16}O-poor ($\Delta^{17}O$ ~ −2‰) and FeO-rich (Mg# < 90) chondrules are also found in them. Increase of $\Delta^{17}O$ values of FeO-rich chondrules indicates that oxidizing environment to form ferroan chondrules was caused by enrichment of an ^{16}O-poor oxidizing agent (most likely ^{16}O-poor H_2O ice) [2]. Assuming that CM, CO, and CV chondrites are derived from C- or K-type asteroids, reducing environment was common and enrichment of ^{16}O-poor H_2O ice occurred in middle to outer asteroid main belt region of the protoplanetary disk.

In addition to these two types chondrules, FeO-rich chondrules with higher $\Delta^{17}O$ values ($\Delta^{17}O$ ≧ 0‰) were found in Tagish Lake meteorite [3]. Such chondrules have been found in Tagish Lake-like meteorites [4], CR chondrites [2 and references therein] and the comet Wild 2 returned samples [e.g., 5, 6]. Since comet Wild 2 is originally a Kuiper belt object and Tagish Lake meteorite is possibly derived from a D-type asteroid [7], the occurrence of FeO-rich chondrules with higher $\Delta^{17}O$ values in Tagish Lake and comet Wild 2 suggests existence of a more ^{16}O-depleted oxidizing agent further out than the outer main belt. Recently, Fujiya et al. [8] found the evidence for accretion of CO_2 ice as well as H_2O ice into the parent body of Tagish Lake meteorite. Higher $\Delta^{17}O$ values of FeO-rich chondrules in Tagish Lake and comet Wild 2 may represent higher $\Delta^{17}O$ values of the chemically distinct icy components existed in the outermost part of chondrule-forming environment.

The ^{26}Al-^{26}Mg systematics of chondrules show that the initial $^{26}Al/^{27}Al$ values of FeO-rich chondrules from comet Wild 2 and CR chondrites (< 3×10^{-6}) are significantly lower than those of typical chondrules in CO and CV chondrites (~5×10^{-6}) [e.g., 9, 10], suggesting that the former group of chondrules formed more than one million years later than the formation of the latter group of chondrules. The occurrence of more ^{16}O-depleted oxidizing agent can be results of temporal isotopic evolution of icy components in the protoplanetary disk.

Although we cannot tell either spatial heterogeneity or temporal change of the oxygen isotopic composition of the oxidizing agents formed distinct FeO-rich chondrule groups ($\Delta^{17}O$ ~ −2‰ or ≧ 0‰), we suggest that oxygen isotopic compositions of chondrules would be important constrains for better understanding of volatile components in the protoplanetary disk.

References:
[1] Ushikubo T. et al. (2012) GCA, 90, 242-240.
[2] Tenner T. J. et al. (2018) Chapter 8 in Chondrules (Cambridge Univ. press).
[3] Ushikubo T. and Kimura M. (2021) GCA, 293, 328-343.
[4] Yamanobe M. et al. (2018) Polar Science, 15, 29-38.
[5] Nakamura T. et al. (2008) Science, 321, 1664-1667.
[6] Nakashima D. et al. (2012) EPSL, 358, 355-365.
[7] Hiroi T. et al. (2001) Science, 293, 2234-2236.

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[8] Fujiya W. et al. (2019) Nature Astornomy, 3, 910-915.
[9] Ogliore R. C. et al. (2012) Astrophys. J. Lett., 745, L19.
[10] Tenner T. J. et al. (2019) GCA, 260, 133-160.

Keywords: Tagish Lake meteorite, Chondrule, Oxygen isotope, SIMS

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Development of a technique for a multi-isotopic analyses of asteroid materials (small amount samples ~ 30 mg) returned by the Hayabusa2 mission

*Tetsuya Yokoyama[1], Ikshu Gautam[1], Yusuke Ohkuma[1], Tsuyoshi Iizuka[2], The Hayabusa2 initial analysis team "Isotopes and Chemistry"

1. Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology, 2. Department of Earth and Planetary Science, School of Science, The University of Tokyo

The sample-return mission Hayabusa2 conducted two sampling sequences that collected the surface and sub-surface materials from a C-type asteroid, Ryugu in 2019. The Sample Return Capsule (SRC) containing the collected materials was brought back to the Earth on Dec 6th of 2020. The curation team opened the SRC in a clean chamber at the curation facility of JAXA at Sagamihara, and found black chunks of rocks and dust from Ryugu, of which the total weight reached >5 g. Although the retrieved sample mass was far more than that was expected at the planning stage (0.1–1 g), each of the initial analysis team can use only limited amount of the samples (< 0.1 g) to obtain scientific data that characterize the asteroidal materials. We have developed a technique for a multi-isotopic analysis that uses ~ 30 mg of the Ryugu sample. Two terrestrial basalts (BCR-2, BHVO-2) and two CM chondrites (Murchison, Jbilet Winselwan) were chosen as the analog samples to evaluate the performance of the developed technique. The powdered sample was decomposed by a mixture of HF + HNO_3 in a Teflon vessel. The sample was conditioned with HBr for the separation of Pb by anion exchange chromatography (Column-1; AG1-X8). The major element fraction of the Column-1 was dried and conditioned with 0.4 M HCl-0.5 M HF for the separation of Ti+Zr+Hf, W, and Mo (Column-2; AG1-X8). The major element fraction of the Column-2 was dried and conditioned with 6 M HCl for the separation of Fe and U (Column-3; AG1-X8), followed by the separation of Sr and Ba (Column-4; Sr-Resin), REEs (Column-5; RE-Resin), Ca (Column-6; DGA-n Resin), and Cr (Column-7; 1:1 mixture of AG50W-X8 and AG50W-X12). Finally, Mg and Ni were separated using Ni Resin (Column-8). The recovery yields of individual target elements are generally >90% during each step of the chromatography. However, these loss are not unique to our method and is always associated during any chemical separation procedures. Although extreme care was taken for handling samples but a certain loss are unavoidable such as during sample drying, pipetting and sample sticking to the Teflon beaker. The isotopic compositions of these analog samples, especially for Cr and Ti, will be reported in the presentation.

Keywords: Hayabusa2, Ryugu, initial analysis, multi-isotope analysis

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Sat. Jun 5, 2021 1:45 PM - 3:15 PM JST | Sat. Jun 5, 2021 4:45 AM - 6:15 AM UTC | Ch.02 Zoom Room 02

[M-IS14] Aqua planetology

convener:Yasuhito Sekine(Earth-Life Science Insitute, Tokyo Institute of Technology), Takazo Shibuya(Japan Agency for Marine-Earth Science and Technology), Hidenori Genda(Earth-Life Science Institute, Tokyo Institute of Technology), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Chairperson:Yasuhito Sekine(Earth-Life Science Insitute, Tokyo Institute of Technology), Takazo Shibuya(Japan Agency for Marine-Earth Science and Technology), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Tomohiro Usui(Japan Aerospace Exploration Agency), Hidenori Genda(Earth-Life Science Institute, Tokyo Institute of Technology)

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

[MIS14-07] Comparative metagenomic studies of diverse serpentinized ecosystems

★Invited Papers

*Shino Suzuki[1], Shunichi Ishii[2], Nealson H. Kenneth[3] (1.JAXA, 2.JAMSTEC, 3.USC)

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

[MIS14-08] Thioester synthesis through geoelectrochemical CO2 fixation on Ni and Mo sulfides.

*Norio Kitadai[1] (1.Japan Agency for Marine-Earth Science and Technology)

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

[MIS14-09] Effects of pH on the ribose synthesis in the formose reaction: implication for abiotic synthesis on ancient Mars

*Chinatsu Ono[1], Takeshi Kakegawa[1], Yoshihiro Furukawa[1] (1.Graduate School of Science, Tohoku University)

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

[MIS14-10] Elucidation of the mechanism of organic matter synthesis process by reducing reaction of clay minerals on the surface of the planet by STXM

*Takahiro Kawai[1], Hiroki Suga[2], Yasuo Takeichi[3], Yoshio Takahashi[1,3] (1.University of Tokyo, 2.JASRI, 3.KEK-PF)

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

[MIS14-11] Solubility of amorphous magnesium carbonate: rarity of Mg-carbonate on surface of closed-basin lakes that existed on early Mars

*TAKUMA KITAJIMA[1], Keisuke Fukushi[2], Yasuhito Sekine[2,3], Masahiro Yoda[3,4], Baasansuren Gankhurel[1], Davaadorj Davaasuren[5] (1.Kanazawa university, 2.The Institute of Nature and Environmental Technology, Kanazawa University, 3.Earth-Life Science Institute, Tokyo Institute of Technology, 4.Department of Earth and Planetary Science, The University of Tokyo, 5.Department of Environment and Forest Engineering, The National University of Mongolia)

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

[MIS14-12] **Parent body processes reproduce soluble organics in carbonaceous chondrites via geo-electrochemistry**

★Invited Papers

*LI Yamei[1], Yasuhito Sekine[1], Norio Kitadai[1,2] (1.Earth-Life science Institute, Tokyo Institute of Technology, 2.Japan Agency for Marine-Earth Science and Technology)

Comparative metagenomic studies of diverse serpentinized ecosystems

*Shino Suzuki[1], Shunichi Ishii[2], Nealson H. Kenneth[3]

1. JAXA, 2. JAMSTEC, 3. USC

Serpentinization is a process whereby water interacts with reduced mantle rock called peridotite to produce a new suite of minerals (e.g., serpentine), a highly alkaline fluid, and hydrogen. The hydrogen and carbon dioxide present in the system are thought to react under the highly reducing and alkaline conditions, leading to the formation of methane and hydrocarbons and the concomitant production of carbon monoxide, formate, formaldehyde and methanol. Given that the reduced compounds delivered from the water-rock reaction can support microbial energy metabolisms, such serpentinization systems have been viewed as potential habitats for early life or the other planetary bodies.

Studies of serpentinizing environments to date have shown that these ecosystems host extremely low-abundance microbial communities, which is presumably attributed to the multiple extremes: 1) the highly-alkaline condition of the fluid; 2) the extremely low concentrations of oxidants (electron acceptors); and, 3) the low levels of and nutrients (available carbon and phosphate). Although it is known that the serpentinization reaction results in unique geochemical conditions overall, terrestrial ophiolite The Cedars (USA), Voltri Massif (Italy), Santa Elena Ophiolite (Costa Rica), terrestrial intrusive body Cabeç o de Vide (Portugal), shallow-water hydrothermal deposit Prony Bay (New Caledonia), deep-sea Mariana serpentine have different geochemical properties due to the reacting waters (natural and seawater) and the depths. Here, we present the microbial genomes from serpentinizing springs in different sites and discuss how diverse chemical characteristics define the microbial communities and metabolisms in this system.

Keywords: serpentinization, early Earth, Enceladus, Microbial genomics

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Thioester synthesis through geoelectrochemical CO2 fixation on Ni and Mo sulfides.

*Norio Kitadai[1]

1. Japan Agency for Marine-Earth Science and Technology

A prevailing scenario of the origin of life postulates thioesters as key intermediates in protometabolism, but there is no experimental support for the prebiotic CO_2 fixation routes to thioesters. Here we introduce a two-steps thioester synthesis pathway starting from CO2 and H2S. First, we show MoS2-catalyzed efficient methanethiol production from CO2 and H2S in seawater in the presence of supercritical CO2. Then, simulating a geoelectrochemical condition in primordial ocean hydrothermal systems (−0.6 to −1.0 V versus the standard hydrogen electrode), we show that nickel sulfide (NiS) gradually reduces to Ni^0 with the surface bound by carbon monoxide (CO) formed through CO_2 electroreduction. The resultant partially reduced NiS realizes thioester (S-methyl thioacetate) formation from CO and methanethiol even at room temperature and neutral pH with the yield up to 35% based on CO. This thioester formation is not inhibited, or even improved, by 50:50 coprecipitation of NiS with FeS or CoS (the maximum yields; 27 or 56%, respectively). Such a simple thioester synthesis likely occurred in Hadean deep-sea vent environments, setting a stage for the autotrophic origin of life.

Keywords: protometabolism

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Effects of pH on the ribose synthesis in the formose reaction: implication for abiotic synthesis on ancient Mars

*Chinatsu Ono[1], Takeshi Kakegawa[1], Yoshihiro Furukawa[1]

1. Graduate School of Science, Tohoku University

DNA, RNA, and proteins work together to support the essential system of the present life. RNAs catalyze biological reactions as well as have nucleotide sequence transcribed from DNA. Therefore, abiotic RNA formation has been regarded as an essential step of the origin of life. Ribose is an essential constituent of RNA and is known to form in the formose reaction in which a series of condensation and polymerization of formaldehyde forms many sugar molecules. Ribose synthesis by the formose reaction is known to proceed under alkaline conditions, but the effects of pH on the ribose synthesis have not been clear. The effects of pH on the formose reaction is important to constrain the possibility of ribose synthesis on prebiotic Earth and on ancient Mars. Therefore, this study investigates the effects of pH on the formose reaction and evaluated potential ribose synthesis on ancient Mars. Ancient Mars is shown to have liquid water on the surface and/or subsurface and had CO_2-rich atmosphere. Thus, photochemical formaldehyde formation would have been possible. Moreover, it is estimated that pH of surface water acidified from mildly alkaline to acidic from Noachian to Hesperian based on the mineral composition found by some of Mars surface explorations.
The formose reaction experiments were conducted with formaldehyde and glycolaldehyde in phosphate buffer solutions of different pH. Ribose was formed even in neutral solutions. The yields decreased one orders of magnitude by the decrease of pH by 1. Ribose formation was below our detection limit in acidic solution, pH < 4, although tetroses were formed.
These results suggest that ribose was spontaneously formed from formaldehyde and glycolaldehyde even in near neutral aquatic environments implying that environments existed on Noachian Mars could promote spontaneous ribose formation.

Keywords: ribose, formose reaction, ancient Mars

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Elucidation of the mechanism of organic matter synthesis process by reducing reaction of clay minerals on the surface of the planet by STXM

*Takahiro Kawai[1], Hiroki Suga[2], Yasuo Takeichi[3], Yoshio Takahashi[1,3]

1. University of Tokyo, 2. JASRI, 3. KEK-PF

[Background]

Many studies have been conducted to elucidate the evolutionary process of organic matter in extraterrestrial materials, which related to the formation of organic matter as a material for life. Elucidation of the process by which organic matter is synthesized from inorganic carbon (CO_2) in the natural environment is important in considering primordial organic matter and its evolution. There is an evolutionary process in which several organic substances change to polycyclic aromatic hydrocarbons (PAHs) due to thermal stability, but the process of aliphatic carbon compounds formation, which cannot be explained by this process, requires further investigation. On the other hand, on Earth, it has been proposed that hydrogen and aliphatic carbon compounds may be produced near minerals containing Fe2+ such as serpentine and iron saponite (Sforma et al., 2018). However, in these studies, local chemical species analysis may be necessary to investigate the interaction between minerals and organic matter in detail, but its application is not yet sufficient.

The scanning transmission X-ray microscopy (STXM) is a method that enables chemical species analysis of carbon (C), nitrogen (N), and iron (Fe) with a spatial resolution of up to 30 nm, and it is important to apply this technique to meteorite and earth geological samples for the above purposes. In this study we analyzed the local chemical species of C and Fe in the Aguas Zarcas and Tagish Lake meteorites, which are expected to show water-mineral-organic interactions using STXM.

[Experiment]

Elemental mapping of C and Fe in thin FIB samples of meteorites were done using STXM at BL19A in KEK-PF. The experimental data were analyzed with aXis2000 (analysis of X-ray microscopy Images and Spectra), and the species mapping was performed using the absorption near edge structure (XANES) of each chemical element. Similarly, the XANES of magnesium (Mg) and aluminum (Al) were used to estimate the type of mineral around the organic matter.

[Results/Discussion]

In this study, based on the hypothesis that when Fe (II) in clay minerals is oxidized to Fe (III), organic matter is reduced to produce aliphatic carbon, the distinction between Fe(II) and Fe(III) and the distribution of carbon species (carbonic acid, aliphatic carbon, carboxylic acid, etc.) were investigated intensively in STXM analysis.

In the Aguas Zarcas meteorite, there was a concentration of aliphatic caron coexisting with carbonate near Fe (II).
In the Tagish Lake meteorite, the distribution of Fe (II) coincided with that of carbonate, suggesting the

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formation of siderite in some parts of the meteorite. In areas with low Fe (II), there was little carbonate, suggesting that carbonate was reduced during the oxidation of Fe (II) to Fe (III). Other peaks derived from carboxylic acids and carbon chains were also observed, but the peak intensities were not sufficient for mapping.
In the future, we plan to investigate how these materials were formed by preparing more appropriate samples, analyzing them by STXM, and conducting isotope analysis of the organic materials found in this study. As related materials, we will search for organic matter around secondary minerals in the dunite layer in the Oman ophiolite boring core samples and analyze the local speciation of carbon and iron.

Keywords: Organic matter, Origin of life, STXM, meteorite

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Solubility of amorphous magnesium carbonate: rarity of Mg-carbonate on surface of closed-basin lakes that existed on early Mars

*TAKUMA KITAJIMA[1], Keisuke Fukushi[2], Yasuhito Sekine[2,3], Masahiro Yoda[3,4], Baasansuren Gankhurel[1], Davaadorj Davaasuren[5]

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Recent advances in in-situ chemical and mineralogical analyses by exploration rovers and high-resolution remote-sensing data by orbiters have revealed the existence of aqueous environments and geochemical cycle on early Mars. Early Mars would have possessed liquid water on the surface in semiarid climates (Ehlmann et al., 2014), evidenced by the widespread presence of valley networks, lake deposits, and clay minerals. The presence of liquid water on early Mars is thought to have been maintained by warmer climates than today’ s, possibly due to a denser CO_2 atmosphere in addition to effective greenhouse effect gas, such as H_2 and CH_4 (David et al., 2017; Wordsworth et al., 2017).

On present-day Earth, authigenic carbonates are, in general, generated in closed-basin lakes developed in semiarid climates as monohydrocalcite and amorphous magnesium carbonate (AMC) (Fukushi and Matsumiya, 2018). Closed-basin lakes as saline, alkaline lakes have a role of fixing CO_2 in the atmosphere through generating carbonates on Earth. On early Mars, saline, circumneutral-to-alkaline lakes, if present, should have also generated authigenic carbonates in a dense CO_2 atmosphere, playing a role of a carbon sink in carbon cycles. Recent studies suggested that such saline, circumneutral-to-alkaline lakes developed within Gale Crater (Fukushi et al., 2019), where the Curiosity rover landed. Formation of authigenic Mg-carbonates is expected on early Mars given both the widespread occurrence of mafic/ultramafic basement rocks on Mars and the facts that Mg-/Fe-carbonates are found by remote-sensing data. However, in-situ mineralogical analyses performed by the Curiosity rover have found little carbonates, including Mg-carbonates, in lacustrine sediments of Gale Crater. from surface of Gale crater. Since AMC is the precursor of authigenic deposition of Mg-carbonates, such as hydromagnesite and magnesite, the lack of Mg-carbonates in early Gale lakes implies the possibility that no effective AMC deposition occurred despite of the presence of a dense CO_2 atmosphere.

In this study, we perform field surveys for closed-basin lakes developed in cold and semiarid climates in Mongolia, which are promising terrestrial analogues of early Martian lakes. In addition to the field surveys, we conduct laboratory experiments on solubility of AMC at low temperatures to understand condition formation of AMC in saline lakes in cold environments.

Keywords: solubility, amorphous magnesium carbonate

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Parent body processes reproduce soluble organics in carbonaceous chondrites via geo-electrochemistry

*LI Yamei[1], Yasuhito Sekine[1], Norio Kitadai[1,2]

1. Earth-Life science Institute, Tokyo Institute of Technology, 2. Japan Agency for Marine-Earth Science and Technology

Organics in carbonaceous chondrites (CCs) and other extraterrestrial bodies recorded the history of solar system chemistry and/or parent body processes. Biologically relevant organics, particularly amino acids, have been intensively investigated owing to their ubiquitous presence and plausible contribution to the prebiotic chemical evolution towards the origin of life on the Earth. Organics in CCs showed substantial heterogeneity in molecular abundance, isomer/homolog, and isotopic features, providing unique chemical signatures. To account for such chemical heterogeneity, the nature of the underlying driving force needs to be clarified in the context of interstellar and/or parent body processes. This will be also important for constraining the geochemical parameters including redox and energetic conditions.
In solvent-extractable fractions of CCs, amino acids typically coexist with a complex suite of other soluble, low molecular weight organics, including α-hydroxy acids, monocarboxylic acids, and monoamines. These organics show associated structures and similar isomer distributions with amino acids, which suggests a strong mechanistic relation in their genesis or conversion. Notably, these soluble organics are biologically significant, because of their participation in various organic syntheses for the chemical evolution or roles as essential nutrients for the primordial life.
Here we attempted to test whether geo-electrochemical processes in icy planetesimals can facilitate the decomposition of amino acids to generate meteoritic organics (e.g., amines, carboxylic and hydroxy acids). Four types of amino acids with aliphatic side chains, including glycine, alanine, valine, and 2-aminobutyric acid (ABA) were tested, which are among the most common and pervasive amino acids in CCs. Our results show that geo-electrochemical decomposition of these amino acids simultaneously generates monoamines, monocarboxylic and α-hydroxy acids under a wide range of redox conditions. The generated amines exhibited a similar homolog tendency as reported in CM2 Murchison meteorites, showing the validity of this model. Based on the quantitative results obtained, the water-rock interaction conditions were constrained for the parent icy planetesimals of Murchison meteorite. The implications on the geochemistry of icy bodies were addressed.

Keywords: Carbonaceous chondrites, Soluble organics, Geo-electrochemistry, Icy planetesimals

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Sat. Jun 5, 2021 3:30 PM - 5:00 PM JST | Sat. Jun 5, 2021 6:30 AM - 8:00 AM UTC | Ch.02 Zoom Room 02

[M-IS14] Aqua planetology

convener:Yasuhito Sekine(Earth-Life Science Insitute, Tokyo Institute of Technology), Takazo Shibuya(Japan Agency for Marine-Earth Science and Technology), Hidenori Genda(Earth-Life Science Institute, Tokyo Institute of Technology), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Chairperson:Hidenori Genda(Earth-Life Science Institute, Tokyo Institute of Technology), Yasuhito Sekine(Earth-Life Science Insitute, Tokyo Institute of Technology), Tomohiro Usui(Japan Aerospace Exploration Agency), Keisuke Fukushi(Institute of Nature & Environmental Technology, Kanazawa University), Takazo Shibuya(Japan Agency for Marine-Earth Science and Technology)

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

[MIS14-13] Degassing history and the structural evolution of Martian mantle

★Invited Papers

*Masaki Ogawa[1] (1.Division of General Systems Studies, Graduate School of Arts and Sciences, University of Tokyo)

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

[MIS14-14] Effect of photo-oxidation reactions of ferrous iron on geochemical conditions required for redox stratification on early Gale lake

*Haruhisa Tabata[1,2], Yasuhito Sekine[2], Kazumi Ozaki[3] (1.Department of Earth and Planetary Science, University of Tokyo, 2.Earth-Life Science Institute, Tokyo Institute of Technology, 3.Department of Environmental Science, Toho University)

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

[MIS14-15] Water vapor vertical distributions on Mars: Results from three years of TGO/NOMAD science operations

*Shohei Aoki[1,2], Ann Carine Vandaele[2], Frank Daerden [2], Geronimo L. Villanueva [3], Giuliano Liuzzi [3], Ian R, Thomas [2], Justin T. Erwin [2], Loic Trompet [2], Lori Neary [2], Severine Robert [2,9], Sebastien Viscardy [2], Arianna Piccialli [2], R. Todd Clancy [4], Michael Smith[3], Matteo Crismani [5], Bojan Ristic [2], Miguel A. Lopez-Valverde[6], Adrian Brines [6], Manish R. Patel [7], James A. Holmes [7], Giancarlo Bellucci[8], Jose J. Lopez-Moreno[6] (1.Université de Liège, 2.Royal Belgian Institute for Space Aeronomy, 3.NASA Goddard Space Flight Center, 4.Space Science Institute, 5.California State University, 6.Instituto de Astrofísica de Andalucía, 7.Open University, 8.Istituto di Astrofisica e Planetologia, 9.Université catholique de Louvain)

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

[MIS14-16] Theoretic study of atmosphere and hydrological cycle with groundwater transportation on land planets

*Taniguchi Keigo[1,2], Yasuhito Sekine[1], Takanori Kodama[3], Natsumi Noda[4], Hidenori Genda[1], Ayako Abe-Ouchi[5] (1.Earth-Life Science Institute, Tokyo Institute of Technology, 2.Department of Earth & Planetary Sciences, Tokyo Institute of Technology, 3.The university of Tokyo, 4.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 5.Atmosphere and Ocean Research Institute, The University of Tokyo)

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

[MIS14-17] Possibility of formation of local reductive environment by cometary impact on the early Earth

*Ryo Miyazaki[1], Hidenori Genda[1] (1.Earth Life Science Institute, Tokyo Institute of Technology)

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

[MIS14-18] Oceanic retention of ammonia and thermal stability of the atmosphere-ocean system on the primitive earth

*Kirara Arima[1], Kiyoshi Kuramoto[1] (1.Hokkaido university)

Degassing history and the structural evolution of Martian mantle

*Masaki Ogawa[1]

1. Division of General Systems Studies, Graduate School of Arts and Sciences, University of Tokyo

The surface environment of Mars was clement in the early Hesperian, about 3.7 Gyr ago, when active magmatism took place in the Tharsis and the surrounding area. The earlier less clement surface environment suggested in the literatures is, however, difficult to explain with the traditional thermal history models of Mars where its magmatic activity is suggested to have been maximum at 4.5 Ga and have monotonously declined with time since then. To resolve this difficulty, I propose a four-stage evolution model of Mars caused by the structural evolution of the mantle based on a numerical model of coupled magmatism-mantle convection system: at 4.5 Ga, extensive magmatism formed the crust and compositionally stratified the mantle (Stage I); the stratification suppressed mantle convection and magmatism for the next several hundred million years (Stage II); then, hot plumes grew from the deep mantle to cause episodic magmatism and degassing to make the surface environment clement (Stage III); eventually, magmatism waned, as heat producing elements are extracted from the deep mantle (Stage IV). The plume magmatism of Stage III is caused by a positive feedback called the magmatism-mantle upwelling feedback, where mantle upwelling flow generates magma whose buoyancy boosts the upwelling flow itself (the MMUb feedback). I extensively carried out numerical experiments at various parameter values to see how robust the four-stage evolution model is. I found that the four stages arise, when the permeability of magma through the coexisting matrix is moderate. When the permeability is too high, the MMUb feedback does not operate, the mantle stratification formed on Stage I suppresses magmatism throughout the 4.5 Gyr history, and Stage III does not arise. When the permeability is too low, the MMUb feedback strongly stirs the mantle on Stage I to suppress mantle stratification, the mantle remains homogeneous throughout the 4.5 Gyr history, and the mantle evolves as traditional thermal history models predict. The permeability is probably “moderate” for Mars, and Mars is likely to have evolved in the four stages.

Keywords: Mars, mantle evolution, degassing

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Effect of photo-oxidation reactions of ferrous iron on geochemical conditions required for redox stratification on early Gale lake

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Recent observations on iron mineralogy and geochemical data by NASA's Curiosity rover suggested that Gale Crater had sustained closed-basin, redox-stratified lakes at around Hesperian (~3.5–3.3 Ga) (Hurowitz et al., 2017). On Earth, redox stratification in closed-basin lakes is largely maintained by biological processes, e.g., photosynthesis. For Martian lakes without photosynthetic life to be redox stratified, photo-oxidation of ferrous iron could have been a source of oxidants at shallow lakes; whereas, upwelling of reducing ferrous iron is hypothesized to have occurred from the bottom (Hurowitz et al., 2017). However, no quantitative evaluations have been conducted to investigate conditions that can achieve redox stratification on early Mars.

In the present study, we investigate geohydrological and atmospheric conditions (e.g., Fe^{2+} fluxes from rivers and groundwater, advection rate and pH of lake water, and UV flux) to achieve redox stratification on early Gale lakes using a one-dimensional reaction-transport model. We took into account pH-dependent, photo-oxidation of Fe^{2+} into the model using our experimental data (Tabata et al., 2021). Attenuation of UV light due to atmospheric gas species and dissolved species was considered in the model; accordingly, the effeciency of oxidant production is highly sensitive to atmospheric and water compositions.

Our results suggest that when Fe^{2+} is supplied from the top of a lake, acidic pH of 4–5, high Fe^{2+} influx (0.1–100 mol m^{-2} yr^{-1}), and thick atmosphere (~1 bar CO_2) are required for redox stratification. In the case of Fe^{2+} input from the top, Fe^{2+} needs to be transported to the deep before being fully photo-oxidized for redox stratification. The required conditions can achieve low efficiency of Fe^{2+} photo-oxidation near the surface sufficient to transport to the deep. When Fe^{2+} is supplied only from the bottom of a lake, required conditions for redox stratification are circum-neutral pH (6–7) and moderate Fe^{2+} influx (0.01–1 mol m^{-2} yr^{-1}). At acidic pH, water became ferruginous throughout a lake due to inefficient photo-oxidation and low levels of Fe^{2+} near the surface. High input flux of Fe^{2+} results in abundance of carbonate formation, which is inconsistent with the finding of little carbonates in Gale's lacustrine sediments. Considering the recent estimate of circum-neutral pH of early Gale lake (Fukushi et al., 2019), our results prefer groundwater upwelling as the major source of Fe^{2+} on the lakes. In addition, low CO_2 in the atmosphere would be prefered to avoid Fe-carbonate formation and to promote efficient Fe^{2+} photo-oxidation for redox stratification, which implies the need of abundance of other efficient greenhouse effect gases to warm the surface on early Mars.

Keywords: Mars, Geochemistry, Photochemistry, Iron oxidation, Redox stratification

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Water vapor vertical distributions on Mars: Results from three years of TGO/NOMAD science operations

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Nadir and Occultation for Mars Discovery (NOMAD) onboard ExoMars Trace Gas Orbiter (TGO) started science measurements on 21 April, 2018. Here, we present results on the retrievals of water vapor vertical distributions in the Martian atmosphere from three years of TGO/NOMAD science operations.

NOMAD is a spectrometer operating in the spectral ranges between 0.2 and 4.3 μm onboard ExoMars TGO. NOMAD has 3 spectral channels: a solar occultation channel (SO –Solar Occultation; 2.3–4.3 μm), a second infrared channel capable of nadir, solar occultation, and limb sounding (LNO –Limb Nadir and solar Occultation; 2.3–3.8 μm), and an ultraviolet/visible channel (UVIS –Ultraviolet and Visible Spectrometer, 200–650 nm). The infrared channels (SO and LNO) have high spectral resolution (λ/dλ ~10,000–20,000) provided by an echelle grating used in combination with an Acousto Optic Tunable Filter (AOTF) which selects diffraction orders. The sampling rate for the solar occultation measurement is 1 second, which provides a good vertical sampling step (~1 km) with higher resolution (~2 km) from the surface to 200 km. Thanks to the instantaneous change of the observing diffraction orders achieved by the AOTF, the SO channel is able to measure five or six different diffraction orders per second in solar occultation mode. In this study, we analyze the solar occultation measurements at diffraction order 134 (3011-3035 cm^{-1}), order 136 (3056-3080 cm^{-1}), order 168 (3775-3805 cm^{-1}), and order 169 (3798-3828 cm^{-1}) acquired by the SO channel in order to investigate water vapor vertical distributions.
Knowledge of the water vapor vertical profile is important to understand the water cycle and its escape process. Solar occultation measurements by two new spectrometers onboard TGO - NOMAD and Atmospheric Chemistry Suite (ACS) - allows us to daily monitor the water vapor vertical distributions through the whole Martian Year and obtain a good latitudinal coverage for every ~20° of Ls. In 2018, for the first time after 2007, a global dust storm occurred on Mars. It lasted for more than two months (from June to August). Moreover, following the global dust storm, a regional dust storm occurred in January 2019. The NOMAD and ACS observations therefore fully cover the majority of the global and regional dust storms and offer a unique opportunity to study the trace gases distributions during the dust storms. We analyzed those datasets and found a significant increase of water vapor abundances in the middle atmosphere (40-100 km) during the global dust storm from June to mid-September 2018 and the regional dust storm in January 2019. In particular, water vapor reaches very high altitude, at least 100 km, during the global dust storm (Aoki et al., 2019). A GCM simulation explained that dust storm related increases of atmospheric temperatures suppress the hygropause, hence reducing ice cloud formation and so allowing water vapor to extend into the middle atmosphere (Neary et al., 2019). This study presents the results with the extended dataset, which covers a full Mars year. The extended dataset newly includes aphelion season that involves interesting phenomena such as sublimation of water vapor from the northern polar cap and formation of the equatorial cloud belt, which are known as key periods to understand the large

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north-south hemispheric asymmetries of Mars water vapor. Yet, only a few papers report the water vapor vertical distributions in the aphelion season. The extended dataset also includes the southern summer season (dusty season) in MY 35, which will allow us to compare the water vapor distributions in the global dust storm year with those in the non-global dust storm year. In the presentation, we will discuss the water vapor vertical profiles as well as the aerosols vertical distributions retrieved from the three-year measurements of the TGO/NOMAD.

Keywords: Mars, Water, Atmosphere

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Theoretic study of atmosphere and hydrological cycle with groundwater transportation on land planets

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The presence of liquid water is essential for planetary habitability. Knowledge of a variety of hydrological cycles and climate systems developed on terrestrial planets is important to understand a diversity of habitable planets. According to the previous theoretical studies using general circulation models (GCM) (Abe et al., 2011; Kodama et al., 2018), there are two major planetary climate systems depending on the amount of water on the surface. One is an aqua planet with wet climates and global oceans, and the other is a land planet with arid climates and polar ice caps. Although the previous studies showed that water distributed predominantly in polar regions as ice caps on a land planet, groundwater circulation could transport liquid water formed at the basement of ice caps to middle to low latitudes. Global-scale groundwater circulations would have occurred in reality on land planets in the Solar System, i.e., early Mars and Titan (e. g., Carr et al., 2003; Faulk et al., 2020). Here, we numerically investigate the roles of groundwater circulations in a diversity of planetary climate systems and hydrological cycles on land planets.

In the numerical simulations, we used two models: One is the general circulation model (GCM) of agcm5.4g (Kodama et al., 2018), which calculates atmospheric dynamics, precipitations, and radiation processes in three dimensions, and the other is the commercially-available groundwater circulation simulator of GETFLOWS (Tosaka et al., 2000), which calculates groundwater transport in three dimensions. To achieve a consistency between the models, we performed calculations in the following 3 steps. In Step 0, spatial distribution of ice caps and precipitation/evaporation on land planets are calculated for given atmospheric CO_2 levels and orbital setting using the GCM. We obtain snow-line latitudes, until which ice caps can exist. In Step 1, we calculated the transport dynamics and distribution of groundwater generated at the basement of the ice caps using the groundwater circulation model. In the calculations, we find that groundwater beneath the ice caps is transported to the middle and low latitudes as the permeability of crustal rocks increases. In particular, if the permeability is higher than 10^5~10^6 md, which corresponds to the permeability of gravels and sands on Earth, efficient groundwater transport extends water-existing areas to low latitudes. In Step 2, we investigated the atmospheric circulations and climatic conditions using the GCM for the surface water distributions derived from the groundwater circulation model. We find that when the permeability is high (higher than 10^5~10^6 md), the water-existing areas reach the edge of Hadley Cell at ~30 degrees in latitude. This leads to wetting of air in low latitudes due to water vapor transport by the Hadley circulation, and the climate state shifts from an extremely dry land planet to a wet aqua planet.

Our results of a combination of the numerical simulations show that planetary climate systems are largely affected by surface and shallow-subsurface geological conditions (i.e., permeability of rocks), which have not been considered previously. In particular, the present study suggests the possible existence of a planetary climate state, which has the characteristics of a land planet in terms of surface water distribution (ice caps at high latitudes) and the characteristics of an aqua planet in terms of climate (wet low latitudes). Given the fact that air in low latitudes becomes wet for high permeabilities, we suggest that land planets do not necessary have a wide habitable zone, depending on geological conditions of the

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surface and shallow subsurface.

Keywords: land planets, atmosphere, groundwater

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Possibility of formation of local reductive environment by cometary impact on the early Earth

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When an impact of asteroids or comets in high velocity occurs, they evaporates due to shock heating, forming an impact vapor plume. Chemical reaction in the impact vapor plume is one of the processes that locally bring a reduced environment on the early Earth. Impact experiments show that some organic materials related to life building blocks are formed via chemical reactions in the impact vapor plume. On the other hand, because it is difficult to reproduce planetary-scale collisions in collision experiments, and it is difficult to achieve collision velocities exceeding 10 km/s , theoretical methods are also important.

Ishimaru et al. (2010), which is one of the theoretical methods estimated the quenched composition of impact vapor plume using numerical model that solves the motion of the plume and the chemical reactions simultaneously. However, this model simplifies the motion of vapor plumes based on a few assumptions.

In this study, we investigated the quench composition generated by cometary impacts on the ocean on the early Earth. Specifically, we first performed impact calculations using the impact code iSALE-2D(cylindrical coordinate system) to precisely follow the physical processes of the vapor plume, and to explore the temperature and pressure changes of the plume. Then, the chemical reaction of the HCNO system was calculated under the obtained temperature and pressure changes to estimate quenched composition.

The impact calculations showed the peak temperature and pressure of the plume are found to be consistent with Ishimaru et al. (2010) for the pressure, but about 1/2~1/3 for the temperature. Tis because the previous study estimated the peak temperature based on the planar impact assumption and did not consider the temperature dependence of the specific heat ratio and evaporation heat of ice. In addition, it was thought that the change in comet size did not affect the peak temperature and pressure of the plume, but it was found that if the comet size is larger than the thickness of the ocean, penetration into the oceanic crust occurs and the peak temperature and pressure increases due to the difference in shock wave characteristics with the ocean.

As a result of chemical reaction calculations, it is found that the quenched composition obtained by cometary impact on the early Earth is rich in H_2, H_2O, CO. Moreover, even at the same collision velocity (15 km/s), the compositions of strongly reducing species (CH_4, NH_3) and life building blocks (HCN) are 10 to 1000 times richer than those in Ishimaru et al.(2010). This is because Ishimaru et al.(2010) overestimated the entropy of the plume.

Considering the formation of vapor plume, which is a mixture of comets and oceans during the impact process, we calculated the chemical reaction when H_2O is mixed in. The result shows, as the mixing ratio of the target ocean(H_2O) in vapor plume increased, the molar fractions of reductive nitrogen and carbon compounds in the quench composition became smaller, while oxidative nitrogen, carbon compounds, and H_2 became larger. This is considered to be due to the fact that the mixed target(H_2O) was used to oxidize the reductive nitrogen and carbon.

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It was found that a strongly reducing quench composition can be obtained at an impact velocity of ~15 km/s, which is favorable for the formation of life building blocks on the early Earth. On the other hand, since cometary impact velocities to the Earth are often much higher, it is difficult to create a strongly reducing environment on the early Earth by simple HCNO system reactions. However, by the use of metallic elements in the comet as catalysts (e.g., Sekine et al., 2006).it is possible that even a high-velocity cometary impact could have brought a strongly reducing environment.

Keywords: early Earth, impact vapor plume, life building block

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Oceanic retention of ammonia and thermal stability of the atmosphere-ocean system on the primitive earth

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One of the hypotheses solving the faint young Sun paradox on the ancient earth is the greenhouse effect of NH_3 that has strong infrared absorptions (Sagan and Mullen, 1972). NH_3 might be important for the synthesis of prebiotic organic compounds like amino acids on primitive earth (Bada and Miller, 1968). Although NH_3 tends to be removed from the atmosphere rapidly due to photochemical conversion to N_2 (Kasting, 1982), Sagan and Chyba (1997) estimate that the lifetime of NH_3 (10^{-5} bar) with the amount required for enough greenhouse effect may be as long as 50 million years as organic haze photochemically derived from CH_4 shields NH_3 from UV. They also argue that it might extend to 500 million years if NH_3 was supplied continuously to the atmosphere from a reservoir initially containing NH_3 with the amount equivalent to the total of current atmospheric N_2. However, it has been little discussed what could be the possible reservoirs of NH_3.

NH_3 has high solubility to water; it dissolves 200 mol/kg in pure water under standard temperature and 1 bar of NH_3. Its solubility increases when CO_2 dissolved in water because H^+ and therefore NH_4^+ concentrations increase in water associated with the ionization of CO_2. Therefore, a large amount of NH_3 might be dissolved in the primitive ocean if NH_3 was present in the primitive earth atmosphere. On the other hand, NH_3 solubility has strong temperature dependence which releases NH_3 from water to gas under high temperatures. Thus, the greenhouse effect of NH_3 and the release of NH_3 from oceans might have a positive feedback relationship. Here we assess whether thermal stability could be established in the NH_3-bearing atmosphere-ocean system and the possible strength of greenhouse effect and the NH_3 partitioning between atmosphere and ocean at stable states if exist. Based on those analyses, we clarify whether or not the primitive ocean could function as a long-term reservoir for NH_3. We used a one-dimensional radiative-convective equilibrium atmospheric model for the atmosphere and the solution equilibria model for the isothermal, uniform ocean taking NH_3 and CO_2 as solvents.

We take N_2, NH_3, CO_2, and CH_4 as atmospheric composition and apply 75% of the present solar constant. The vertical NH_3 profile in the atmosphere is given taking into account the effect of rainout. The outgoing planetary radiation to space is calculated by using a line-by-line model and the surface temperature balanced with the absorption of solar radiation is obtained as a function of atmospheric composition, especially NH_3 partial pressure. Here the planetary albedo is fixed at 0.3. The solution equilibria model shows the amount of NH_3 dissolution to the ocean with the present oceanic mass as a function of NH_3 and CO_2 partial pressures. For simplicity, other dissolved components are ignored. The thermal stability of the atmosphere-ocean system can be judged by comparing the temperature dependence of NH_3 partial pressure at solution equilibria under a fixed total amount of NH_3 in the system and the dependence of surface temperature on NH_3 partial pressure in the radiative-convective equilibrium atmosphere.

As the reference case, we suppose 1 bar of N_2 atmosphere with 0.1 vol% of CO_2 and CH_4, respectively, and 1.0×10^{19} mol (equivalent to 3% of N_2 in the present atmosphere) for the total amount of NH_3. In this case, a thermally stable solution is uniquely obtained. At this solution, NH_3 is partitioned 5.8×10^{16} mol (2.0×10^{-4} bar) to the atmosphere and the surface temperature is 330 K which exhibits a strong NH_3 greenhouse. Thermally stable solutions are found when the total amount of NH_3 and partial pressures of N

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$_2$, CO_2, CH_4 are varied. Surface temperatures at thermally stable solutions little depend on the CH_4 volume fraction. We obtained single stable solutions with surface temperatures from 273 K to 373 K when the CO_2 volume fraction is smaller than to 10^{-5}. On the other hand, two stable solutions with high and low surface temperatures appear under larger CO_2 volume fractions. The surface temperature at thermally stable solution increases with increasing the total amount of NH_3 and N_2 partial pressure. Our result suggests that thermally stable states with surface temperatures above 273 K were possibly established when NH_3 existed in the ancient atmosphere in solution equilibrium with the ocean. If NH_3 loss from the atmosphere-ocean system is mostly caused by photolysis, a sufficient greenhouse effect by NH_3 might have lasted 500 million years because the ocean could store a large amount of NH_3 with replenishing NH_3 into NH_3 into the atmosphere.

Keywords: primitive earth, ammonia, atmosphere-ocean system, reduced atmosphere, faint young Sun paradox

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Sat. Jun 5, 2021 9:00 AM - 10:30 AM JST | Sat. Jun 5, 2021 12:00 AM - 1:30 AM UTC | Ch.26 Zoom Room 26

[M-IS16] Paleoclimatology and paleoceanography

convener:Yusuke Okazaki(Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University), Hitoshi Hasegawa(Faculty of Science and Technology, Kochi University), Atsuko Yamazaki(Faculty of Science, Kyushu University), Akitomo Yamamoto(Japan Agency for Marine-Earth Science and TechnologyAtmosphere and Ocean Research Institute), Chairperson:Akitomo Yamamoto(Japan Agency for Marine-Earth Science and TechnologyAtmosphere and Ocean Research Institute)

Past environmental changes and events at interannual 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 JpGU2021, a series of presentations on "high-resolution" paleo data and model studies 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

[MIS16-11] **Reconstruction of the ice sheet history since the Last Glacial Maximum based on field-based geomorphological observations and surface exposure ages along the southern Soya Coast, Lützow-Holm Bay, East Antarctica**

*Moto Kawamata[1], Yusuke Suganuma[2,1], Koichiro Doi[2,1], Keiji Misawa[2,1], Motohiro Hirabayashi[2], Akihisa Hattori[1], Takanobu Sawagaki[3] (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)

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

[MIS16-12] Characteristic of radiocarbon dates in response to sea-level changes in the Bonaparte Gulf, Northwestern Australia

*Takeshige Ishiwa[1,2,3], Yusuke Yokoyama[2,3,4], Stephen Obrochta[5], Katsuto Uehara[6], Jun'ichi Okuno[1,7], Minoru Ikehara[8], Yosuke Miyairi[2] (1.National Institute of Polar Research, 2.Atmosphere and Ocean Research Institute, The University of Tokyo, 3.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 4.Japan Agency for Marine-Earth Science and Technology, 5.Graduate School of International Resource Science, Akita University, 6.Research Institute for Applied Mechanics, Kyushu University, 7.Department of Polar Research Science, School of Multidisciplinary Science, The Graduate University for Advanced Studies (SOKENDAI), 8.Center for Advanced Marine Core Research, Kochi University)

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

[MIS16-13] Wind-wave changes in Tokyo Bay during the Holocene: impact of sea-level change and land configuration

*Katsuto Uehara[1] (1.Kyushu University)

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

[MIS16-14] Reconstruction of organic matter inflow fluctuations from the Bolling-Allerod interstadial to Late Holocene using Lake Baikal sediments

*Keiko Takehara[1], Masatoshi Nakakuni[2], Shuichi Yamamoto[3] (1.Kochi university Graduate School of Integrated Arts and Sciences, 2.Faculty of Agriculture, Kagawa University, 3.Department of Environmental Engineering for Symbiosis, Graduate School of Engineering, Soka University)

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

[MIS16-15] Reconstruction of Early Pleistocene sea-surface temperature in the Northwestern Pacific Ocean based on calcareous microfossils

*Daisuke Kuwano[1], Yuki Tsuchiya[2], Yuma Oura[1], Hiroki Hayashi[3], Yoshimi Kubota[4], Kanako Mantoku[5], Koji Kameo[1] (1.Chiba University, 2.Nagoya University, 3.Shimane University, 4.National Museum of Nature and Science, 5.National Institute for Environmental Studies)

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

[MIS16-16] Variation of the North Pacific Ocean circulation during the Late Pleistocene glacial-interglacial cycles

*Furukawa Keisuke[1], Osamu Seki[1], Masanobu Yamamoto[1], Tomohisa Irino[1] (1.Hokkaido University)

Reconstruction of the ice sheet history since the Last Glacial Maximum based on field-based geomorphological observations and surface exposure ages along the southern Soya Coast, Lützow-Holm Bay, East Antarctica

*Moto Kawamata[1], Yusuke Suganuma[2,1], Koichiro Doi[2,1], Keiji Misawa[2,1], Motohiro Hirabayashi[2], Akihisa Hattori[1], Takanobu Sawagaki[3]

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The thinning and retreat history of the East Antarctic Ice Sheet (EAIS) since the Last Glacial Maximum (LGM) is essential for understanding the mechanisms and drivers of the large-scale and potentially non-linear (abrupt) response of the ice sheet melting. Such information is needed to assess and capture the key process enacting of abrupt deglaciation over this century and beyond for the future prediction. However, a detailed reconstruction of the history of the EAIS involving changes in its thickness and lateral extent since the LGM remains sparse. Here, we show a new detailed ice sheet history from the southern Soya Coast, Lützow-Holm Bay, East Antarctica, based on field-based geomorphological observations and surface exposure ages. Our results demonstrate that the ice sheet completely covered the highest peak of Skarvsnes (400 m a.s.l.) prior to ~9 ka and retreated eastward by at least 10 km during the Early to Mid-Holocene (ca. 9 to 6 ka). The timing of the abrupt ice-sheet thinning and retreat is consistent with the intrusion of modified Circumpolar Deep Water into deep submarine valleys in Lützow-Holm Bay, as inferred from fossil foraminifera records of marine sediment cores. Thus, we propose that the process of marine ice-sheet instability and ocean-driven melting most likely cause the abrupt thinning and retreat of the EAIS along the southern Soya Coast since the LGM. Such abrupt ice-sheet thinning and retreat with similar magnitude and timing have also been reported from an outlet glacier from Enderby Land, East Antarctica. This geological evidence emphasizes the importance of understanding paleo ice-sheet changes based on geological and geomorphological study not only in West Antarctica but also in East Antarctica to predict potential ice mass loss areas associated with the ocean–ice-sheet interactions in the future.

Keywords: East Antarctic Ice Sheet, Glacial geomorphology, Surface exposure dating, Marine ice-sheet instability, Ice sheet history

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Characteristic of radiocarbon dates in response to sea-level changes in the Bonaparte Gulf, Northwestern Australia

*Takeshige Ishiwa[1,2,3], Yusuke Yokoyama[2,3,4], Stephen Obrochta[5], Katsuto Uehara[6], Jun'ichi Okuno[1,7], Minoru Ikehara[8], Yosuke Miyairi[2]

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Radiocarbon dating is an essential method for constraining Late Quaternary age models and applied to carbon-containing materials. Past climate and sea-level changes influence depositional process so that paleoenvironmental reconstruction is needed to select an appropriate dating material. We present radiocarbon dates variation performed on macrofossils, foraminifers, and acid-insoluble carbon (AIC), as well as paleo-tidal modeling results from the Bonaparte Gulf in northwestern Australia. The varied topography and large tidal range of this gulf are the dominant factors of the past depositional process in response to sea-level change. We will reveal the variation of radiocarbon dates in response to sea-level changes, which appear as changes in paleowater depth and paleotide. Carbonate fossil material reveals a more reliable depositional age than acid insoluble carbon at sea level below -70 m because of little lateral transport caused by reduced tidal activity. On the other hand, acid insoluble carbon ages are more reliable at sea level above −70 m because redeposition of old fossil influences carbonate fossils ages due to enhanced tidal activity. Our results indicate that the age models' reliability has changed over time, especially on the continental shelf, where environmental changes due to sea-level fluctuations are significant.

Keywords: Radiocarbon dating, Sea-level change, Paleotidal modeling

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Wind-wave changes in Tokyo Bay during the Holocene: impact of sea-level change and land configuration

*Katsuto Uehara[1]

1. Kyushu University

A paleowave simulation has been carried out to reconstruct changes in the wind-wave field in Tokyo Bay during the Holocene, when the bay configuration altered greatly due to the inundation of a drawn valley associated with a rapid sea-level rise and subsequent infilling of the valley by fluvial sediments. The numerical run was conducted by combining a third-generation wave model SWAN and paleobathymetries reconstructed by the author for every 1kyr from 10ka to 4ka. A preliminary experiment made by applying uniform sea-surface winds indicated an increase of the significant wave height by 10-20% compared to the present-day state.

Keywords: paleowave reconstruction, numerical modeling, Holocene, estuary

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Reconstruction of organic matter inflow fluctuations from the Bolling-Allerod interstadial to Late Holocene using Lake Baikal sediments

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Stable oxygen isotope ($d^{18}O$) records in ice cores obtained by the North Greenland Ice Core Project show climate change due to periodic temperature changes from 130,000 to 20,000 years ago. Whereas, the records show a more stable warm period during Holocene (present to 11,700 years ago) when comparing to the previous temperature changes. However, Bond et al. (1997) have reported that rapid climate change (RCC; Mayewski et al., 2004) has occurred in the Holocene. Most of such reports are discovered from marine area including the North Atlantic Ocean and the Indian Ocean regions, but the elucidation of the actual situation on continental regions has been delayed because it is difficult to secure samples for restoration of the paleoenvironment.

Lake Baikal is located in the area that receives the most significant solar radiation fluctuations on the earth (Short et al., 1991). Therefore, it is recognized that the lake records continental climate changes relating the solar radiation fluctuations in detail, and therefore many studies have been conducted using various paleo-environmental proxies. However, most of such papers were focused on glacial to interglacial cycles due to the limitation on sedimental time resolution (> 1 kyr sample^{-1}). Thus, in previous studies, elucidating short-term and rapid climate changes such as the Bolling-Allerod, the Younger Dryas, and Holocene was difficult to (Horiuchi et al., 2000). Therefore, using high time resolution sediment samples obtained from Lake Baikal, the purpose of this study is to reconstruction climate changes from the last glacial termination to Holocene and the accompanying changes in the inflow of organic matter into the lake.

A 1.9 m-long gravity core (VER98-1 St.5GC) was collected from the Academician Ridge, Lake Baikal central basin in 1998. We selected on the upper 0.8 m sediment to study focused on the Pleistocene–Holocene interval including the Bolling-Allerod warming period and the Younger Dryas period. At two intervals of 70–63 cm (the Bolling-Allerod) and 60–20 cm (pre-boreal to sub-boreal in Holocene), TOC ranged from 1–2%, slightly higher than before and after of the depths, the C/N ratios (terrestrial input proxy) ranged from 8.4–11.3 and the ratios of Va to Vh ((Ad/Al)v) were showed maximum 5.6, and these records suggesting high degraded terrestrial material inputs to the lake during these intervals (the Bolling-Allerod and the pre-boreal to sub-boreal period). At the same intervals, $\delta^{13}C$ values showed lighter values of −26 to −29 ‰, which is within the values of C3 plants (C3 plants: −20 to −37 ‰; Kohn, 2010), and ratios of syringyl to vanillyl phenols (S/V) and cinnamyl to vanillyl phenols (C/V) was shown that sediments OM was derived from the non-woody angiosperms (grasses and leaves). The vegetation around Lake Baikal from the last glacial period to about 6,000 years ago was composed of tundra (herbs) characteristic of the permafrost zone (Demske et al., 2005). Additionally, at the present, $\delta^{13}C$ values in DOM of Siberian permafrost melting water showing −25 to −27.6 ‰(Tesi et al., 2016) and Canadian high arctic permafrost spring flush (Ad/Al)v in DOM implying maximum at 3.6 (Woods et al., 2011) were reported. From these results and investigations, it is considered that the inflow of high decomposition products from the pre-boreal period to the late Holocene is caused by the inflow of

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permafrost melting water containing herbaceous plants into the lake. Such a Siberian permafrost melting during the Bolling-Allerod and pre-boreal periods has also been reported in lake Baikal southern basin and lake Hovsgol (Katsuta et al., 2019). In addition, in this study, Siberian permafrost melting during the sub-boreal period was inferred because similar organic records were observed during this interval as well as the previous one. However, the organic records probably also be influenced by increasing amount of vegetation by warmer climates.

Keywords: Lake Baikal, TMAH method, Holocene

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Reconstruction of Early Pleistocene sea-surface temperature in the Northwestern Pacific Ocean based on calcareous microfossils

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Planktonic foraminifera and calcareous nannofossils have been used to clarify past marine environments based on relationships between distributions of living taxa and sea-water conditions (e.g., Takemoto and Oda, 1997; Aizawa et al., 2004). In this study, we reconstruct the sea surface temperature (SST) based on the Modern Analog Technique (MAT) of calcareous microfossil assemblages. The MAT is a useful method for reconstructing SST by comparing the similarity between fossil and modern assemblages (e.g., Pflaumann et al., 1996). Around the Pacific coast of Japanese islands, many surface sediments have been obtained by grab sampler and piston corer, and the modern microfossil assemblages of those have been studied (e.g., Tanaka, 1991). We apply the MAT to 27 samples of the upper part of the Kiwada Formation, Kazusa Group, obtained by Kuwano et al. (in press). We estimated the SST by calculating the squared chord distance (SCD) between fossil and modern assemblages, subsequently taking the weighted temperature average of the top five samples with the highest similarity. The modern foraminiferal and nannofossil assemblage dataset were obtained from Takemoto and Oda (1997) and Tanaka (1991), respectively. The modern SST dataset was used in July from the Japan Oceanographic Data Center (2004).
The reconstructed SST tends to be high during interglacial, and the summer SST ranged between 23.4 and 27.7 ℃. On the other hand, during the glacial Marine Isotope Stage (MIS) 38, the SSTs temporarily dropped by 1–2 ℃. This sea-surface variation is similar to that of planktonic foraminiferal $\delta^{18}O$ change although the nannofossil SSTs were sharp declines rather than planktonic $\delta^{18}O$ changes in some horizons.

[Reference]
Aizawa et al., 2004, *Marine Micropaleontology*, 52, 277–297.
Japan Oceanographic Data Center, 2004, https://jdoss1.jodc.go.jp/vpage/bts_j.html
Kuwano et al., in press, *Stratigraphy*.
Pflaumann et al., 1996, *Paleoceanography*, 11, 15–35.
Takemoto and Oda, 1997, *Paleontological research*, 1, 291–310.
Tanaka, 1991, *Sci. Rep., Tohoku Univ., 2nd ser. (Geol.)*, 61, 127-198.

Keywords: Calcareous nannofossils, Planktonic foraminifera, Modern Analog Technique, Paleoceanography, Pleistocene, Kazusa Group

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Variation of the North Pacific Ocean circulation during the Late Pleistocene glacial-interglacial cycles

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1. Hokkaido University

The Late Pleistocene glacial-interglacial (G-IG) cycle, characterized by 100 kyr variations in global ice volume and atmospheric CO_2 concentration, governs the global climate (e.g., global mean surface temperature). Reported long-term SST records in the Equatorial and North Pacific show a unique response to the orbital forcing, despite their overall patterns reflecting the G-IG cycle. This suggests the reorganization of the ocean-atmosphere circulation in the region associated with the G-IG cycle. However, available SST records in the subarctic region of the North Pacific are limited to the Last Glacial Maxima. Therefore, the whole picture of the North Pacific response to global climate change remains unclear.

In this study, we reconstructed changes in sea surface temperature (SST) at the western and eastern margins of the North Pacific subarctic region for the past 470 kyrs based on TEX_{86}^{L} and U^{K}_{37}' analyses in Ocean Drilling Program (ODP) Sites ODP 882 and 887. The SST records in Sites 882 and 887 during the last glacial cycle show a typical G-IG pattern. This correspondence confirms the robustness of our reconstruction. However, extended SST records back to 470 ka revealed a unique response to the orbital forcing with relatively low SSTs during the super interglacials compared to the Holocene. The subarctic region's unique response appears to be linked climate variation in the low latitude Pacific, implying large-scale reorganization of the ocean-atmosphere circulation associated with the global climate change.

Keywords: North Pacific, glacial-interglacial cycle, SST reconstruction

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Sat. Jun 5, 2021 10:45 AM - 12:15 PM JST | Sat. Jun 5, 2021 1:45 AM - 3:15 AM UTC | Ch.26 Zoom Room 26

[M-IS16] Paleoclimatology and paleoceanography

convener:Yusuke Okazaki(Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University), Hitoshi Hasegawa(Faculty of Science and Technology, Kochi University), Atsuko Yamazaki(Faculty of Science, Kyushu University), Akitomo Yamamoto(Japan Agency for Marine-Earth Science and TechnologyAtmosphere and Ocean Research Institute), Chairperson:Hitoshi Hasegawa(Faculty of Science and Technology, Kochi University)

Past environmental changes and events at interannual 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 JpGU2021, a series of presentations on "high-resolution" paleo data and model studies 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

[MIS16-17] Reconstruction of the Mediterranean sulfur cycle during the Messinian salinity crisis using evaporites

*Takeru Kochi[1], Junichiro Kuroda[1], Nanako O. Ogawa[2], Toshihiro Yoshimura[2], Takashi Miyazaki[2], Bogdan Stefanov Vaglarov[2], Naohiko Ohkouchi[2] (1.the University of Tokyo, 2.Japan Agency for Marine–Earth Science and Technology)

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

[MIS16-18] Increased eolian dust in the Pacific since around the Eocene-Oligocene boundary estimated from a rock-magnetic study of red clay

*Toshitsugu Yamazaki[1], Wei Fu[1], Takaya Shimono[2], Yoichi Usui[3] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Geological Survey of Japan, AIST, 3.Japan Agency for Marine-Earth Science and Technology)

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

[MIS16-19] **Authigenic and detrital Mg and Li isotopes as a tracer of Antarctic chemical silicate weathering across the EOT**

*Adam David Sproson[1,2,3], Toshihiro Yoshimura[1], Yusuke Yokoyama[1,3], Takahiro AZE[3], Tsuyoshi Ishikawa[4], Shigeyuki Wakaki[4], Naohiko Ohkouchi[1] (1.Department of Biogeochemistry, Japan Agency for Marine-Earth Science and Technology, 2-15 Natsushima, Yokosuka, Kanagawa 237-0061, Japan, 2.Submarine Resources Research Center, Japan Agency for Marine-Earth Science and Technology, 2-15 Natsushima, Yokosuka, Kanagawa 237-0061, Japan, 3.Atmosphere and Ocean Research Institute, University of Tokyo, 5-1-5 Kashiwanoha, Kashiwa, Chiba 277-8564, Japan, 4.Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology 200 Monobe Otsu, Nankoku City, Kochi 783-8502, Japan)

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

[MIS16-20] Terrestrial environmental response to the global climate change during the early to middle Eocene (52.7-43.8 Ma): evidence from lacustrine deposits of the Green River Formation, Utah, USA

*Ryusei Kuma[1], Hitoshi Hasegawa[2], Koshi Yamamoto[1], Jessica H. Whiteside[3], Amy L. Elson[3], Hidekazu Yoshida[1], Koichi Mimura[1] (1.Nagoya University, 2.Kochi University, 3.University of Southampton)

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

[MIS16-21] C40-alkenone unsaturation index from the Cretaceous and paleothermometry in southern high latitude of Proto-Indian Ocean

*Takashi Hasegawa[1], Akiko S. Goto[2,1], Hiromichi Komiya[3], Shota Morikawa[3] (1.Faculty of Geoscience and Engineering, Institute of Science and Engineering, Kanazawa University, 2.Center of Ecological Research, Kyoto University, 3.Graduate School of Natural Science and Engineering, Kanazawa University)

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

[MIS16-22] Opposing responses in the hydrological cycle of the East Asia to climate warming related with the Tibetan Plateau

*Taro Higuchi[1], Ayako Abe-Ouchi[1], Wing-Le Chan[1] (1.Atmospheric and Ocean Research Institute, the University of Tokyo)

Reconstruction of the Mediterranean sulfur cycle during the Messinian salinity crisis using evaporites<gdiv></gdiv>

*Takeru Kochi[1], Junichiro Kuroda[1], Nanako O. Ogawa[2], Toshihiro Yoshimura[2], Takashi Miyazaki[2], Bogdan Stefanov Vaglarov[2], Naohiko Ohkouchi[2]

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Evaporite is a group of rocks composed of minerals precipitated from a saturated brine through solar evaporation. Halite (NaCl) and gypsum ($CaSO_4 \cdot 2H_2O$) are representative evaporite-forming minerals in the natural environment. During the Phanerozoic, voluminous evaporite bodies, so-called “salt giant”, have been formed repeatedly. The Messinian Salinity Crisis (MSC: 5.97-5.33 Ma) occurred in the Mediterranean Sea during the later stage of Messinian (7.246-5.333 Ma) represents one of the largest and the youngest salt giants in the Phanerozoic. This event is subdivided into three stages (Stages 1 to 3) based on the lithological features of evaporites. It has been proposed that the MSC was caused by tectonic uplift around the Atlantic spillway and global sea level drop, both of which could have limited the connection between the Mediterranean Sea and the Atlantic Ocean. During the MSC, a huge amount of gypsum was deposited in marginal and central deep basins of the Mediterranean Sea. The sulfate removed from seawater could have affected the sulfur isotopic composition ($\delta^{34}S$) in the Mediterranean Sea. Previous studies have already demonstrated that, gypsum samples deposited during the MSC have sulfur isotopic compositions slightly heavier than that of the contemporaneous global seawater sulfate. However, there are few studies on the detailed spatiotemporal variation of sulfur isotopic composition within the Mediterranean basins through the MSC, which is necessary to quantitatively reconstruct the sulfur cycles in the Mediterranean Sea during the MSC.
In this study, we assessed how sulfur cycles in the Mediterranean Sea changed during the MSC based on sulfur isotopic composition of sulfate minerals deposited on six sites all around the Mediterranean Sea (three on land sites and three offshore borehole sites). The sulfur isotopic compositions were measured using an Elemental Analyzer-Isotope Ratio Mass Spectrometer (EA-IRMS) at Japan Agency for Marine-Earth Science and Technology (JAMSTEC). Sulfur isotopic compositions of evaporite samples deposited during the MSC are summarized as follows: gypsum deposited during Stage 1 ranges from 22.37 to 23.75 ‰, gypsum and halite deposited during Stage 2 ranges from 22.61 to 23.60 ‰, and gypsum deposited during Stage 3 is from 21.20 to 22.82 ‰. Based on these values, we reconstructed the sulfur isotopic composition of the brine water of the Mediterranean Sea with applying sulfur isotopic fractionation associated with the precipitation of evaporitic minerals from brine water estimated by our evaporation experiments (i.e., $\varepsilon^{34}S = \delta^{34}S_{mineral} - \delta^{34}S_{brine} = 1.4$ ‰for gypsum and $\varepsilon^{34}S = 0$ ‰for halite). This reconstruction showed that the sulfur isotopic compositions were constant during Stage 1 throughout the Mediterranean Sea, but they decreased by 1-1.5 ‰from Stage 2 to Stage 3. To explain the decreasing sulfur isotopic composition, we estimated seawater exchange rate and gypsum deposition volume using a box model. The calculation results suggest that the variation of sulfur isotopic compositions could be explained by combined effects of (1) a decrease in the relative contribution of seawater influx from the Atlantic Ocean (or increased riverine flux), (2) voluminous deposition of gypsum with ^{34}S-enriched sulfur, and (3) additional local effects by biological sulfate reduction that may account for the local heterogeneity in sulfur isotopic compositions.<gdiv></gdiv>

Keywords: sulfur isotope, evaporite, the Messinian Salinity Crisis

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Increased eolian dust in the Pacific since around the Eocene-Oligocene boundary estimated from a rock-magnetic study of red clay

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Red clay widely occupies the seafloor of pelagic environments in middle latitudes, and potentially preserves long paleoceanographic records. We conducted a rock-magnetic study of Pacific Ocean red clay to elucidate paleoenvironmental changes. Three piston cores from the western North Pacific Ocean and IODP Hole U1365A cores in the South Pacific Ocean were studied here. Principal component analyses applied to first-order reversal curve diagrams (FORC-PCA) reveal three magnetic components (endmembers EM1 through EM3) in a core of the western North Pacific. EM1, which represents the features of interacting single-domain (SD) and vortex states, is interpreted to be of terrigenous origin. EM2 and EM3 are carried by non-interacting SD grains with different coercivity distributions, which are interpreted to be of biogenic origin. The EM1 contribution suddenly increases upcore at a depth of ~2.7 m, which indicates increased eolian dust input. The age of this event is estimated to be around the Eocene-Oligocene (E/O) boundary. Transmission electron microscopy reveals that EM2 is dominated by magnetofossils with equant octahedral morphology, while EM3 has a higher proportion of bullet-shaped magnetofossils. An increased EM3 contribution from ~6.7 to 8.2 m suggests that the sediments were in the oxic-anoxic transition zone (OATZ), although the core is oxidized in its entire depths now. The chemical conditions of OATZ may have been caused by higher biogenic productivity near the equator. FORC-PCA of Hole U1365A cores identified two EMs, terrigenous (EM1) and biogenic (EM2). The coercivity distribution of the biogenic component at Hole U1365A is similar to that of the lower coercivity biogenic component in the western North Pacific. A sudden upcore terrigenous-component increase is also evident at Hole U1365A with estimated age around the E/O boundary. The eolian increase may have been coeval in both hemispheres and associated with the global cooling at the E/O boundary.

Keywords: eolian dust, biogenic magnetite, red clay, Eocene-Oligocene boundary

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Authigenic and detrital Mg and Li isotopes as a tracer of Antarctic chemical silicate weathering across the EOT

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Future warming beyond 2C could lead to the crossing of a threshold beyond which positive feedbacks within the Earth System, such as permafrost thawing, increased bacterial respiration and forest dieback, would create a “Hothouse Earth” [1]. Understanding the interplay of feedback mechanisms is therefore of utmost importance to predicting future climate change. On million-year timescales, the hydrolysis of silicate minerals and subsequent precipitation of carbonate minerals in the ocean acts as a negative feedback within the carbon-cycle [2]. On shorter, more relevant, timescales, the production of fine-grained material and associated subglacial chemical weathering during expansion and contraction of glaciers may influence atm. CO_2 and temperature [3].

The Eocene-Oligocene Transition (EOT; ca. 34 Ma) marks the sudden appearance of large ice sheets on Antarctica which caused a surge in erosion recorded by Nd isotopes, Pb isotopes and clay mineralogy [4, 5]. However, the response of chemical silicate weathering is not well understood. Here, we present Mg and Li isotope and rare-earth element (REE) data for the authigenic and detrital phases of marine sediments from ODP Site 738 on the Kerguelen Plateau. Magnesium and Li isotopes fractionate significantly during chemical weathering, with the retention of the heavier ^{26}Mg and ^{7}Li in weathering residues [6, 7]. During secondary mineral formation, the heavier (lighter) isotopes of Mg (Li) become preferentially incorporated, driving the $\delta^{26}Mg$ ($\delta^{7}Li$) to higher (lower) values.

The $\delta^{26}Mg$ and $\delta^{7}Li$ records of the authigenic and silicate phases from Site 738 display similar variation to previous Pb and Nd isotope records, revealing a dramatic intensification of silicate weathering across the EOT. This intensification is well correlated to oxygen isotopes suggesting continental ice sheet expansion over Antarctica led to increased silicate weathering, atm. CO_2 drawdown and further cooling. Such feedbacks may help reverse future warming as ice sheets begin to retreat.

[1] Steffen et al. (2018) *PNAS* **115**, 8252-8259. [2] Berner (2006) *GCA* **70**, 5653-5664. [3] Kump & Alley (1994) 46-60. [4] Basak & Martin (2013) *Nature Geoscience* **6**, 121-124. [5] Scher et al. (2011) *Geology* **39**, 383-386. [6] Wimpenny et al. (2011) *EPSL* **304**, 260-269. [7] Huh et al. (1998) *GCA* **62**, 2039-2051.

Keywords: Chemical weathering, Eocene-Oligocene Transition, Mg & Li isotopes

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Terrestrial environmental response to the global climate change during the early to middle Eocene (52.7-43.8 Ma): evidence from lacustrine deposits of the Green River Formation, Utah, USA

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The evolution of early Eocene climate and oceans has been the focus of significant study due to the elevated atmospheric CO_2 levels (>1,000 ppm) of this warmest interval of the Cenozoic. In contrast, the terrestrial response during this period is less understood. This study focused on the Early Eocene Climatic Optimum (EECO) recorded in the Uinta Basin’ s lower to middle Green River Formation, western United States, ca. 52.7-43.8Ma This section (ca. 1000 m in thickness) affords a high temporal resolution of 1-2 m (10-20 kyrs resolution).
In this study, detailed lithofacies descriptions of lake level change, as well as elemental and mineralogical analyses, were used to quantitatively reconstruct the terrestrial environment. Alterations in lithofacies allow us to subdivide the succession into the following nine paleoenvironmental stages: the fluvio-lacustrine stage; the deep-lake stage; the fluvio-lacustrine stage; the deep-lake stage; the shallow lake stage; the evaporative lake stage; the shallow lake stage; fluctuating lake stage; and the fluvio-lacustrine stage, in ascending order. By comparing the lithofacies and the composition of major elements, Ca/Al can be utilised as a proxy of lake level, Mn/Fe as an indicator of lake bottom redox conditions, and K/Al as a proxy for chemical weathering rates. Each paleoclimatic proxy suggests that the Green River Formation had high lake levels, an anoxic lake bottom environment, and high chemical weathering during the EECO. Mineral composition changes reflect variation in the degree of chemical weathering during and after the EECO. In concert, these results suggest abundant precipitation during the EECO in the mid-latitudes of North America. In addition, our results correspond to the positive $\delta^{13}C$ trend in deep-sea benthic foraminifera and insolation phase change during the early to middle Eocene, indicating that the mid-latitudes of the Northern Hemisphere may have become wetter during the "hothouse" period of EECO which probably correspond to the northward expansion of the intertropical convergence zone due to global warming.

Keywords: lake sediment, Eocene, greenhouse, paleoclimate, carbon cycle, Milankovitch cycle

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C40-alkenone unsaturation index from the Cretaceous and paleothermometry in southern high latitude of Proto-Indian Ocean

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What would happen on regional environments on the Earth with the worst scenario of global warming? Geologic archives memorized the results of “grand experiments of global warming” during greenhouse period of the past, like Cretaceous. As greenhouse periods are deep past older than 4000 Myr, geochemical signals are lost or seriously affected by diagenesis. In addition, because such periods are much warmer than the Quaternary, some paleoceanographic proxies cannot be applied with the same manner.

Sea surface temperature (SST) and its fluctuation (cyclicity, magnitude and their rate of changes etc.) is the most important environmental information. Only collecting SST information of greenhouse periods as same resolution as Quaternary can answer the question that we mentioned at the start.

Alkenones (strait chain alkyl ketone) are potential tool for this purpose. Alkenone molecules from marine sediments are known to be products of haptophyte algae and are often employed for paleothermometry for Quaternary and Neogene. Di- and Tri-unsaturated alkenones with 37 carbon atoms (C37 alkenones) are the target molecules for this purpose. On the other hand, only di-unsaturated one has been reported from Paleocene or Cretaceous. Thus alkenone paleothermometry cannot be applied as same manner for the greenhouse periods.

This study detected alkenones with 37-40 carbon atoms in the late Cretaceous sediments from southern margin of proto-Indian Ocean (IODP Exp. 369 Site U1516). Di-unsaturated C40 alkenone ($C_{40:2}$Et) was the most dominant species among the alkenones. In addition to $C_{40:2}$Et, tri-unsaturated C40 alkenone ($C_{40:3}$ Et) was observed by this study for the first time. Then we calculated C40 alkenones unsaturation index ($U^{K'}_{40}$) and discussed its stratigraphic characteristics through the Albian to uppermost Cenomanian up to OAE2 interval.

Content of $C_{40:2}$Et was highest at the top of black clay layer (BCL: sediment associated with OAE2). It is relatively low through the interval below BCL. It decreased above BCL and reach to substantially zero at 30 cm above the top of BCL, then no detection above.

$U^{K'}_{40}$ showed characteristic fluctuation in the Upper Cenomanian. Maximum value near 1.0 were detected from the lowest sample of BCL, as well as from samples of Albian/Cenomanian boundary interval. In the BCL, it showed dramatic decrease toward 0.85 within the interval of 15 cm. Not only C37 alkenones, C38, C41 and C42 alkenones also show their temperature-dependent nature of the unsaturation ratio based on *in vitro* experients (Araie et al., 2019). This fact strongly suggests that C40 alkenones produced during Cretaceous also had similar temperature dependence. If it is accepted, then following interpretation is possible for interval near the OAE2: (1) on the half way of the 1st build-up of the carbon isotope excursion (CIE), SST reached maximum. It is as same SST as that of Albian/Cenomanian boundary; (2) through the later phase of 1st build-up of CIE, SST dropped considerably and reached minimum just above the 1st peak of CIE. It could be comparable event with

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“Plenus Cold Event”.

$U^{K'}_{40}$ cannot be converted into SST value so far, however, some approaches are possible to improve $U^{K'}_{40}$ as a proxy of SST for Cretaceous. Oxygen isotope study on individual planktonic foraminifera with excellent preservation from identical sample with C40 alkenones can provide SST information comparable with $U^{K'}_{40}$. Collecting haptophyte strain that produce C40 alkenones from present saline lake and cultural experiments using them could help discussion on temperature dependence of $U^{K'}_{40}$. Thus $U^{K'}_{40}$ is a promising proxy for quantitative paleothermometry for high temperature regime (>28 C).
Citation: Araie et al. (2018) Org. Geochem. 121, 89-103

Keywords: alkenone, Cretaceous, biomarkers, paleothermometry, OAE

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Opposing responses in the hydrological cycle of the East Asia to climate warming related with the Tibetan Plateau

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The water cycle is closely linked to human lives, the ecosystem, ocean circulation and the carbon cycle, and its change due to increased atmospheric CO2 concentration is one of the major concerns in the field of global warming research. Numerical modelling studies using GCMs suggested that, in East Asia, the mean precipitation increases with future global warming, leading to more humid conditions. On the other hand, Cretaceous proxy data showed that aridification in the low latitudes of East Asia proceeded the mid-Cretaceous which was the warmest time during the Cretaceous Period, with an especially high CO2 concentration, compared to the relatively cold early and late Cretaceous. However, it remains unclear why the response of the water cycle in East Asia to increased CO2 differs during the present day and the Cretaceous and how the response in the Cretaceous compares with other periods. The aim of this study is to investigate the response of the climate and water cycle to increased atmospheric CO2 for a Cretaceous paleogeography and to compare results with the proxy data and warming experiments using the present-day, Pliocene, and Eocene conditions. In this study, simulations of the present-day, Pliocene, Eocene, and Cretaceous climate with different CO2 levels are carried out using the atmosphere-ocean general circulation model, MIROC4m. For all the experiments, the global hydrological sensitivity ranges from 1.98 to 2.14 %/K, which is fairly small. The "rich gets richer" mechanism can be seen zonally in all cases. On the other hand, there are two opposing responses in the local hydrological cycle in East Asia to climate warming. One response is that annual precipitation in East Asia increases as the climate warms, provided there is an elevated Tibetan Plateau (Present day, Pliocene), similar to global warming prediction. The other is that annual precipitation decreases without a Tibetan Plateau (Eocene, Cretaceous), consistent with the change in the hydrological cycle during the mid-Cretaceous as shown in proxy data. These opposing responses in the hydrological cycle may be attributed to the different basic climate fields and atmospheric circulation responses in Asia which, in turn, is associated with the presence or absence of the Tibetan Plateau. Furthermore, from the idealized sensitivity experiments of the Tibetan Plateau, it is found that the changes in the annual precipitation of East Asia due to increasing atmospheric CO2 are reversed by around 60% on the Tibetan Plateau.

Keywords: Hydrological cycle, East Asia, Global warming, Cretaceous, Tibetan plateau

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Sat. Jun 5, 2021 1:45 PM - 3:15 PM JST | Sat. Jun 5, 2021 4:45 AM - 6:15 AM UTC | Ch.03 Zoom Room 03

[M-IS17] Interface- and nano-phenomena on crystal growth and dissolution

convener:Yuki Kimura(Institute of Low Temperature Science, Hokkaido University), Hitoshi Miura(Graduate School of Science, Department of Information and Basic Science, Nagoya City University), Hisao Satoh(Low-Level Radioactive Waste Disposal Center, Japan Nuclear Fuel Limited), 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.

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

[MIS17-01] Nucleation of water particles in the mesosphere

*Kyoko Kitakami Tanaka[1,2], Yuki Kimura[3], Ingrid Mann[4] (1.Tohoku University, 2.Nihon University, 3.ILTS, Hokkaido University, 4.UiT the Arctic University of Norway)

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

[MIS17-02] Possible new water on an ice III crystal in water

*Hiromasa Niinomi[1], Tomoya Yamazaki[2], Hiroki Nada[3], Tetsuya Hama[4], Akira Kouchi[2], Junpei Okada[1], Nozawa Jun[1], Satoshi Uda[1], Yuki Kimura[2] (1.Institute for Materials Research, Tohoku University, 2.Institute of Low Temperature Science, Hokkaido University, 3.National Institute of Advanced Industrial Science and Technology, 4.Komaba Institute for Science, The University of Tokyo)

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

[MIS17-03] HCl droplets induced bunched steps on ice crystal surfaces under atmospheric-concentration HCl gas

*Ken Nagashima[1], Ken-ichiro Murata[1], Gen Sazaki[1] (1.The Institute of Low Temperature Science, Hokkaido University)

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

[MIS17-04] Adsorption of nucleotides on clay induced by change in hydration structure by magnesium ion

*Yuki Araki[1], Yoshihiro Furukawa[2] (1.Ritsumeikan University, 2.Tohoku University)

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

[MIS17-05] Surface-Selective Vibrational Micro-Spectroscopy Unveils Physicochemical States and the History of Crystals

★Invited Papers

*Hiroharu Yui[1] (1.Tokyo University of Science)

Nucleation of water particles in the mesosphere

*Kyoko Kitakami Tanaka[1,2], Yuki Kimura[3], Ingrid Mann[4]

1. Tohoku University, 2. Nihon University, 3. ILTS, Hokkaido University, 4. UiT the Arctic University of Norway

In the summer polar mesosphere at the altitude of 80-90 km, which is the coldest part of the earth’s atmosphere, small ice particles can form. They are observed from satellites, they form radar echoes observed from ground and they can form a dawn cloud from mid latitudes to the North, referred as a nuctilucent cloud (NLC) [1]. Although the condensed ice particles are known to exist in the high altitude mesosphere, the mechanism of condensation remains uncertain. In this study, we investigate a process of non-equilibrium condensation from dilute water vapor in relation to the origin of the NLCs. The previous study showed that amorphous solid water particles can nucleate homogeneously under conditions in the mesosphere using classical nucleation theory (CNT) [2]. However, it is known that rate predictions of water in the CNT disagree with experimental measurements by several order of magnitude [3]. In this study, we focus on the nucleation process and consider two possibilities of the homogeneous and heterogeneous nucleations. We adopt a semi-phenomenological model for nucleation process which corrects the evaluation of the formation energy of a molecular cluster with the use of the second virial coefficient and agrees with the results of both experiments and molecular dynamics simulations [3-5]. The condensation process depends on the atmospheric conditions such as temperature, pressure, number density of dust grains, and cooling rate. We find that the homogeneous nucleation of water is extremely difficult to occur in the mesosphere. The results show that the number density of dust grains necessary for heterogeneous nucleation is much lower than the observed value for the cooling rate smaller than 0.1 K/s. Our results imply that the heterogeneous nucleation occurs effectively in the upper mesosphere and the dust particles from meteoroids would work as nuclei of heterogeneous nucleation because meteoroids ablate at the high upper altitude in the mesosphere.

[1] T. Antonsen , O. Havnes , and I. Mann, Journal of Geophysical Research: Atmospheres, 122, 12,353, 2017

[2] B. J. Murray and E. J. Jensen, Journal of Atmospheric and Solar-Terrestrial Physics 72, 51, 2010

[3] A.Dillmann and G.E.A.Meier, Journal of Chemical Physics, 94, 3872, 1991

[4] K.K. Tanaka, A. Kawano, and H. Tanaka, Journal of Chemical Physics, 140, 114302, 2014

[5] R. Angelil, J. Diemand, K. K. Tanaka, and H. Tanaka, Journal of Chemical Physics, 143, 064507, 2015

Keywords: water, condensation, nucleation, mesosphere, ice

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Possible new water on an ice III crystal in water

*Hiromasa Niinomi[1], Tomoya Yamazaki[2], Hiroki Nada[3], Tetsuya Hama[4], Akira Kouchi[2], Junpei Okada[1], Nozawa Jun[1], Satoshi Uda[1], Yuki Kimura[2]

1. Institute for Materials Research, Tohoku University, 2. Institute of Low Temperature Science, Hokkaido University, 3. National Institute of Advanced Industrial Science and Technology, 4. Komaba Institute for Science, The University of Tokyo

Ice is an abundant material on the Earth, and its surface plays a crucial role in controlling and catalyzing key chemical reactions governing the environment on the Earth. It is well-known that a wide variety of chemical reactions are governed by the structure and dynamics of interfacial layers on ice surfaces. The nature of the interface between water vapor and ice Ih has been actively debated in the context of a quasi-liquid layer as predicted by Michael Faraday in 1842. These active debates have highlighted the fact that ice surfaces are rich, not only in undiscovered phenomena governing key but obscure chemical processes but also in their underlying physics important for materials science. It is indisputable, therefore, that the elucidation of surface phenomena on ice is highly desirable for a broad range of scientific fields. However, other interfaces between liquid water and ice that are abundant on the Earth and on icy extraterrestrial bodies remain relatively underexplored, despite having an importance comparable with that of the water vapor-ice interface. Here, we investigated the interface between water and high pressure ice III growing/melting in water by in-situ optical microscopic observation. We show that a macroscopic thin layer of “unknown” liquid, separated from bulk water by a clear interface, forms on the water/ice III interface.

Ice III was crystallized from ultrapure water by attaining high pressure condition (~248 MPa) using a symmetric-type sapphire anvil cell (SEED; Syntek Co. Ltd, Yokohama) in a low-temperature room kept at −20°C (Figure 1B). Growth and melting of the ice III crystal in the cell were controlled by compression and decompression of anvil cell, respectively. The dynamics of crystallization/melting of water in the cell was observed in situ by using a polarized-light microscope in the low-temperature room. The microscopic images were recorded in situ by using a CCD camera.

Figure 1 shows the time-lapse micrographs of the faceted ice III crystal grown/melted in compressed water. The surface morphology of one of the faceted crystal face fluctuated in a wave-like manner during the crystal growth, suggesting fluidity of the surface (Figure 1 A ii). On the other hand, slight depressurization caused the formation of numerous partially wetting liquid droplets on the crystal surface (Figure 1 A i). The contrast difference between the wave-like liquid film and droplets on the crystal surface suggests that the wave-like liquid thin layer is thin layer with concave holes. These observation shows that an unknown liquid distinguishable from surrounding bulk water by a clear interface existed on the interface between bulk water and ice III crystal. Moreover, we found that the liquid thin layer exhibited bicontinuous pattern when the compression was stopped (Figure 1B). Bicontinous pattern can be often seen in spinodal-type liquid-liquid phase separation (LLPS) of two kinds of immiscible liquid in two component system, suggesting the unknown liquid is immiscible with water. This immiscibility should originate from the difference of density and liquid structure because of one-component system.

So far, the hypothesis that there exists the liquid-liquid critical point (LLCP) in which water separates into two kinds of liquid −high density liquid (HDL) and low density liquid (LDL)- via LLPS under a low-temperature and high pressure condition has been considered to explain the abnormal thermodynamic properties of water. However, direct observation and confirmation of the LLPS of water has never been achieved because the hypothesized LLCP lies on an experimentally inaccessible condition due to the limit of supercooling. Our observation of the separation of two kinds of immiscible liquid water

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at water-ice III interface may have implications for the long-standing mystery of abnormal properties in water governing the environment on the Earth.

Keywords: Water, High-Pressure Ice, Liquid immiscibility , Interface, In-situ Microscopic Observation

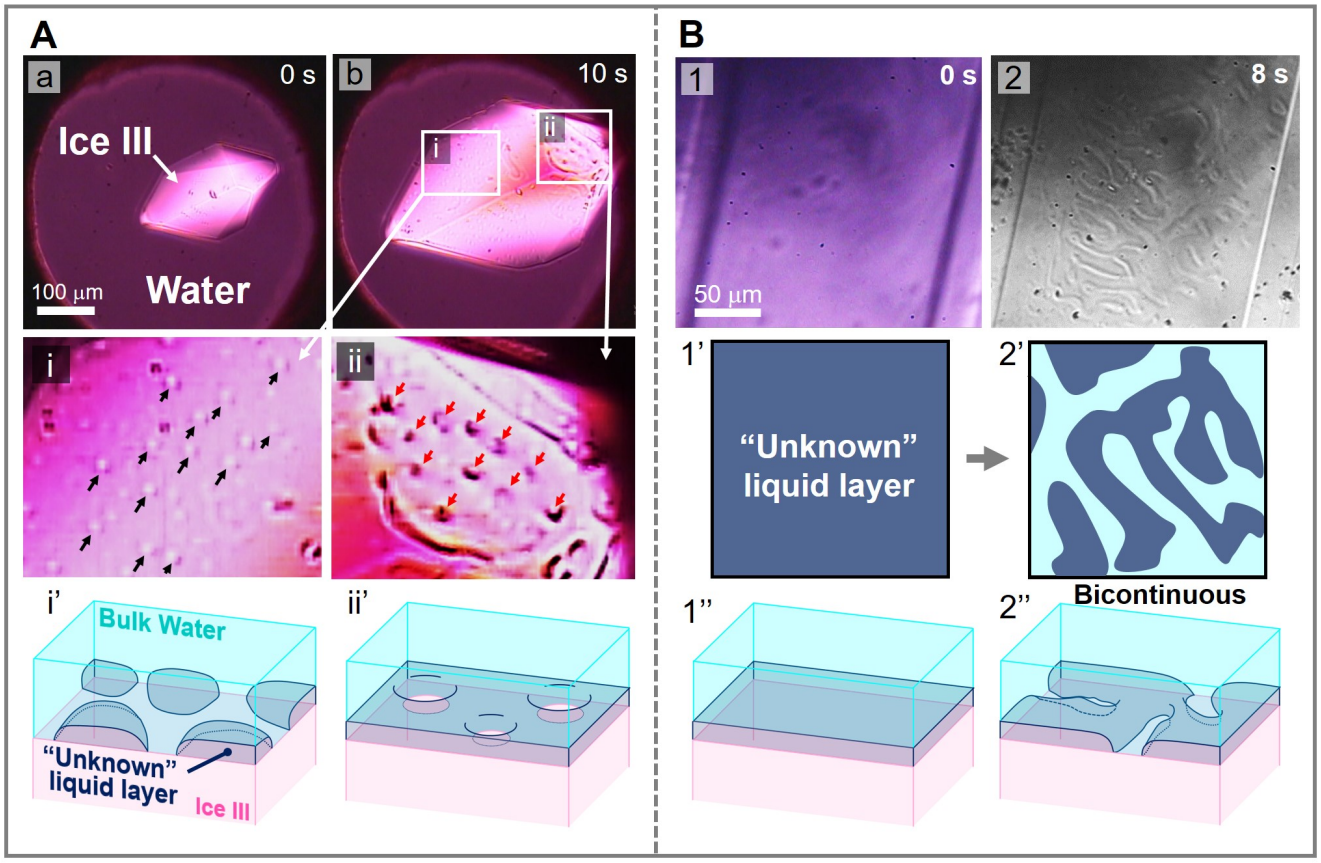

Figure 1 Time-lapse micrographs of in-situ microscopic observation on ice III crystallization from water. (A) the formation of liquid droplet and thin liquid layer of the unknown liquid. (B) the formation of bicontinous pattern of the liquid thin layer. Adopted with modification with permission from {Niinomi, H.; Yamazaki, T.; Nada, H.; Hama, T.; Kouchi, A.; Okada, J. T.; Nozawa, J.; Uda, S.; Kimura, Y. High-Density Liquid Water at a Water–Ice Interface. *J. Phys. Chem. Lett.* **2020**, 11, 6779−6784.} Copyright {2020} American Chemical Society.

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HCl droplets induced bunched steps on ice crystal surfaces under atmospheric-concentration HCl gas

*Ken Nagashima[1], Ken-ichiro Murata[1], Gen Sazaki[1]

1. The Institute of Low Temperature Science, Hokkaido University

Ice is one of the most abundant crystals on the earth, and hence the molecular-level understanding of ice crystal surfaces holds the key to unlocking the secrets of a number of fields. In addition, surfaces of ice act as sites of various chemical reactions of atmospheric acidic gases, which cause serious environmental issues, such as the catalytic ozone depletion by hydrogen chloride (HCl) gas. As a means of direct observation of QLLs on ice surfaces, we and Olympus Engineering Co. Ltd., have developed laser confocal microscopy combined with differential interference contrast microscopy (LCM-DIM), which can directly visualize 0.37-nm-thick elementary steps [1] and QLLs on ice crystal surfaces [2].
Recently, we studied effects of HCl gas (10^2 Pa) on the behavior of QLLs on ice basal faces by LCM-DIM [3-4]. Then we found that the QLLs were not pure water but an HCl aqueous solution, whose HCl concentration was very close to that of a liquidus line of a binary phase diagram of water and HCl. Therefore, the HCl droplets did not disappear and were embedded in ice crystals stably without freezing [4]. However, in our previous studies, we used the HCl gas of 10^2 Pa HCl partial pressure, which is extremely higher than ordinary atmospheric partial pressure of HCl. Here, we show direct observations of ice basal faces by advanced optical microscopy under atmospheric-concentration HCl gases of from 10^{-4} to 10^{-2} Pa. Then, we investigated the appearance/disappearance of liquid water on ice surfaces and their effects on the growth of ice crystals [5].
Under atmospheric-concentration HCl gas, we found that liquid droplets and thin layers appeared/disappeared on the ice basal faces at about -1 ˚C with increasing/decreasing temperatures. These behaviors were similar to those in the absence of the HCl gases. In contrast, at temperatures below -10 ˚C, surprisingly we found that with decreasing temperature, the HCl gases induced the appearance of droplets of an HCl aqueous solution on the basal faces. In addition, the HCl droplets pinned the lateral advancement of spiral steps, resulting in the formation of bunched steps. The HCl droplets were finally embedded in the ice crystals by further growth of the bunched steps. In contrast, with increasing temperatures, the HCl droplets and the bunched steps disappeared at -10 ˚C.
These results indicate that a bulk of an ice crystal plays an important role in the uptake of HCl. So far, it has been believed that the contribution of a bulk of an ice crystal to the HCl uptake is less important than that of an ice surface, because of the small solubility of HCl and the slow diffusion of chloride ions in an ice crystal. Hence, the results found in this study suggest that the uptake of HCl in an ice crystal can be promoted via the bunching and embedding mechanism at temperatures below -10 ˚C. Our findings will give significant insights into various environmental issues caused by acidic gases in polar regions. However, it is crucially important to study whether the similar phenomena occur at -70 ˚C, at which temperature HCl on ice crystals plays an important role in the ozone depletion by the heterogeneous photochemical reactions in polar stratospheric clouds.

[1] Sazaki et al. (2010) PNAS 107, 19702.
[2] Sazaki et al. (2012) PNAS 109, 1052.
[3] Nagashima et al. (2016) Cryst. Growth Des. 16, 2225.
[4] Nagashima et al. (2018) Cryst. Growth Des. 18, 4117.
[5] Nagashima et al., Cryst. Growth Des. submitted.

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We will present this study from other viewpoints in "A-AS05 Atmospheric Chemistry".

Keywords: ice crystal, air-snow interaction, atmospheric-concentration HCl gas, bunched step, HCl uptake, advanced optical microscopy

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Adsorption of nucleotides on clay induced by change in hydration structure by magnesium ion

*Yuki Araki[1], Yoshihiro Furukawa[2]

1. Ritsumeikan University, 2. Tohoku University

Polymerization of nucleotide is an early stage of origin of life on the Earth. It is a dehydration reaction, so there are very few investigations which have succeeded to reproduce the polymerization in liquid environment. However, formation of long-chain oligomers in an aqueous solution in the presence of cations (transition metals, magnesium ion) and clay minerals have been reported [Ferris and Ertem (1992) Science 257, 1387-1389]. We have investigated the effects of impurities on the crystal growth in solution and the hydration structure by frequency modulation atomic force microscopy (FM-AFM). FM-AFM enables us to observe the atomic-scale phenomena and the three-dimensional water distribution at the solid surface *in situ*. So far, we have found that magnesium ions have the effect of disturbing the hydration structure at the calcite surface. This finding provided us an idea that hydrophilic ions such as magnesium instantly and locally induce dehydration of the molecular surface even in the polymerization reaction of nucleotide on the clay surface.

In this study, we carried out *in situ* observation of adsorption of nucleotide oligomers on mica by FM-AFM. All solution were prepared by using RNase free water. A solution of 30 oligomer (1 μg/mL) designed to have a characteristic ring shape as shown in the figure 1 was dropped onto a mica substrate and observed in RNase free water. No adsorbents were found on the mica surface (Fig.2a). Then, a magnesium chloride solution was added so as to be 100 mM. The adsorbate gradually increased on the mica (Fig.2b), and after 1 hour, the surface was almost covered with the adsorbates (Fig.2c). Such changes were not observed with the addition of KCl. These results indicate remarkable effect of magnesium ions on adsorption of oligomers. In the presentation, we will discuss the relation of hydration structure and the oligomer adsorption rate showing the results of changes the adsorption rate by the other cations and the change in hydration structure of mica.

Keywords: Clay, Hydration, Origin of Earth

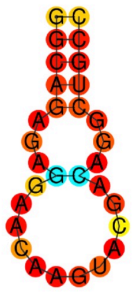

Fig.1 Designed nucleotide oligomer

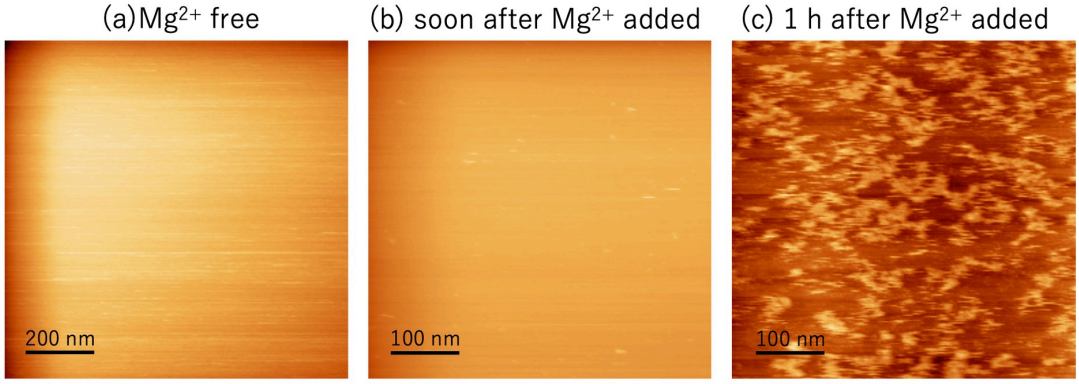

Fig.2 Topographic images of Mica surface in oligonucleotide solution.

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Surface-Selective Vibrational Micro-Spectroscopy Unveils Physicochemical States and the History of Crystals

*Hiroharu Yui[1]

1. Tokyo University of Science

Vibrational spectroscopies, such as infrared (IR) absorption and Raman scattering ones, provide detailed information on the structures, orientations, and environments of the molecules and crystals that we focus on. The merits of these spectroscopies are that they do not require vacuum system and are easy to combine with optical microscopes. These properties provide us an advantage for investigating buried water / material interfaces as well as inhomogeneous material surfaces including water molecules at optional points. Here I introduce some examples of our researches on the surface analyses of crystals utilizing vibrational spectroscopies with combining surface-selective techniques and optical microscopes.

The first example is detecting surface hydroxyl (OH) groups on titanium dioxide (TiO_2) on single crystals. By combining polarization-modulation technique to external reflection IR spectroscopy (PM-ER-IR), we realized surface-selective measurements of OH groups buried under adsorbed water layers in atmospheric condition. We discriminated the surface OH groups from adsorbed water molecules by real-time cancellation of the signals derived from isotopically oriented water molecules. We discuss their binding site on TiO_2 surfaces and the origin of the super-wettability emerged under UV light irradiation.[1)]

The second example is probing the nanoscopic wetting phenomena of water molecules adsorbed on silica (SiO_2) surfaces by combining heterodyne detection technique with surface-selective vibrational sum frequency generation spectroscopy (HD-VSFG).[2)] The heterodyne detection allows us to extract “phase” information of the SFG signals and to obtain “true” absorption spectra with the molecular orientation information. With changing relative humidity (RH%) of the environments and comparing the spectra with those obtained by ATR-IR technique, we clarified inhomogeneous growth of the wetting site on the SiO_2 surfaces, especially under 50 RH %. [2)] We have also applied IR spectroscopic techniques to in-situ & real-time monitoring for the crystallization and the melting of the ice nanocrystals confined in reversed micelles, and the melt structures of triacylglycerol self-assemblies. [3,4)]

The final one is polymorphism discrimination of microcrystals embedded on the surfaces of carbonaceous chondrite meteorites utilizing Raman microscopy. Carbon materials and water molecules in phyllosilicate such as serpentinite are abundantly embedded in carbonaceous chondrites. They are believed to be one of the important origins of carbon atoms and water molecules to the early Earth. By probing the physical and/or chemical states of carbon materials and discriminating the polymorphism of the minerals that bring water molecules, we discussed the origin and the history of various types of carbonaceous chondrites. However, abundant amorphous carbons on them generally emit strong fluorescence, hindering us from discussing slight changes of Raman shift. Now we are considering another type of Raman microscopy utilizing near-infrared (NIR) excitation and/or non-linear Raman scattering techniques to avoid strong backgrounds of the fluorescence and enhance the ability to discriminate slight changes in crystal structures that should carry important information on the origin of the organic carbons and water molecules at the initial stage of the Earth and the solar system.

Acknowledgements
I would like to express my sincere thanks to the research collaborators: Dr. Shu-hei Urashima, Dr.

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Toshinori Morisaku, Mr. Taku Uchida, and Mr. Aruto Kashima (Tokyo University of Science), Dr. Akira Yamaguchi and Dr. Naoya Imae (National Institute of Polar Research), and Dr. Yuki Araki (Ritsumeikan University).

References

1) K. Takahashi & H. Yui, *J. Phys. Chem. C*, **113**, 20322 (2011).
2) S. Urashima, T. Uchida, & H. Yui, *Phys. Chem. Chem. Phys.*, **22**, 27031 (2020).
3) A. Suzuki & H. Yui, *Langmuir*, **30**, 7274 (2014).
4) H. Yui, Y. Isozaki, & T. Morisaku, *Anal. Sci.*, **33**, 75 (2017).

Keywords: vibrational spectroscopy, titanium dioxide, silica, carbonaceous chondrite, surface, water

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Sat. Jun 5, 2021 3:30 PM - 5:00 PM JST | Sat. Jun 5, 2021 6:30 AM - 8:00 AM UTC | Ch.03 Zoom Room 03

[M-IS17] Interface- and nano-phenomena on crystal growth and dissolution

convener:Yuki Kimura(Institute of Low Temperature Science, Hokkaido University), Hitoshi Miura(Graduate School of Science, Department of Information and Basic Science, Nagoya City University), Hisao Satoh(Low-Level Radioactive Waste Disposal Center, Japan Nuclear Fuel Limited), Chairperson:Hitoshi Miura(Graduate School of Science, Department of Information and Basic Science, Nagoya City 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.

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

[MIS17-06] Control of particles by electric field and its applicability in LC-TEM for observing crystallization and dissolution processes

*Tomoya Yamazaki[1], Hiromasa Niinomi[2], Yuki Kimura[1] (1.Institute of Low Temperature Science Hokkkaido University, 2.Institute for Materials Research, Tohoku University)

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

[MIS17-07] Time lapse imaging of pH/ionic concentration distribution for understanding the dissolution/formation process of minerals in aqueous solution

*Jun Kawano[1], Makoto Yazaki[2], Shinji Matsumoto[2], Takashi Toyofuku[3,4], Yukiko Nagai[3,5], Kazuya Ohno[2], Takaya Nagai[1] (1.Faculty of Science, Hokkaido Univ., 2.Graduate School of Science, Hokkaido Univ., 3.JAMSTEC, 4.TUMSAT, 5.NMNS)

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

[MIS17-08] Pore space property of clayey materials in the forms of gelled to compacted: a strategy for designing buffer materials

*Hisao Satoh[1], Yuki Araki[2] (1.Japan Nuclear Fuel Limited, 2.Ritsumeikan University)

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

[MIS17-09] Hidden stability of norsethite revealed by phase diagram

*Harutoshi Asakawa[1], Kaoru Isobe[1], Hiroshi Uneda[1], Itaru Echigo[1], Ryuichi Komatsu[1] (1.Graduate School of Sciences and Technology for Innovation Yamaguchi University)

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

[MIS17-10] Control of defect structure in functional bulk crystals

★Invited Papers

*Harada Shunta[1,2] (1.Nagoya University, 2.PRESTO JST)

Control of particles by electric field and its applicability in LC-TEM for observing crystallization and dissolution processes

*Tomoya Yamazaki[1], Hiromasa Niinomi[2], Yuki Kimura[1]

1. Institute of Low Temperature Science Hokkkaido University, 2. Institute for Materials Research, Tohoku University

Crystallization and dissolution in a solution are quite important not only for generation of new functional materials and protein crystallization, but also for understanding geochemical processes of ubiquitous phenomena on the Earth. Recent advances in microfabrication techniques have made it possible to fabricate liquid cells for observing liquid samples in electron microscopy. This combined technique is called liquid-cell transmission electron microscopy (LC-TEM) and allows us to visualize crystallization and dissolution processes in spatial and temporal resolution of TEM. However, this method is still struggling at observing these processes because decreasing temperature and concentration of sample, which are crucial parameters for crystallization, at observing area is still difficult. To solve this problem, here we focus on the technique of particle manipulation by applying electric field using electrodes in a liquid sample. We expect this technique to increase local concentration (number density) of particles, such as nanoparticles and colloidal particles, in a liquid sample. To introduce this technique into LC-TEM, it is required to develop liquid cells with adequate design for the particle manipulation by electric field. Firstly, we performed experiments using a existing liquid cell with electrodes and optical microscopy to confirm the effectiveness of the manipulation technique for increasing local concentration of nanoparticles in the cells. We used colloids to observe the electromechanics of each particle under electric field by an optical microscopy. In addition, we considered that the efficiency of electric field to control crystallization and dissolution processes of colloidal crystals.

Acknowledgement
This work was supported partly by the GIMRT Program of the Institute for Materials Research, Tohoku University (Proposal No. 20K0038) and JSPS KAKENHI Grant Numbers JP18J01470 and 20H02580.

Keywords: crystallization, electric field, colloid, dissolution, liquid-cell transmission electron microscopy, particle manipulation

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Time lapse imaging of pH/ionic concentration distribution for understanding the dissolution/formation process of minerals in aqueous solution

*Jun Kawano[1], Makoto Yazaki[2], Shinji Matsumoto[2], Takashi Toyofuku[3,4], Yukiko Nagai[3,5], Kazuya Ohno[2], Takaya Nagai[1]

1. Faculty of Science, Hokkaido Univ., 2. Graduate School of Science, Hokkaido Univ., 3. JAMSTEC, 4. TUMSAT, 5. NMNS

Recent works have revealed that growth or dissolution mechanism of minerals in aqueous solution is more complicated than we had imagined. To understand these mechanisms, analyzing the local conditions of the solution around the dissolving or forming minerals is important. Recently, we succeeded in visualizing the distribution of pH around a calcium carbonate crystal dissolving in aqueous solution using a fluorescent probe. However, the ionic concentration is another important factor to describe the formation/dissolution reaction of calcium carbonate. In this study, we attempted to visualize the distribution of Ca^{2+} concentration along with the pH around a dissolving calcium carbonate crystal in aqueous solution.

By simultaneously using HPTS (8-hydroxypyrene-1,3,6-trisulfonic acid) and Rhod-FF as fluorescent probes, pH and Ca^{2+} could be measured independently and their distributions around the dissolving calcium carbonate in an aqueous solution were successfully visualized. Tendencies of their distributions were basically similar, but the pH was found to increase and saturate rapidly just above the surfaces, while the Ca^{2+} concentration changed more slowly and its 2D features seemed to be different from those of pH. Rough estimation of the solution composition just above the surface showed that concentration of bicarbonate ions was comparable with Ca^{2+} concentration, which suggest that bicarbonate ions play an important role in the surface reaction.

Here we will also report the result of pH/ionic concentration imaging for the calcium carbonate formation process in gel media. These results could provide new insights into the knowledge of the dissolution/formation reaction of minerals in aqueous solutions.

Keywords: imaging, calcium carbonate, pH, dissolution

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Pore space property of clayey materials in the forms of gelled to compacted: a strategy for designing buffer materials

*Hisao Satoh[1], Yuki Araki[2]

1. Japan Nuclear Fuel Limited, 2. Ritsumeikan University

Context: Rock and clay are still used as major constructive materials in the modern ages, even for the underground facilities such as radioactive waste repository due to their long-term stability. The chemical and mineralogical robustness of these materials is promised by their low reactivity. Until recently, there are many studies developing the geochemical models to validate the safety of waste disposal, because the repository uses buffer clay barrier and dissolution information of clay is top priority. Direct measurement revealed that dissolution rate of clay is lowered by suppressed surface area as a function of compaction density [1]. Recently, we have successfully formulated the effective ESA as the function of density involving isotropic-nematic transition [2]. Step-interaction also affects the dissolution kinetics [1, 3] by the step-dynamic law [4, 1]. Very recently, we have developed an atomistic scale method to evaluate the surface property of hydration structure on clay in groundwater [5]. These knowledges need to be confirmed for the actual bentonite system.

Methods: Direct comparison between observation and measurement is the most persuasive approach. We used FESEM to observe pores in a clay rock from Tsukinuno mine (Kunimine Industries Co.). The tomographic observation was also made on this clay with micro focus X-ray CT (Fig. 1). Direct dissolution measurement with interferometer and AFM was carried out on a purified separate from same clay rock (Kunipia P) under compaction [4]. We newly applied FM-AFM to visualize electric double layer (EDL) above Stern layer. [6].

Results and Discussion: When we consider that groundwater passes though these pores of the clay-rock underlain at the mine, the pore spaces between clay grains are not only the flow-path but also hydration volume with swelling pressure. The actual space can be simply regarded as restricted by the EDL as well as clay density. Generally, it is understood that the hydraulic conductivity varies as the function of clay density. Recent FM-AFM exhibits that the water-path in the compacted clay is prepared by free space excluded from the EDL [5]. This approach realized that dissolution of clay mineral at the pore space filled with equilibrium groundwater (pH 8) is restricted by the pore size that affects the curvature made of elemental steps, unless the pore size is below ~20 nm. Based on the step-dynamics and hydration structure with EDL, we can give a constraint on evolution of actual pore size during alteration [5]. Clay density can affect not only the exposed area of the grain edge at which dissolution mainly occurs [2], but also the hydraulic property by the variety of EDL in the compacted clay. If the clay contains other secondary minerals such as zeolite or silica (see Fig. 1a), the pore structure can be developed as mixture of inter and intra-grains. Furthermore, from the scope of elemental migration by groundwater like pollution, hydration of the minerals changes their sorption property appeared as partition coefficient, Kd (ml/g) that suppresses contamination.
Consequently, in order to design the clayey buffer materials, (1) grain structure from gel to compacted states, (2) electrochemical property as the EDL, (3) diffusion and dissolution, (4) alteration by nucleation of secondary zeolite, and (5) elemental migration by Kd need to be focused to evaluate water-stopping behavior and elemental retardation in case of damage of the barrier. Such a bottom-up approach with focusing pore space science is necessary for repository safety.

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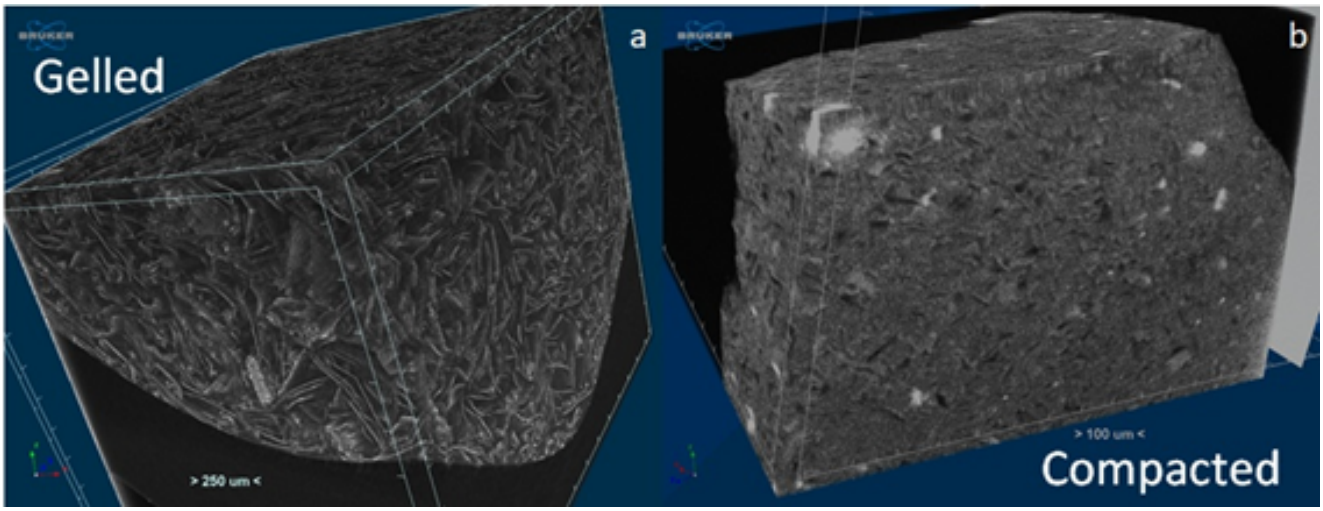
References: [1] Satoh et al. (2013) Clay Min., 48, 285-294.; [2] Terada et al. (2017) Mat. Res. Exp. 6 (3) 035514.; [3] Satoh et al. (2007) Am. Min., 92, 503-509.; [4] Burton et al. (1951) Phil. Trans. Royal Soc. London, 243, 299; [5] Satoh et al. (2019), Abst. Migration 2019; [6] Araki et al. (2017) Surf. Sci, 665 32-36.

Figure 1. Micro XCT images of gelled (a) and compacted (b) montmorillonite clay-stone.

Keywords: clay, pore space, electric double layer: EDL, frequency mopdulation atomic force microscope: FM-AFM, microfocus X-ray computed tomography: micro XCT



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Hidden stability of norsethite revealed by phase diagram

*Harutoshi Asakawa[1], Kaoru Isobe[1], Hiroshi Uneda[1], Itaru Echigo[1], Ryuichi Komatsu[1]

1. Graduate School of Sciences and Technology for Innovation Yamaguchi University

Since the norsethite $BaMg(CO_3)_2$ can be relatively easily synthesized at atmospheric pressure, the utilization of the norsethite is promising as a model crystal for solving the dolomite problem, which is the longstanding mineralogical problems. It is known that the norsethite is formed by the solution-mediated transformation from the $BaCO_3$. Hence, the driving force of the norsethite crystallization corresponds to the difference of solubility between the norsethite and $BaCO_3$. In contrast, our preliminary study has shown a two-step pH change during the dissolution process. When the dissolution of the norsethite started, pH steeply increased owing to the appearance of HCO_3^- at first. Then, pH remained constant. In 20 minutes, pH gradually decreased owing to the appearance of $BaCO_3$, pH, finally, remained constant in 20000 min again. When comparing between the solution-mediated transformation and the two-step dissolution, the inferences based on these results are thermodynamically difficult. This incoherence is resulting in the difficulty of understanding on the formation of the norsethite. Then, we expect that the ratio of Ba^{2+} and Mg^{2+} in an aqueous solution plays an important role in the norsethite crystallization from the difference of cations between the noresethite and $BaCO_3$ from the viewpoint of thermodynamics. In this study, we examined the relationship between the stability of the norsethite and the ratio of Ba^{2+} and Mg^{2+}.

The 100mg norsethite powder was added into 50 ml pure water heated at growth temperature T=40~90^{O}C, and the solution was kept stirring with measuring pH for one month. After the elution, the concentration of Ba^{2+}, Mg^{2+}, and CO_3^{2-} in the solution was evaluated by inductivity coupled plasma optical emission spectrometer and total organic carbon measurement. To confirm the stability of the norsethite, the sample was measured by XRD measurement.
Consequently, a small amount of the $BaCO_3$ appeared from the norsethite powder after the dissolution of the norsethite at more than 60 ^{O}C. In addition, the ratio of Ba^{2+} and Mg^{2+} in the solution became Mg^{2+} rich at less than 70 ^{O}C and Ba^{2+} rich at more than 70 ^{O}C. In contrast, the $BaCO_3$ became undersaturated in the saturated solution of the norsethite at more than 70 ^{O}C. These results demonstrate that the aqueous solution with the norsethite exhibits the saddle point composition, which is more stable than the stoichiometric composition.

Keywords: Norsethite, phase diagram, solution-mediated transformation

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Control of defect structure in functional bulk crystals

*Harada Shunta[1,2]

1. Nagoya University, 2. PRESTO JST

Defects in crystalline materials often govern their physical properties. Therefore, control of defects in crystalline materials, especially in semiconductor materials, is very important. For example, the present electronics is largely depending on silicon as a semiconductor material because dislocation-free silicon crystal is possible to produce by necking technique established by Dash about 60 years ago[1]. In the field of electronics, defects in semiconductor materials are often harmful for electric device and should be eliminated. However, from a different point of view, defects can be regarded as local nanostructure in a perfect crystal, which would express novel new function. For both purpose, it is necessary to understand the structural principle and control the defect structures. In this talk, I will introduce the defect control for functional bulk crystals including ordered arrangement of vacancies in thermoelectric silicide[2,3], reduction of dislocation in silicon carbide for power electronic[4,5] and ordered arrangement of planar faults in titanium oxide natural superlattice for control of thermal phonons toward advanced heat control[6].

References
[1]W. C. Dash, J. Appl. Phys. **30** (1959) 459.
[2]S. Harada et al., Appl. Phys. Express **5** (2012) 035203.
[3]S. Harada et al., Phil. Mag. **91** (2011) 3108.
[4]S. Harada et al., APL Mater. **1** (2013) 022109.
[5]S. Harada et al., Acta Mater. **91** (2014) 284.
[6]S. Harada et al., J. Appl. Phys. **108** (2011) 083703.

Keywords: crystalline defect, dislocation, planr fault, power device, phonon

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Sat. Jun 5, 2021 1:45 PM - 3:15 PM JST | Sat. Jun 5, 2021 4:45 AM - 6:15 AM UTC | Ch.10 Zoom Room 10

[M-IS20] Ocean Plastics, an earth science perspective

convener:Atsuhiko Isobe(Research Institute for Applied Mechanics, Kyushu University), Kiichiro Kawamura(Yamaguchi University), Yusuke Okazaki(Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University), Masashi Tsuchiya(Research Institute for Global Change, Japan Agency for Marine-Earth Science and Technology), Chairperson:Atsuhiko Isobe(Research Institute for Applied Mechanics, Kyushu University)

Mismanaged plastic wastes accounting for 70% of marine debris remain persistently in the marine environment, even if they are degraded and fragmentized to tiny microplastics. To date, it has been unknown how this anthropogenic, buoyant, and persistent matter which was first appeared in the earth history, contaminates (or is incorporated into) the earth system. The ocean plastic study requires the insight and methodology of a variety of earth sciences such as the oceanography, geology, and palaeontology. Studies on the plastic circulation loaded from the land/atmosphere to upper oceans and bottom sediments, studies on microplastics as a proxy of the 'Anthropocene', and studies to establish procedures in monitoring and analyzing macro/microplastics are welcomed.

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

[MIS20-01] Numerical model approach on the fate of pelagic plastics in the world's ocean

*Atsuhiko Isobe[1] (1.Research Institute for Applied Mechanics, Kyushu University)

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

[MIS20-02] Estimating vertical distribution of microplastic particles under wind-driven and Langmuir turbulence by Large Eddy Simulation

*Yoshimasa Matsumura[1], Shin-ichi Ito[1], Chiharu Sasaki[1] (1.Atmosphere and Ocean Research Institute, University of Tokyo)

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

[MIS20-03] Numerical experiment on vertical motion of microplastics with biological processes

*Miho Yoshitake[1], Atsuhiko Isobe[1] (1.Kyushu university)

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

[MIS20-04] Numerical model approach of macroplastic transport to find microplastic sources around the Indonesian archipelago

*Ryohei Kono[1], Atsuhiko Isobe[1] (1.Research Institute for Applied Mechanics, Kyushu University)

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

[MIS20-05] Quantifying the degree of pollution of beaches using an AI technique

*Mitsuko Hidaka[1], Daisuke Sugiyama[1], Daisuke Matsuoka[1], Fumiaki Araki[1], Masafumi Kamachi[1], Yoichi Ishikawa[1] (1.Japan Agency for Marine-Earth Science and Technology)

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

[MIS20-06] Estimation of plastic litter abundance in cities using big data associated with citizen science and deep learning

*Shinichiro Kako[1], Shintaro Kanno[2], Atsuhiko Isobe[3], Masato Kuki[4], Kotaro Yamamoto[4], Fujio Kojima[4] (1.Graduate School of Science and Engineering, Kagoshima University, 2.Faculty of engineering, Kagoshima University, 3.Research Institute for Applied Mechanics, Kyushu University, 4.Pirika, Inc. / Prika association)

Numerical model approach on the fate of pelagic plastics in the world's ocean

*Atsuhiko Isobe[1]

1. Research Institute for Applied Mechanics, Kyushu University

A particle tracking model (PTM) computing behavior of both plastic debris and microplastics in the upper ocean was established. These particles were carried by surface ocean currents provided by an ocean reanalysis product, Stokes drift computed using a wave model driven by satellite-derived winds, and windage. The generating plastic debris was given from river mouths and fisheries worldwide based on the observed data. The PTM includes the processes of beaching/re-drifting, fragmentation from plastic debris to microplastics on beaches, and removal of microplastics from the model domain. These processes proceed on timescales specified in the model. The timescales for beaching/re-drifting were determined by the field experiments, while other two timescales were chosen through trial and error to be consistent with the actual abundance of oceanic microplastics worldwide. To obtain the actual abundance of oceanic microplastics, a total of 8156 pelagic microplastics samples from the world’ s oceans were synthesized to create a dataset composed of raw, calibrated, and processed data. The raw microplastic abundance data were obtained by different research projects using surface net tows or continuous seawater intake. Fibrous microplastics were removed from the calibrated dataset. Microplastic abundance, which fluctuates of microplastic abundance owing to vertical mixing under different oceanic conditions, was standardized in the processed data.
On the basis of the modeled results validated by the observed data, quantities of floating plastic debris, plastic debris washed ashore on beaches, floating microplastics, microplastics on beaches, and removing microplastics from the model domain were computed by reducing the PTM results to a linearized model.

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Estimating vertical distribution of microplastic particles under wind-driven and Langmuir turbulence by Large Eddy Simulation

*Yoshimasa Matsumura[1], Shin-ichi Ito[1], Chiharu Sasaki[1]

1. Atmosphere and Ocean Research Institute, University of Tokyo

While microplastic particles consist of buoyant materials such as polypropylene (PP) and polyethylene (PE) are supposed to be suspended at the sea surface, these can be vertically dispersed in a water column under turbulent condition due to stormy weather and/or severe waves. The vertical distribution of microplastic particles in the open ocean may have strong effect on the frequency of biological removal processes (e.g., aggregation by detritus or ingestion by zooplankton), but is poorly understood particularly under severe condition due to difficulty of direct measurement. In the present study the vertical distribution of microplastic particles in an open ocean surface mixed layer was investigated using an idealized large eddy simulation (LES) model coupled with on-line Lagrangian particle tracking system under various wind and wave forcing.

The numerical code used in the present study is kinaco, a non-hydrostatic ocean model developed in AORI, University of Tokyo. We adopted the filtered structure function (FSF) model for the LES subgrid scheme and the effect of waves was introduced by the vortex-force term. The computational domain is horizontally 128 m x 128 m and vertically 80 m with periodic boundaries. We introduced two categories of plastic particles consist of PP and PE, whose density is set as 910 kg/m^3 and 965 kg/m^3, respectively. The diameter of particles is classified into 10 bins from 10 μm to 5.12 mm, and the buoyant terminal velocity for each size and material is estimated from the empirical formula derived by Kaiser et al. (2019).

The initial stratification is based on the CTD observation carried out around the Tsushima Island in August 2020. The model was forced by surface wind of 0, 5, 10, 20 m/s and wave amplitude of 0, 0.316, 1.0, 3.16 m (total 15 cases), and integrated for 48 hours. The result of each case shows strong dependency of vertical distribution on the particle size but less dependency on the material difference. While almost all particles of greater than 1.28 mm diameter floated at the surface, certain amount of smaller particles were dispersed in the mixed layer. However, no particle was transported below pycnocline even in the severest case with 20 m/s wind and 3.16 m wave amplitude.

To investigate the seasonal variation, we also performed experiments with using monthly stratification of the same location simulated by DREAMS-D ocean forecast system operated by RIAM, Kyushu university. As expected, the vertical distribution of particles has strong dependency on the stratification. In particular, substantial number of particles less than 320 μm diameter reached the domain bottom in the winter season. The result suggests the possibility of physical removal of fine microplastic particles of buoyant material under severe weather condition in winter seasons over continental shelves.

The present simulations also recorded ultraviolet (UV) radiation exposure for each particle. It is suggested that floating plastic debris will be decomposed into finer particles by UV exposure, but finer particles tend to stay underwater for relatively longer period and be protected from UV radiation. The quantitative data provided by the present study may contribute to the estimation of decomposition process of plastic debris in the open ocean.

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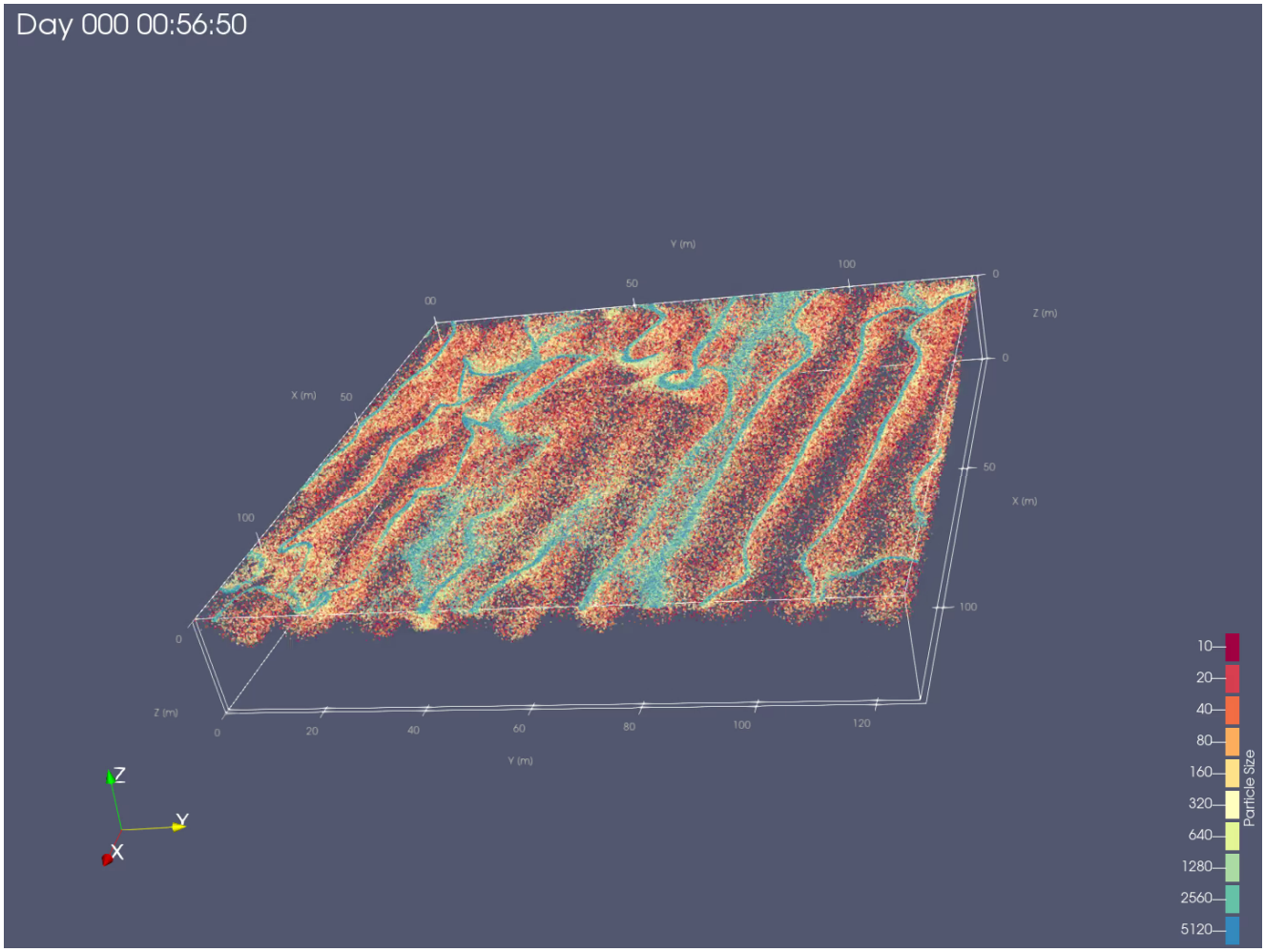
Keywords: Large Eddy Simulation, Langmuir turbulence, microplastic particles



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Numerical experiment on vertical motion of microplastics with biological processes

*Miho Yoshitake[1], Atsuhiko Isobe[1]

1. Kyushu university

Plastic waste has flowed out into the world’s ocean through various routes, and gradually changes to microplastics with sizes are smaller than 5 mm. The relatively large plastics are degraded due to ultraviolet radiation and hydrolysis and are thereafter fragmentized by physical stimuli received from waves and sand on beach. Very small microplastics are easily intruded into various marine organisms, which may be damaged by these plastic debris. To investigate the influences of microplastics on the natural environment, field observations have been conducted worldwide. Although these observations adopted surface net towing to sample microplastics with a density lower than seawater, previous studies suggested that some process actually occurred to transport microplastics vertically downward from the sea surface to deeper layers. One of them is the inclusion into aggregation of phytoplankton, however, there have been not yet quantitative studies showing how the transport by aggregates affects the distribution of microplastics. Therefore, the purpose of this study was to verify the effect of biological processes on the vertical distribution of microplastics by reproducing the horizontal and vertical transport of microplastics with a numerical model with both physical and biological processes. Specifically, the model results were compared with the vertical distribution of microplastics reported by Song et al., (2018), where they collected very small microplastics > 20 micrometers from the sea surface to 1 m above the ocean floor in coastal waters.

Before modeling to reproduce both physical and biological processes, we started with a transport model based only on the physical processes: wind speed, significant wave height and buoyancy of microplastics were given to the model reproducing the oceanic turbulence. From this model, the physical process was sufficient to reproduce the size distribution of microplastics with a particle size range 0.2 to 5 mm at a depth of 5 m from the sea surface as that expected by a theoretical model given by Kukulka et al., (2012). However, particles < 100 μm disappeared from the water column in the observed results of Song et al., (2018), while the disappearance was not revealed in the numerical model which reproduce the vertical distribution in line with a physical mixing. Therefore, it was suggested that this inconsistency with the physical processes is caused by biological processes.

In the model considering both physical and biological processes, we added the aggregation of phytoplankton as a biological process to the above physical model. In this model, the particles representing phytoplankton move by oceanic turbulence, and aggregate to a single particle if they exist within the aggregation radius: aggregation occurs within this distance. Meanwhile, particles representing microplastics will be involved in the aggregated particle when they exist within the aggregation radius, and when the particle size is less than or equal to the aggregates. This model was able to reproduce the vertical distribution of Song et al., (2018), in which microplastics were transported to the seafloor together with heavy aggregates generated by biological processes, and their particle number reached the maximum in the subsurface layer. This indicates that if phytoplankton is present to some extent, the vertical distribution of microplastics will not show the maximum at sea surface, thus biological processes are more important than physical processes to determine the vertical distribution of microplastics. To support this, it was also suggested that these aggregates may have a sinking rate sufficiently large for the vertical velocity typically in the actual ocean. It is noted that the phytoplankton concentration given to this model occurs during spring or autumn bloom and red tide in the actual oceans.

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Keywords: Microplastic, Numerical model, Aggregation

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Numerical model approach of macroplastic transport to find microplastic sources around the Indonesian archipelago

*Ryohei Kono[1], Atsuhiko Isobe[1]

1. Research Institute for Applied Mechanics, Kyushu University

Accordingly to the increase of plastic materials' demand around the world, the amount of plastic garbage has been correspondingly enlarging. This plastic garbage is degraded and thereafter fragmentized to microplastics with size <5mm under the natural conditions such as ultra-violet radiation and waves. However, the areas where microplastics intensely generate are still undiscovered. Additionally, there is a concern that the absorption of toxic substances on microplastic surface is potentially harmful to living marine organisms after ingestion. Therefore, it is urgent to understand how macroplastics from the land sources changes to microplastics in the ocean, and how microplastics thereafter move from these oceanic sources to the marine ecosystem.
In this study, using a particle tracking model, macroplastic releases were given to river mouths around the Asian seas. Thereafter the beaches on which these macroplastics were washed ashore were recognized as potential sources of microplastics under the assumption that the inflow of plastic garbage to the ocean is all converted into microplastics at these potential sources.

Keywords: Microplastic, Particle tracking model, Numerical simulation

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Quantifying the degree of pollution of beaches using an AI technique

*Mitsuko Hidaka[1], Daisuke Sugiyama[1], Daisuke Matsuoka[1], Fumiaki Araki[1], Masafumi Kamachi[1], Yoichi Ishikawa[1]

1. Japan Agency for Marine-Earth Science and Technology

Beached marine litter is harmful to both humans and nature. Monitoring litter on beaches solely through human effort is limiting in terms of both time and expenditure constraints. Establishing technologies that can quantify beached marine litter automatically will contribute to mitigation strategies and scientific understanding of litter. Therefore, we have attempted to develop an AI (Artificial Intelligence) system that can automatically estimate the degree of pollution of beaches using a deep-learning method. The core technology is “semantic segmentation”, which gives pixel-wise classification on images. For the training dataset, pairs of the original image and corresponding labels (ground truth) were prepared. We received monitoring data from the local government (Yamagata prefecture) and prepared the training dataset for the deep-learning model based on these images. For the labels, each region of an image is categorised into eight classes: sky, sea, sand beach, artificial litter, natural litter, installed object, and natural object. Using this dataset, we trained a deep-learning model that can classify an image into the eight classes. The mean IoU (Intersection over Union) between predicted results and ground truth was 76% for all classes. We will present preliminary results from the model, and would also like to discuss the detection of plastic litter.

Keywords: Artificial litter, Beach, Litter monitoring , Artificial Intelligence , Deep-learning , Object detection

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Estimation of plastic litter abundance in cities using big data associated with citizen science and deep learning

*Shinichiro Kako[1], Shintaro Kanno[2], Atsuhiko Isobe[3], Masato Kuki[4], Kotaro Yamamoto[4], Fujio Kojima[4]

1. Graduate School of Science and Engineering, Kagoshima University, 2. Faculty of engineering, Kagoshima University, 3. Research Institute for Applied Mechanics, Kyushu University, 4. Pirika, Inc. / Prika association

In this study, we constructed a deep learning model using training data consisting of litter images in cities collected by citizen science using a smartphone application “Pirika.” Our deep learning model can classify and quantify the amount of litter in cities into various categories (plastic bags, plastic bottles, cans, and others). The model’s accuracies of object detection and classification were 83.0% and 82.9%, respectively. However, these accuracies of the model are guaranteed only under limited conditions and must be improved for practical use. The results of the learning curve shows that there is a limit to learning with the current training data and raises a concern that the model overfits the training data (validation accuracy of 70% and training accuracy of 99%). In future studies, the versatility of the model must be improved by increasing the size of the learning dataset by including various patterns for detection and classification. The smartphone app “Pirika” must also be updated with a function that disallows taking images that might lower the accuracy of our model.

Keywords: citizen science, deep learning, smartphone app “Pirika”, big data, plastic litter abundance in cities

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Sat. Jun 5, 2021 3:30 PM - 5:00 PM JST | Sat. Jun 5, 2021 6:30 AM - 8:00 AM UTC | Ch.10 Zoom Room 10

[M-IS20] Ocean Plastics, an earth science perspective

convener:Atsuhiko Isobe(Research Institute for Applied Mechanics, Kyushu University), Kiichiro Kawamura(Yamaguchi University), Yusuke Okazaki(Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University), Masashi Tsuchiya(Research Institute for Global Change, Japan Agency for Marine-Earth Science and Technology), Chairperson:Kiichiro Kawamura(Yamaguchi University)

Mismanaged plastic wastes accounting for 70% of marine debris remain persistently in the marine environment, even if they are degraded and fragmentized to tiny microplastics. To date, it has been unknown how this anthropogenic, buoyant, and persistent matter which was first appeared in the earth history, contaminates (or is incorporated into) the earth system. The ocean plastic study requires the insight and methodology of a variety of earth sciences such as the oceanography, geology, and palaeontology. Studies on the plastic circulation loaded from the land/atmosphere to upper oceans and bottom sediments, studies on microplastics as a proxy of the 'Anthropocene', and studies to establish procedures in monitoring and analyzing macro/microplastics are welcomed.

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

[MIS20-07] Large-scale distribution and composition of floating plastic debris in the transition region of the North Pacific

*Kentaro Miyazono[1], Rei Yamashita[2], Hiroomi Miyamoto[3], Kazuaki Tadokoro[4], Yugo Shimizu[5], Kazutaka Takahashi[1] (1.Graduate school of agricultural and life science, The University of Tokyo , 2.Atmosphere and Ocean Research Institute, The University of Tokyo , 3.Fisheries Research Agency, Hachinohe, 4.Fisheries Research Agency, Shiogama, 5.Fisheries Agency)

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

[MIS20-08] TARA-JAMBIO Microplastic Mission : Distributions of microplastics in water surface and sediment of Japanese coastal waters

*Kugako Sugimoto[1], JAMBIO Consortium[3], Tara Japan[2], Sylvain Agostini[1] (1.Shimoda Marine Research Center, University of Tsukuba, 2.Tara Océan Fondation, 3.Japanese Association for Marine Biology)

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

[MIS20-09] Distribution of Microplastics in the Deep-sea Sediments

*Tomo Kitahashi[1], Masashi Tsuchiya[1], Ryota Nakajima[1], Rie Matsui[1], Kazumasa Oguri[1,2], Kiichiro Kawamura[3], Yosaku Maeda[1], Sanae Chiba[1], Katsunori FUJIKURA[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.University of Southern Denmark, 3.Yamaguchi University)

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

[MIS20-10] Chemical properties of film coatings developed on microplastics distributed on the urban river shore in Mongolia

*Masayuki Kawahigashi[1], Batdulam Battulga[1] (1.Tokyo Metropolitan University)

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

[MIS20-11] A trial of small microplastics collection by Neuston net

*Haodong XU[1], Haruka NAKANO[1], Tadashi TOKAI[1], Hisayuki ARAKAWA[1] (1.Tokyo University of Marine Science and Technology)

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

[MIS20-12] Non-contact real-time identification of microplastics in flow by combining holography and Raman spectroscopy

*Tomoko Takahashi[1,2,3], Zonghua Liu[2], Thangavel Thevar[4], Nicholas Burns[4], Dhugal Lindsay[1], John Watson[4], Sumeet Mahajan[3], Blair Thornton[2,3] (1.Japan Agency for Marine-Earth Science and Technology, 2.Institute of Industrial Science, The University of Tokyo, 3.University of Southampton, 4.University of Aberdeen)

Large-scale distribution and composition of floating plastic debris in the transition region of the North Pacific

*Kentaro Miyazono[1], Rei Yamashita[2], Hiroomi Miyamoto[3], Kazuaki Tadokoro[4], Yugo Shimizu[5], Kazutaka Takahashi[1]

1. Graduate school of agricultural and life science, The University of Tokyo , 2. Atmosphere and Ocean Research Institute, The University of Tokyo , 3. Fisheries Research Agency, Hachinohe, 4. Fisheries Research Agency, Shiogama, 5. Fisheries Agency

Distribution and composition of the floating plastic debris in the transition region across 4600 km between 141ºE to 165ºW in the North Pacific was investigated to obtain the information of its transportation process from coastal area of Asian continent to central/eastern subtropical Pacific based on the samples collected by a neuston-net for pre-season survey of Pacific saury. The concentration and composition in terms of size, colour, shape and polymer type (determined with a Fourier transform infrared spectrophotometer) were determined for 77 stations and those data were analyzed in relations to the oceanographic parameters including water temperature, salinity, and current flow pattern on sea surface. In the study area, on average, 152,762 ±459,807 pieces km^{-2} of floating plastic debris was found, with a maximum of 3,914,195 pieces km^{-2} and distribution was primarily influenced by the current system but the process to generate the high concentration area seemed to be different between western and eastern area of the transition region. In the west of 180º, floating plastic debris largely accumulated around convergent in the nearshore area and transported by eddies and quasi-stationary jet to the subarctic region. Furthermore, in addition to the effect of Stokes drift, floating plastic debris retained by the anti-cyclonic eddies (warm core rings) may be kept remained within the coastal area due to its westward migration. Meanwhile some plastics like styrene foam and lines seems to be selectively eliminated from water column and decrease towards offshore. The average of the western area (68,575 ± 74,734 pieces km^{-2}) was 15 % higher than previously reported value in 1989, suggesting the possible increase of plastic debris during this 30 year. In the east of 180º, floating plastic debris accumulated in the calm water area corresponds to the downstream of the Kuroshio Bifurcation, a northern branch of the Kuroshio Extension. The concentration (505,032±991,989 pieces km^{-2}) was considerably higher than in the western area, implying that the heavily polluted area of floating plastic debris in the central subtropical North Pacific is larger than our prediction. The high concentration seemed to be related with intensification of surface accumulation of small-sized transparent film caused by calm weather condition in this area, suggesting the importance of further investigation focusing on small-sized plastic (< 1mm) including film type in the subsurface depth in the subtropical central/eastern Pacific.

Keywords: Microplastics, the North Pacific Ocean, Kuroshio/Kuroshio Extension

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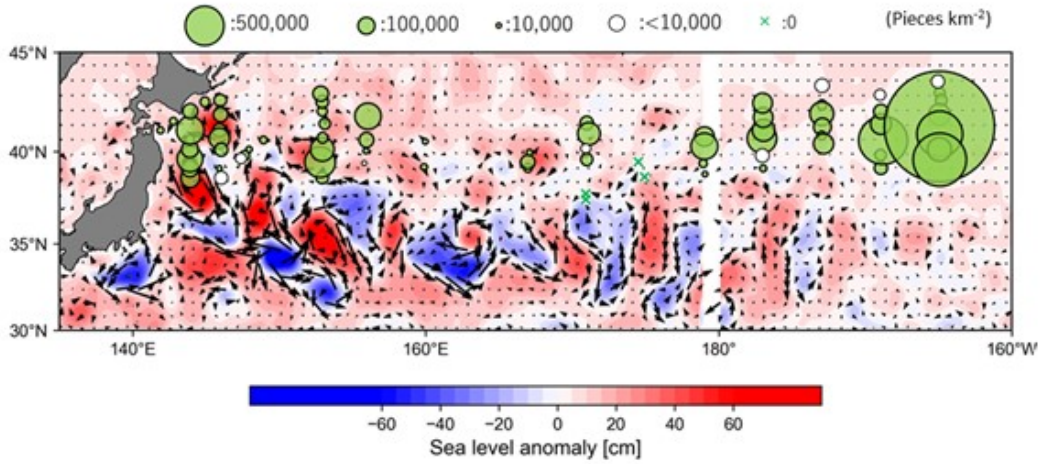

Fig.1. Sea level anomaly and current with plastic debris distribution

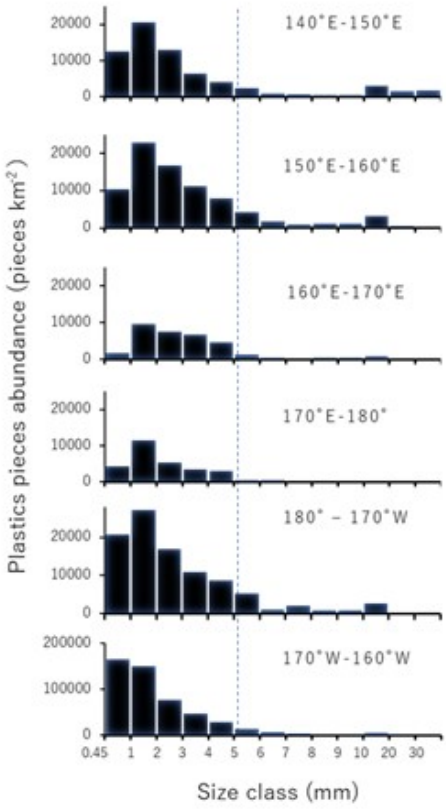

Fig. 2. Longitudinal variation of size distribution of plastic debris in the transitional zone of North Pacific in June, 2016. Note that scale unit of y-axis of 170° W-160° W is 10-fold higher than others.

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TARA-JAMBIO Microplastic Mission : Distributions of microplastics in water surface and sediment of Japanese coastal waters

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1. Shimoda Marine Research Center, University of Tsukuba, 2. Tara Océan Fondation, 3. Japanese Association for Marine Biology

The Tara Océan Fondation is deidcated to the world’ s ocean and collaborates with scientific partners to organise scientific expeditions, raise awareness and educate, mobilize policy makers at the highest level, and enable emerging and developing countries to access the latest knowledge about the ocean. From 2020, the fondation partnered with the JAMBIO, the network of japanese marine stations to start a joint mission on microplastic pollution in japanese coastal waters. Due to their small size, microplastics cannot be fully retrieved from the ocean once they enter it and may cause damage to marine ecosystems and the organisms that ingest them. However there is still an important lack in the knowledge on the quantity, the sources and fluxes of microplastic in the ocean. The mission has two aims: 1) to assess the microplastic pollution in surface waters and sediment of Japanese coasts, the fluxes of microplastics from rivers and bays, and the microbial communities on the plastic fragments, the “plastisphere”; 2) to raise awareness of plastic pollution, promote a reduction in the use of plastic and generally inform on the threats that the ocean is facing due to human activities. A first sampling and outreach mission was conducted at six marine stations in West Japan. Namely sampling were performed at the Ushimado Marine Institute (Okayama University), the Takehara station (Hiroshima University), the Oki Marine station (Shimane University), the Amakusa Marine Station (Kyushyu University) and the Sugashima Marine Biological Laboratory (Nagoya University). Surface water were sampled using a Neuston net and sediment using a Smith McIntyre Sediment Grab. Microplastics were (300 –5000 μm) extracted using density separation following the degradation of organic materials by peroxide oxidation. For the plastisphere study, microplastic fragments were sampled under the microscope immediately after the sampling. Sampling was conducted in each station at a river mouth, within a bay and outside a bay, in order to assess the horizontal fluxes. Samples are now being analyzed but all surface waters visibly contained microplastic fragments. Outreach activities were also conducted at each location. Moreover a local artist also participated to the sampling and each artists produced a piece of art. Collaboration with artists has been an outreach approach used in all Tara expeditions and allow to reach a new public. The next sampling mission in East Japan is being organized for 2021.

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Distribution of Microplastics in the Deep-sea Sediments

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Marine plastic pollution is of global concern, and one of the Sustainable Development Goals (SDGs) set by the United Nations includes the reduction of marine pollution, including plastic, as one of its targets. Plastics are miniaturized by ultraviolet light and waves, and especially those particles smaller than 5 mm are called microplastics (MPs), and there are concerns about their adverse effects on marine organisms. It is an urgent issue to understand the actual status of MP pollution in the ocean, and it is essential to identify the sources and routes of plastic spills in order to properly regulate plastics and take measures against marine outflow.

MPs exist not only in the sea surface and water column, but also in sediments Especially, they are accumulated at the bottom of ocean trenches. In this study, we focused on the possibility of MPs transport from Sagami Bay, which has the largest population density in Japan in its hinterland, to the plate triple junction. We compared the number of MPs in the sediments of Sagami Bay and the triple junction to examine the transport process of MPs from the bathyal to the hadal zone.

Sediment samples at two stations of Sagami Bay (St. 1: off Hatsushima, 855 m water depth; St. 2: center of the bay, 1,387 m water depth) and at two stations of triple junction (St. 4, 9,218 m water depth; St. 5, 9,232 m water depth) were collected with push corers manipulated by the HOV *Shinkai 6500* and a free-fall camera system, respectively, during the research cruise of R/V *Yokosuka* YK19-11. Sediment samples were subjected to specific gravity separation using sodium iodide (NaI), dissolution of calcium carbonate using hydrochloric acid, and dissolution of organic matter using Fenton treatment to separate MPs from the sediment. The separated MPs were stained with Nile Red and observed and counted under a fluorescence microscope.

The results shows that the number of MPs per dry weight of sediment at the sediment surface (0-1 cm) was 25.5±19.3 MPs/g at St. 1, 67.5±14.7 MPs/g at St. 2, 26.6±0.05 MPs/g at St. 4, and 48.8 MPs/g at St. 5, respectively. The highest number of MPs was detected in the center of Sagami Bay, while the same level of MPs as those in Sagami Bay was detected at the two stations at the plate triple junction, which are far from human activities. In addition, no particles larger than 250 μm in diameter were detected at the two stations of the plate triple junction, and the average diameter tended to be smaller than that of the two stations in Sagami Bay. These results suggest that the MPs at the plate triple junction are transported through the submarine canyons, and that size fractionation of MPs occurs during the transport process. In the future, we plan to analyze the accumulation and depositional processes of MPs in more detail by using micro-Fourier Transform Infrared Spectroscopy (μ-FT-IR) to identify the types of plastics and by dating of the sediments.

Keywords: Microplastic, Deep-sea floor, Trench

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Chemical properties of film coatings developed on microplastics distributed on the urban river shore in Mongolia

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Plastics released into environment are deteriorated by solar radiation, physical impacts and freeze-thaw cycles, resulting in increase in surface areas of microplastics accompanied by reaction with pollutants. The reactivity of plastics can also be altered by organic matter coating which mainly mediated by microbial activity. Plant residues and minerals participated to the surface coating can induce various reaction on the surface. Environmental conditions where plastics reside also characterize the surface coating of plastics. Composition of plastic coatings can record the fate of plastics after release into environment. This study targets the surface coating of plastics by spectral analyses.

Samples of microplastics were polystyrene foams collected on a river shore along the Tuul River in Ulaanbaatar, Mongolia. Polystyrene foams, which were dominant plastics in the study area, distribute widely from the upper to lower stream. Those polystyrene foams have reached to the present positions through various processes, resulting that some are broken into numerous pieces with different color and others are probably well aged. Components consisting of the coating on the polystyrene surface were evaluated by a micro-FTIR spectroscopy. The differences in spectra between intact and digested surfaces of polystyrene were considered as spectra from the surface coating of polystyrene. IR absorptions at specific wavenumbers were statistically analyzed by the principal component analysis for classification of types of coatings.

Most of absorption peaks were assigned as characteristic organic functional groups mainly consisting of microorganisms, fragments of arthropods and plant debris derived from ligno-cellulose. Contribution of the assigned organic constituents were diverse in various coatings on polystyrenes which distributed in different environments. The nitrogen containing functional groups such as amino residues and peptides coupling with carbonyl groups strongly contributed to PC1 and classified polystyrene foams well. Polystyrene foams coated with living or dead microorganisms can be separated by PC1. The second principal component was characterized by lignin moieties consisting of aromatic rings with carbonyl stretching vibration, indicating that positive scores mean participation of plant residues into the surface coating developed on polystyrene distributed a dry shore region covered with vascular plants. The collected information from organic coatings explained the status of polystyrene foams under several different environmental conditions.

Keywords: biofilm, polystyrene foam, composition of organic substances, N containing functional groups, micro-FTIR

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A trial of small microplastics collection by Neuston net

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1. Tokyo University of Marine Science and Technology

Introduction:

The most efficiently as well as widely used sampling method for microplastics is neuston net due to its easy maneuverability, which normally has mesh size around 350μm. Therefore, researchers could be able to estimate the abundance and distribution of microplastics of the sea area. However, the contamination of small microplastics (less than 350μm) in the ocean cannot be researched and known because small microplastics escape from mesh. It is considered that the small microplastics perhaps cause more harm to the ecosystem and marine organism. Thus, we need to research on small microplastics urgently and systematically.

In this study, double neuston net (interior mesh size: 350μm; exterior mesh size: 50μm; 2 cod ends, Rigo Co. Ltd) and normal neuston net (mesh size: 350μm, Rigo Co. Ltd) were used to sample both the large microplastics (>350μm) and the small microplastics (50μm-350μm). Further, the aims of this study examined collecting method of the small microplastics and revealing the pollution of small microplastics in the sea area.

Materials and Methods:

Two observations were accomplished on 2020, in which, the fist observation containing 2 stations (Station 1, Station 2) was complemented from Nov. 9-Nov.11 in Tokai off the sea area, Japan, by T/V Shinyo Maru (986t, 64.6m) of Tokyo University of Marine Science and Technology (TUMSAT), the second observation containing 2 stations (Station 3, Station 4) was conducted on Dec. 12 in Tokyo Bay by T/V Seiyo Maru (170t, 35.5m) of TUMSAT.

Both neuston nets were equipped with flow meter. Moreover, tow speed, tow time were set to 1 knot of log speed, 10 minutes, respectively. Additionally, 2 samples can be obtained by double neuston net at one time. After sampling, samples were kept at refrigerator on cruise then transferred to laboratory. As to samples from 350μm-mesh neuston net, they were processed in a sequence of wet peroxide oxidation (WPO), density separation, picking up, microscope-based morphology recording, FTIR-based (Fourier-Transform infrared spectroscopy) spectrum measuring. On the other hand, the procedures of samples from 50μm-mesh neuston net were as same as 350μm-mesh neuston net samples until density separation, and the samples were filtrated by PTFE filters and the filters were scanned by μFTIR.

Results:

The concentrations of normal neuston net are 0.28 pieces/m^3 in Station 1, 0.11 pieces/m^3 in Station 2. Comparatively, double neuston net with 350μm mesh has the concentrations of 0.38 pieces/m^3 in Station 1, 0.10 pieces/m^3 in Station 2. No significant difference was found between these two neuston net. Yet, double neuston net with 50μm mesh has definitely higher concentration than those with 350μm, with the values of 15205±1288 pieces/m^3 in Station 1, 3389±1315 pieces/m^3 in Station 2.

As to the categories, PE (25.9%), PP (7.1%), PA (4.5%), PS (23.2%), PET (8.0%) have high percentage of large microplastics, while ‘others’ only account for 8.9%. By comparison, PE (5.4%), PP (1.5%), PA (1.5%), PS (0.2%), PET (1.9%) are all the minorities while ‘others’, including PolyHexadeculethylene, PolyOctadecylacrylamide, plastics additives etc., take a large proportion (74.2%) of small microplastics.

Particles within 50μm~60μm have the peak concentration in the particle size distribution. Besides, the particle concentrations decrease with increasing size. Therefore, it could be concluded that particles below 50μm have the higher concentration compared to particles above 50μm.

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Keywords: Small Microplastics, Neuston Net

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Non-contact real-time identification of microplastics in flow by combining holography and Raman spectroscopy

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Hundreds of millions of tons of plastic waste are generated, and millions of tons enter the ocean every year [1]. “Microplastics”, with the size of less than 5 mm, become coated with biofilms, get attached to other particles, or ingested by microorganisms while floating in the ocean, and transported to all parts of the oceans. The global awareness of pollution in marine and other aquatic environments by microplastics has risen recently [2]. While spectroscopic techniques such as Fourier transformed infrared and Raman spectroscopy have been widely used for identification of plastics collected from aquatic environments, these are time-consuming due to the need for separation from other organic and inorganic particles, filtration, and long measurement time [3]. In this work, a novel method for non-contact fast identification of microplastics suspended in water was investigated.

An integrated method of holography and Raman spectroscopy for *in situ* real-time monitoring of microplastics is reported. Polystyrene (PS) and poly(methyl methacrylate) (PMMA) pellets with a size of 3 mm located in a 20 cm water channel were illuminated using a collimated continuous wave laser beam with a diameter of 4 mm and wavelength of 785 nm. The same laser beam was used to take a holograms for size and shape information, and produce a Raman spectrum for composition information of the suspended material. By the proposed method, PS and PMMA beads in a large water volume were successfully identified using a compact setup [4]. We have also demonstrated classification of particle types by this combined morphological and chemical analysis. While particles with distinctive shapes, such as plankton, can be easily identified by holography, chemical analysis by Raman measurements is necessary for some particles as shown in the Figure. Corresponding Raman peaks of the materials are observed in the Raman spectra of plastic pellets of PS and PMMA. Inorganic matter (Foraminifera) shows a $CaCO_3$ peak and other peaks that match Raman peaks taken for the same sample in air as a ground truth. While no obvious Raman peak is observed in the spectrum of organic matter (paste of replicated marine snow), a broad fluorescence peak is seen.

The proposed method demonstrates the potential for non-contact continuous *in situ* monitoring of marine particles, including microplastics, suspended in water without the need for collection/extraction. It is particularly promising for long-term measurements in deep-water columns, where the particle density is extremely low. The concept of the measurement process using the system is the following: holographic images are continuously captured in an open measurement chamber with a high frame rate to detect a particle. When a particle is detected, the chamber is closed to trap the particle and a Raman measurement is initiated (which takes several tens of seconds, but can be faster using higher power lasers). After the Raman measurement, the chamber is opened again and onset of holographic imaging waits for the next particle. The whole measurement process can be fully automated, which makes it possible to deploy the system on an autonomous platform such as autonomous underwater vehicles and buoys. This could be game-changing for current sampling-based analysis and will contribute to the understanding of global-scale microplastic pollution in aquatic environments.

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References:

[1] J. Jambeck, R. Geyer, C. Wilcox, et al., Science (2015); **347**, 768–771.

[2]T. Galloway, C. Lewis, Curr. Biol. (2017); **27**, R445-R446.

[3] W. J. Shim, S. H. Hong, S. E. Eo, Anal. Methods (2017); **9**, 1384-1391.

[4] T. Takahashi, Z. Liu, T. Thevar, et al., Appl. Optics (2020); **59**, 5073-5078.

Keywords: Microplastics, Monitoring , Holography, Raman spectroscopy

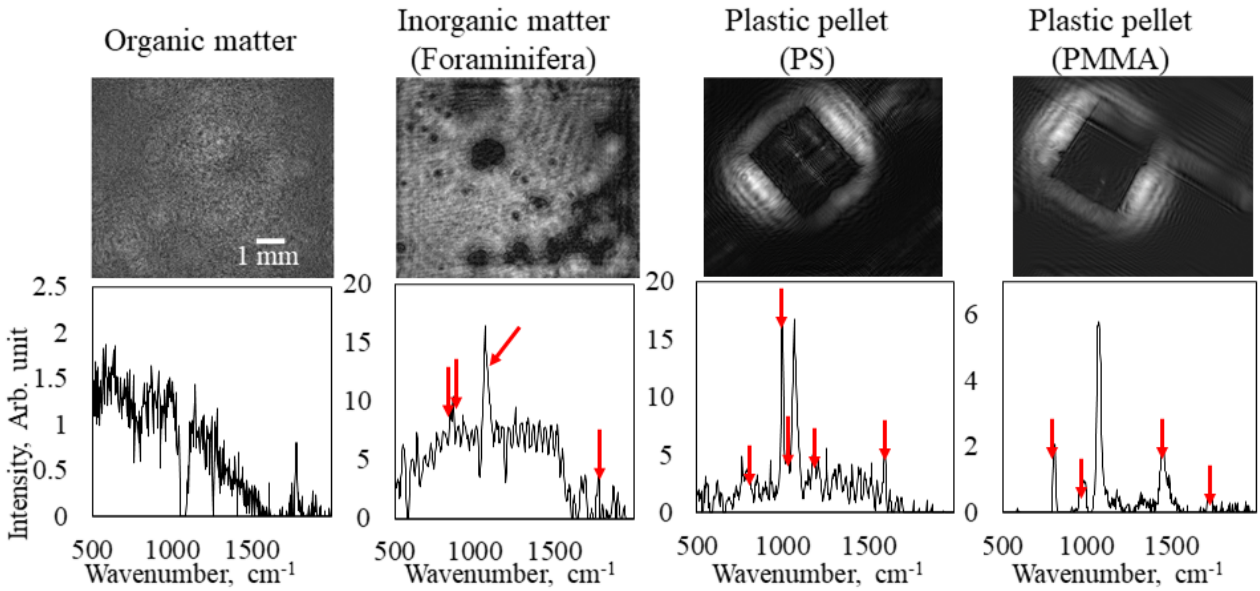

Figure: Holographic images and Raman spectra obtained for organic matter, inorganic matter, and two different types of plastic pellets. The red arrows indicate corresponding peaks of the materials.

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[J] Oral | M (Multidisciplinary and Interdisciplinary) : M-IS Intersection

Sat. Jun 5, 2021 1:45 PM - 3:15 PM JST | Sat. Jun 5, 2021 4:45 AM - 6:15 AM UTC | Ch.26 Zoom Room 26

[M-IS28] Evolution of Pelagic Realm

convener:Atsushi Matsuoka(Department of Geology, Faculty of Science, Niigata University), Toshiyuki Kurihara(Graduate School of Science and Technology, Niigata University), Junichiro Kuroda(Department of Ocean Floor Geoscience, Atmosphere and Ocean Research Institute, the University of Tokyo), XIN LI(State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences), Chairperson:Atsushi Matsuoka(Department of Geology, Faculty of Science, Niigata University), Junichiro Kuroda(Department of Ocean Floor Geoscience, Atmosphere and Ocean Research Institute, the University of Tokyo)

This session focuses on the evolution of ecosystem and physical-chemical environments in the pelagic realm, including discussions on all aspects of pelagic biota covering evolution, biostratigraphy, biochronology, and biogeography, which are important to the reconstruction of the spatiotemporal framework in the pelagic realm. Reconstructions of plate configuration through time are included in the scope of this session. Biological, geochemical, and sedimentological approaches to the pelagic environments are welcomed. Science on form encompasses everything from plankton to outer space. We will discuss the evolution of the Panthalassa-Pacific Ocean since the scientific research vessel JOIDES Resolution comes back to the Pacific in 2023-2024.

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

[MIS28-01] Toward a global correlation of the Jurassic–Cretaceous boundary among pelagic, neritic and terrestrial sequences in the Pacific and Asia

*Atsushi Matsuoka[1] (1.Department of Geology, Faculty of Science, Niigata University)

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

[MIS28-02] **Early Cretaceous anti-tropical radiolarians of from Tibet at the breakup timing of Gondwana**

*XIN LI[1], Noritoshi Suzuki[2], Peter Baumgartner[4], Atsushi Matsuoka[3] (1.State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, 2.Institute of Geology and Paleontology, Gradute School of Science, Tohoku University, 3.Department of Geology, Faculty of Science, Niigata University, 4.Institut des sciences de la Terre, Université de Lausanne)

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

[MIS28-03] Repeated organic-rich deposition in Early Triassic pelagic deep Panthalassa and its relationship with global seafloor anoxia

*Shun Muto[1] (1.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology)

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

[MIS28-04] Marine Os isotope record from the uppermost Barremian to the lowest Turonian

*Hironao Matsumoto[1], Rodolfo Coccioni[2], Fabrizio Frontalini[2], Kotaro Shirai[1], Junichiro Kuroda[1] (1.Atmosphere and Ocean Research Institute, the University of Tokyo, 2.University of Urbino)

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

[MIS28-05] Depositional ages of multiple REY peaks in deep-sea sediments around Minamitorishima Island based on osmium isotope stratigraphy

*Yuta Oda[1], Junichiro Ohta[1,2], Erika Tanaka[1], Kazutaka Yasukawa[1,2], Yusuke Kuwahara[1], Moei Yano[2,1], Koichiro Fujinaga[2,1], Kentaro Nakamura[1], Yasuhiro Kato[1,2] (1.School of Engineering, The University of Tokyo, 2.ORCeNG, Chiba Institute of Technology)

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

[MIS28-06] Depositional environments of the Late Cretaceous REY-rich mud in the western North Pacific Ocean inferred from deep-water agglutinated foraminifers

*Kondo Yuta[1], Junichiro Ohta[1,2], Kazutaka Yasukawa[1,2], Kentaro Nakamura[1], Koichiro Fujinaga[2,1], Yasuhiro Kato[1,2] (1.School of Engineering, The University of Tokyo, 2.ORCeNG, Chiba Institute of Technology)

Toward a global correlation of the Jurassic–Cretaceous boundary among pelagic, neritic and terrestrial sequences in the Pacific and Asia

*Atsushi Matsuoka[1]

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The decision of the Global Boundary Stratotype Section and Point (GSSP) of the Jurassic–Cretaceous boundary (JKB) is one of urgent tasks because the JKB is the last system boundary without stratotype in the Phanerozoic. The previous Berriasian Working Group (BWG) in the International Subcommission on Cretaceous Stratigraphy (ISCS) decided to use the base of the *Calpionella alpina* Subzone as the primary marker and proposed the Tre Maroua section in south France as the candidate for the GSSP of the Berriasian Stage in 2019. However, the ISCS did not support this proposal as the result of ballot by the voting members. Upon this situation, a new working group was organized in December 2020. The new chairperson is Jacek Grabowski in the Polish Geological Institute. The author (AM) is one of the BWG members (20 in total) and is expected to review radiolarian biostratigraphy and to provide new data from the pelagic sequences especially in the Pacific and Asian regions. Aims of the current BWG are to choose the primary marker and to propose the GSSP candidate for the base of the Berriasian Stage. Continuous sequences in the pelagic realm have a great potential for clarifying tie points among biostratigraphy, chemostratigraphy, magnetostratigraphy and any stratigraphies. This presentation introduces ongoing activities of the BWG including a global correlation among pelagic, neritic and terrestrial sequences in the Pacific and Asian regions around the JKB. A new proposal for deep-sea drilling in the western Pacific is also presented.

Keywords: Jurassic-Cretaceous boundary, International Subcommission on Cretaceous Stratigraphy, Berriasian Working Group, Global Boundary Stratotype Section and Point , deep-sea drilling, radiolaria

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Early Cretaceous anti-tropical radiolarians of from Tibet at the breakup timing of Gondwana

*XIN LI[1], Noritoshi Suzuki[2], Peter Baumgartner[4], Atsushi Matsuoka[3]

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The Yarlung–Tsangpo suture zone, which contains remnants of the ancient Neotethys Ocean, marks the tectonic boundary between Eurasia and India. South of the suture lies the Tethyan Himalaya, composed of sedimentary and volcanic rocks. Early Cretaceous marine sediments preserved in the northernmost Indian passive margin contain abundant radiolarians. Coeval radiolarian faunas and their paleobiogeographical affinities from the southern Tibet and Argo Basin have the potential to elucidate the northern extent of Greater India and the breakup of East Gondwana.

Parvicingulids, which are useful indicator of mid- to high-latitude deposition during the Jurassic to the Early Cretaceous, are common from radiolarians in southern Tibet and Argo Basin. However, the antitropical distribution of Parvicingulids have not been systematically analysed and their paleobiogeographical implications are still unclear. The locations, sedimentary setting, age assignment of species belong to Parvicingulidae are summarized to elucidating the time of their origin and, accordingly, outline how their antitropical distribution developed.

Tethyan species dominant in Gyangze during the Berriasian to Valanginian (145–132 Ma) indicate the deposition position of paleobiogeographical Tethyan Province. The change of radiolarian assemblages in Gyangze from Tethyan species dominant to Parvicingulids dominant occurred around Valanginian (140–130 Ma). The occurrence and dominance of Parvicingulids at Gyangze around 140–130 Ma indicate a later influx of southern paleolatitude origin circumantarctic current to the west. The influx of circumantarctic current transported to Zhongba around 130–125 Ma and the influence became weaker according to the dominance of Tethyan species with low abundance and diversity of Parvicingulids. Wide distribution of Parvicingulids in West Timor (Munasri and Sashida, 2017), Gyangze, Kangma, and Zhongba around 130 Ma corresponds to the breakup at 130 Ma and the Greater India’ s anticlockwise rotation from 136 to 120 Ma.

References:

Munasri and Sashida (2017) Earth Evolution Sciences, **12**, pp. 3-12

Keywords: Early Cretaceous, Parvicingulids, antitropical distribution, Gandwana

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Repeated organic-rich deposition in Early Triassic pelagic deep Panthalassa and its relationship with global seafloor anoxia

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Deep-sea sedimentary rocks deposited in pelagic Panthalassa during the Early Triassic are characterised by the presence of black organic-rich claystone and the general absence of radiolarian chert. This was considered to be a result of one of the most extensive episodes of oceanic oxygen depletion in the Phanerozoic. However, while oceanic anoxia repeatedly occurred throughout the Early Triassic according to studies on peri-continental sections, black claystone deposition in pelagic Panthalassa was thought to be restricted to earliest Triassic times.

In this study, the lithostratigraphy, conodont biostratigraphy and chemical composition are investigated for the Lower Triassic sedimentary sequence deposited in pelagic deep-water areas of Panthalassa with some new data for the upper part (upper Olenekian). Sedimentation rates and major element compositions of upper Olenekian to lower Anisian strata support published findings that the absence of chert is a consequence of increased clastic input while there is no apparent evidence of radiolarian extinction due to oceanic anoxia. Correlation of several sections from the Jurassic accretionary complex of Japan based on conodont biozonation reveals that the deposition of extensive black claystone occurred in the Induan, early Spathian (early late Olenekian) and across the Olenekian–Anisian boundary. Though a complete assessment is pending, sedimentary and geochemical evidence of anoxia in the water column and bottom waters have been obtained from the black claystone lithofacies. Conodont biozonation and stable carbon isotope curves allowed the correlation of the lithostratigraphy of pelagic deep Panthalassa and uranium (U) isotope records from shallow-marine carbonate, the latter of which is used as a proxy of the areal extent of anoxic seafloor on the global scale. Results showed that organic-rich deposition in pelagic Panthalassa was generally coeval with episodes of expanded anoxic seafloor, although the two phenomena are decoupled in Smithian (early Olenekian) times. This implies that the deposition of black organic-rich claystone in pelagic deep Panthalassa reflects global trends in the spatial extent of bottom water anoxia during the Early Triassic, probably controlled mainly by nutrient input to the oceans. Black claystone lithofacies straddling the Olenekian–Anisian boundary is particularly important, because it represents the first finding of a laterally extensive deposit associated with oceanic anoxia during this time interval.

Keywords: Black claystone, chert gap, siliceous claystone, total organic carbon, stable carbon isotope, conodont

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Marine Os isotope record from the uppermost Barremian to the lowest Turonian

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Mid-Cretaceous is characterized by repeated episodic phases of organic-carbon burial in various oceanographic settings (oceanic anoxic events: OAEs) and following marine biotic crises. Since the radiometric ages of huge basaltic plateaus called large igneous provinces (LIPs) roughly correspond to these environmental perturbations, the massive volcanic eruptions associated with the emplacement of LIPs have been proposed as the trigger of the mid-Cretaceous environmental perturbations. Indeed, the volcanic gases released from these LIPs eruptions could have played an important role to sustain the warm, high-pCO_2 mid-Cretaceous climate. Recent studies on sedimentary Os isotopic records have provided evidence suggesting their linkages. Marine Os isotopic ratios ($^{187}Os/^{188}Os$) reflect the balance between radiogenic Os from the continental crust and unradiogenic Os sources (e.g., hydrothermal activity, weathering of the basaltic plateau, and meteorite impact). During Early Aptian OAE1a and end-Cenomanian OAE2, $^{187}Os/^{188}Os$ of the sedimentary rocks show rapid shifts to unradiogenic values (~0.2). Since radiometric ages of Ontong Java Plateau and Caribbean Plateau correspond to the sedimentary ages of OAE1a and OAE2, respectively, these Os isotopic declines have been interpreted as the massive input of mantle-derived unradiogenic Os through submarine volcanism forming these basaltic plateaus. However, the Os isotopic data during the mid-Cretaceous are limited to the short interval around major Cretaceous OAEs (e.g., OAE1a, OAE1b, and OAE2), which have hampered a long-term reconstruction of the hydrothermal activity. Here, we reconstruct the continuous marine Os isotopic record during the mid-Cretaceous using Tethyan sedimentary records in order to reveal the long-term variation of hydrothermal activity and the unknown massive volcanic activity associated with the formation of LIPs.

Keywords: osmium, Cretaceous

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Depositional ages of multiple REY peaks in deep-sea sediments around Minamitorishima Island based on osmium isotope stratigraphy

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Deep-sea sediments highly enriched in rare-earth elements and yttrium (REY), lying in the Japanese exclusive economic zone around Minamitorishima Island, are expected as a promising new resource for the industrially critical metals [1-4]. Multi-elemental chemostratigraphic correlation revealed that the deep-sea sediments around Minamitorishima Island have three distinct layers with >2000 ppm of total REY concentrations. These layers were named as the 1st, 2nd, and 3rd REY peaks from shallow to deep [4]. Using marine osmium isotope ratio ($^{187}Os/^{188}Os$), a previous study [5] revealed that the 1st REY peak was formed at 34.4 Ma and proposed that an enhanced northward flow of bottom water associated with the late Eocene event, a temporal expansion of Antarctic ice sheet, caused the upwelling of deep-ocean nutrients along with topographic highs, such as large seamounts. This upwelling could have stimulated the biological productivity and resulted in an increased fish productivity, leading to the substantial deposition of fish debris that accumulate REY on the seafloor [5].

In contrast to the detailed investigation of the 1st REY peak from a paleoceanographic perspective, the depositional ages and causes of the 2nd and 3rd REY peaks still remain uncertain. Here, we will report new results of the Os isotope analysis on the sediment samples from MR15-E01 PC07 core that clearly contains three REY peaks. The depositional ages of the REY peak of MR15-E01 PC07 core were estimated based on the osmium isotope stratigraphy. In the presentation, we will discuss the possible causes of the REY peaks based on their depositional ages.

[1] Kato et al. (2011) *Nature Geoscience* **4**, 535-539. [2] Iijima et al. (2016) *Geochemical Journal* **50**, 557-573. [3] Takaya et al. (2018) *Scientific Reports* **8**, 5763. [4] Tanaka et al. (2020) *Ore Geology Reviews* **119**, 103392. [5] Ohta et al. (2020) *Scientific Reports* **10**, 9896.

Keywords: deep-sea sediment, rare-earth elements, REY-rich mud, Minamitorishima Island, age determination, osmium isotopes

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Depositional environments of the Late Cretaceous REY-rich mud in the western North Pacific Ocean inferred from deep-water agglutinated foraminifers

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Deep-sea sediments highly enriched in rare-earth elements and yttrium (REY), called REY-rich mud, are widely distributed in the Pacific Ocean [1]. Notably, very high-grade REY-rich mud lies around Minamitorishima Island in the western North Pacific Ocean, and it is expected to be a promising new resource for REY [2]. Some radiolarian fossils in the uppermost part of the chert imply that the REY-rich mud around Minamitorishima Island started to deposit in the Late Cretaceous [3,4].

Pelagic clay including REY-rich mud has deposited very slowly over a long period of time, and thus, are expected to have recorded the history of pelagic environment. However, the water depth greater than the carbonate compensation depth (CCD) and generally low surface productivity hampered preserving calcareous and siliceous fossils, making it difficult to decipher the environmental changes in the pelagic realm.

Here, we focused on a certain type of benthic foraminifers called deep-water agglutinated foraminifers (DWAF). DWAF have agglutinative shells of aluminosilicates that do not dissolve even at depths below the CCD [4] and consist of various species such as those highly dependent on biological production or tolerant of oligotrophic environments [5]. Therefore, it is expected that investigation of DWAF assemblage will provide a new insight into the depositional environments of REY-rich mud. In the presentation, based on the production and species composition of DWAF, we will discuss the environmental conditions during the time of deposition of REY-rich mud around Minamitorishima Island in the Late Cretaceous.

[1] Kato et al. (2011) *Nature Geoscience* **4**, 535-539. [2] Takaya et al. (2018) *Scientific Reports* **8**, 5763. [3] Wightman and Kuhnt (1992) *Proc. ODP, Scientific Results* **129**, 247-264. [4] Nakamura et al. (2016) *Geochemical Journal* **50**, 605-619. [5] Kaminski and Gradstein (2005) *Grzybowski Foundation Special Publication* **10**, 547

Keywords: deep-water agglutinated foraminifers, pelagic clay, REY-rich mud, microfossils, Pacific Ocean, Cretaceous

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[J] Oral | EVENT：EVENT

Sat. Jun 5, 2021 12:20 PM - 1:00 PM JST | Sat. Jun 5, 2021 3:20 AM - 4:00 AM UTC | Ch.01 Zoom Room 01

[EV-22] Lunchtime Special Lecture

12:20 PM - 1:00 PM JST | 3:20 AM - 4:00 AM UTC

[E-11-24] Uncover the cryptic nitrogen flows in the terrestrial ecosystems

[J] Oral | EVENT | EVENT

[EV-22] Lunchtime Special Lecture

Sat. Jun 5, 2021 12:20 PM - 1:00 PM Ch.01 (Zoom Room 01)

12:20 PM - 1:00 PM

[E-11-24]Uncover the cryptic nitrogen flows in the terrestrial ecosystems

Nitrogen fluxes in the natural ecosystems are difficult to study partly due to the high variety of the nitrogen compounds and to their low concentrations maintained by the biological nitrogen use. In this lecture, I introduce some case studies elucidating the cryptic nitrogen flows driven by the microbes and plants in the terrestrial ecosystems with the help of stable isotope techniques.

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[J] Oral | EVENT：EVENT

Sat. Jun 5, 2021 1:45 PM - 2:30 PM JST | Sat. Jun 5, 2021 4:45 AM - 5:30 AM UTC | Ch.12 Zoom Room 12

[EV-24] Exhibitors' Seminar

昨年と同じく、出展者様にセミナーを開催していただきます。
地球惑星科学関連の、有用な情報を発信してくださいますので是非ご参加ください。

1:45 PM - 2:30 PM JST | 4:45 AM - 5:30 AM UTC

[E-11-25] An introduction to Research Institute for Humanity Nature (RIHN)'s interdisciplinary researches on global environmental issues. Earth Scientists, join our Research Projects!

[J] Oral | EVENT | EVENT

[EV-24] Exhibitors' Seminar

Sat. Jun 5, 2021 1:45 PM - 2:30 PM Ch.12 (Zoom Room 12)

昨年と同じく、出展者様にセミナーを開催していただきます。
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1:45 PM - 2:30 PM

[E-11-25]An introduction to Research Institute for Humanity Nature (RIHN)'s interdisciplinary researches on global environmental issues. Earth Scientists, join our Research Projects!

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