2019年5月28日(火)

[E] 口頭発表 | セッション記号 P (宇宙惑星科学)：P-PS 惑星科学

9:00 ~ 10:30 | A03 東京ベイ幕張ホール

[P-PS01] Outer Solar System Exploration Today, and Tomorrow

コンビーナ:木村 淳(大阪大学)、笠羽 康正(東北大学 惑星プラズマ・大気研究センター)、Kunio M. Sayanagi(Hampton University)、座長:Kunio Sayanagi(Hampton University)、黒田 剛史

9:00 ~ 9:15

[PPS01-06] Radiative transfer simulation including a non-LTE model for terahertz observations of Ganymede's atmosphere

*山田 崇貴[1]、Rezac Ladislav[2]、Larsson Richard[2]、Hartogh Paul[2]、吉田 尚弘[3]、笠井 康子[1,3] (1.情報通信研究機構、2.マックスプランク太陽系研究所、3.東京工業大学)

9:15 ~ 9:30

[PPS01-07] Vertical Mass Flux by the 2010-2011 Great Storm of Saturn

*Sayanagi Kunio M.[1]、Gunnarson Jacob L.[1]、Blalock John J.[1]、Achterberg Richard K.[2]、Flasar F. Michael[2]、Ingersoll Andrew P.[3]、Ewald Shawn P.[3]、Dyudina Ulyana A.[3] (1.Hampton University、2.NASA Goddard Space Flight Center、3.California Institute of Technology)

9:30 ~ 9:48

[PPS01-08] Microwave observations of the giant planets - Cassini/Radar and Juno/MWR

★Invited Papers

*Cheng Li[1]、Virgil Adumitroaie[2]、John Arballo[2]、Sushil K Atreya[3]、Scott J Bolton[4]、Andrew Ingersoll[1]、Michael Janssen[2]、Steven Levin[2]、Jonathan Lunine[5]、Glenn Orton[2]、Paul Steffes[6]、Hunter Waite[4] (1.California Institute of Technology、2.Jet Propulsion Laboratory、3.University of Michigan Ann Arbor、4.Southwest Research Institute、5.Cornell University、6.Georgia Institute of Technology)

9:48 ~ 10:06

[PPS01-09] Tracing Formation and Evolution of Outer Solar System Bodies through Stable Isotopes and Noble Gas Abundances

★Invited Papers

*Kathleen Mandt[1] (1.Johns Hopkins University Applied Physics Laboratory)

10:06 ~ 10:24

[PPS01-10] Icy Giant Planet Exploration

★Invited Papers

*Sushil K Atreya[1]、Mark D. Hofstadter[2]、Amy Simon[3]、Kim R. Reh[2]、Olivier Mousis[4]、Krista Soderlund[5] (1.University of Michigan Ann Arbor、2.Jet Propulsion Laboratory、3.Goddard Space Flight Center、4.Laboratoire d'Astrophysique de Marseille、5.University of Texas at Austin)

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[P-PS01] Outer Solar System Exploration Today, and Tomorrow

コンビーナ:木村 淳(大阪大学)、笠羽 康正(東北大学 惑星プラズマ・大気研究センター)、Kunio M. Sayanagi(Hampton University)、座長:Jun Kimura(Osaka University)、鎌田 俊一(北海道大学創成研究機構)

10:45 ~ 11:03

[PPS01-11] Saturn's ring rain and Enceladus' subsurface ocean as seen by the Cassini Cosmic Dust Analyser

★Invited Papers

*Sean Hsu[1]、Sascha Kempf[1]、Mihaly Horanyi[1]、Ralf Srama[2]、James O'Donoghue[3] (1.LASP, University of Colorado, Boulder, CO, USA、2.IRS, University of Stuttgart, Stuttgart, Germany、3.NASA Goddard Space Flight Center, Greenbelt, Maryland, USA)

11:03 ~ 11:18

[PPS01-12] **Titan Trek: A New Online NASA Visualization and Analysis Portal for Saturn's Largest Moon**

*Emily Law[1]、Brian Hamilton Day[2] (1.NASA Jet Propulsion Laboratory、2.NASA Ames Research Center)

11:18 ~ 11:36

[PPS01-13] Internal structure of icy moons: ice-ocean systems as commonly seen in the outer solar system

★Invited Papers

*Hauke Hussmann[1] (1.DLR Institute of Planetary Research)

11:36 ~ 11:51

[PPS01-14] Callisto as a keystone to reproduce the formation process of the Jovian system

*関根 康人[1]、鎌田 俊一[2]、青山 雄彦[3]、生駒 大洋[3]、谷川 享行[4] (1.東京工業大学地球生命研究所、2.北海道大学創成研究機構、3.東京大学大学院理学系研究科、4.一関高等工業専門学校)

11:51 ~ 12:09

[PPS01-15] Origin of Jupiter Trojan asteroids: To be explored by OKEANOS

★Invited Papers

*癸生川 陽子[1]、岡田 達明[2]、伊藤 元雄[3]、青木 順[4]、河井 洋輔[4]、松本 純[2]、Grand Noel[5]、Buch Arnaud [6]、豊田 岐聡[4]、Cottin Hervé[5]、圦本 尚義[7,2]、矢野 創[2]、岩田 隆浩[2]、森 治[2] (1.横浜国立大学、2.宇宙航空研究開発機構、3.海洋研究開発機構　高知コア研究所、4.大阪大学、5.LISA, Université Paris-Est Créteil、6.Ecole Centrale Paris、7.北海道大学)

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10:45 ~ 12:15 | A01 東京ベイ幕張ホール

[P-PS03] Solar System Small Bodies: A New Frontier Arising Hayabusa 2, OSIRIS-REx and Other Projects

コンビーナ:石黒 正晃(ソウル大学物理天文学科)、中本 泰史(東京工業大学)、安部 正真(宇宙航空研究開発機構宇宙科学研究所)、Olivier S Barnouin(Johns Hopkins University Applied Physics Laboratory)、座長:Masateru Ishiguro(Seoul National University)

10:45 ~ 11:00

[PPS03-01] ラブルパイル小惑星リュウグウの形状と起源

★招待講演

*渡邊 誠一郎[1,5]、平林 正俊[2]、平田 成[3]、平田 直之[4]、野口 里奈[5]、嶌生 有理[5]、池田 人[6]、巽 瑛理[7]、吉川 真[5]、菊地 翔太[5]、薮田 ひかる[8]、中村 智樹[9]、橘 省吾[7,5]、石原 吉明[10]、諸田 智克[1]、北里 宏平[3]、坂谷 尚哉[5]、松本 晃治[11,12]、和田 浩二[13]、千秋 博紀[13]、本田 親寿[3]、道上 達広[14]、竹内 央[5]、神山 徹[15]、本田 理恵[16]、Robert Gaskell[17]、Eric Palmer[17]、Olivier Barnouin[18]、Patrick Michel[19]、Paul Abell[20]、山本 幸生[5]、田中 智[5]、白井 慶[5]、松岡 萌[5]、杉田 精司[5,7]、岡田 達明[5]、並木 則行[11]、荒川 政彦[4]、石黒 正晃[21]、小川 和律[4]、照井 冬人[5]、佐伯 孝尚[5]、中澤 暁[5]、津田 雄一[5]、はやぶさ2サイエンスチーム (1.名古屋大学大学院環境学研究科地球環境科学専攻、2.オーバン大学、3.会津大学、4.神戸大学、5.宇宙航空研究開発機構 宇宙科学研究所、6.宇宙航空研究開発機構 研究開発部門、7.東京大学、8.広島大学、9.東北大学、10.国立環境研究所、11.国立天文台、12.総合研究院大学、13.千葉工業大学、14.近畿大学、15.産業技術総合研究所、16.高知大学、17.惑星科学研究所、18.ジョンホプキンス大学、19.コート・ダジュール大学/観測所、20.NASA ジョンソンスペースセンター、21.ソウル大学)

11:00 ~ 11:15

[PPS03-02] Results of Hayabusa2 Near Infrared Spectroscopy at Asteroid Ryugu

*岩田 隆浩[1]、北里 宏平[2]、安部 正真[1]、大竹 真紀子[1]、仲内 悠祐[1]、松岡 萌[1]、津村 耕司[3]、松浦 周二[4]、Riu Lucie[1]、NIRS3 チーム (1.宇宙航空研究開発機構　宇宙科学研究所、2.会津大学、3.東北大学、4.関西学院大学)

11:15 ~ 11:30

[PPS03-03] はやぶさ２SCI/DCAM3による人工クレーターの形成と観測

★招待講演

*荒川 政彦[1]、佐伯 孝尚[2]、門野 敏彦[3]、高木 靖彦[4]、和田 浩二[5]、飯島 祐一[2]、今村 裕志[2]、岡本 千里[1]、嶌生 有理[2]、白井 慶[2]、中澤 暁[2]、早川 雅彦[2]、平田 成[6]、矢野 創[2]、澤田 弘崇[2]、小川 和律[1]、石橋 高[5]、木村 宏[5]、小林 正規[5]、坂谷 尚哉[2]、早川 基[2]、本田 理恵[7]、杉田 精司[8]、諸田 智克[9]、亀田 真吾[10]、巽 瑛理[8]、本田 親寿[6]、横田 康弘[2]、神山 徹[11]、山田 学[5]、鈴木 秀彦[12]、吉岡 和夫[13]、長 勇一郎[8]、松岡 萌[2] (1.神戸大学大学院理学研究科、2.宇宙航空研究開発機構 宇宙科学研究所、3.産業医科大学医学部、4.愛知東邦大学 、5.千葉工業大学惑星探査研究センター 、6.会津大学　コンピュータ理工学部 、7.高知大学自然科学系理工学部門 、8.東京大学大学院理学系研究科地球惑星科学専攻 、9.名古屋大学大学院環境学研究科 、10.立教大学理学部 、11.産業技術総合研究所 、12.明治大学理工学部物理学科 、13.東京大学大学院新領域創成科学研究科)

11:30 ~ 11:45

[PPS03-04] サイズ分布をもつガラスビーズ層へのクレーター形成実験：小惑星Ryuguのクレーター形成過程の解明

*保井 みなみ[1]、荒川 政彦[1]、長谷川 直[2]、山本 裕也[1]、杉村 瞭[1] (1.神戸大学大学院理学研究科、2.宇宙航空研究開発機構 宇宙科学研究所)

11:45 ~ 12:00

[PPS03-05] Enhancement of impact heating in strength-supported media

*黒澤 耕介[1]、玄田 英典[2]、脇田 茂[2]、Thomas Davison[3]、兵頭 龍樹[2]、中村 智樹[4] (1.千葉工業大学　惑星探査研究センター、2.東京工業大学　地球生命研究所、3.Department of Earth Science & Engineering, Imperial College London、4.東北大学 地球惑星物質科学科・地学専攻)

12:00 ~ 12:15

[PPS03-06] Global Thermal Inertia and Surface Roughness of Asteroid 162173 Ryugu by TIR on Hayabusa2

*嶌生 有理[1]、千秋 博紀[2]、坂谷 尚哉[1]、岡田 達明[1,3]、福原 哲哉[4]、田中 智[1]、田口 真[4]、荒井 武彦[5]、出村 裕英[6]、小川 佳子[6]、須古 健太郎[6]、関口 朋彦[7]、神山 徹[8]、滝田 隼[9]、松永 恒雄[10]、今村 剛[3]、和田 武彦[1]、長谷川 直[1] (1.宇宙航空研究開発機構宇宙科学研究所、2.千葉工業大学、3.東京大学、4.立教大学、5.足利大学、6.会津大学、7.北海道教育大学、8.産業技術総合研究所、9.北海道北見北斗高校、10.国立環境研究所)

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13:45 ~ 14:00

[PPS03-07] Asteroid Ryugu's parent body and its properties inferred from Haybusa2 multi-band imaging observations

★Invited Papers

*杉田 精司[1,6]、本田 理恵[2]、諸田 智克[3]、亀田 真吾[4]、巽 瑛理[1]、本田 親寿[7]、横田 康弘[2,5]、神山 徹[8]、坂谷 尚哉[5]、山田 学[6]、鈴木 秀彦[10]、吉岡 和夫[1]、長 勇一郎[1]、松岡 萌[5]、小川 和律[9]、Domingue Deborah[11]、宮本 英昭[1]、Barnouin Olivier[12]、Michel Patrick[13]、Ernst Carolyn[12]、渡邊 誠一郎[3]、津田 雄一[5] (1.東京大学、2.高知大学、3.名古屋大学、4.立教大学、5.宇宙航空研究開発機構 宇宙科学研究所、6.千葉工業大学 惑星探査センター、7.会津大学、8.産総研、9.神戸大学、10.明治大学、11.惑星科学研究所、12.ジョンズホプキンス大学 応用物理学研究所、13.ニース天文台)

14:00 ~ 14:15

[PPS03-08] 小惑星リュウグウにおける表面赤化と層序

*諸田 智克[1]、長 勇一郎[2]、金丸 仁明[3]、本田 理恵[4]、亀田 真吾[5]、巽 瑛理[2]、横田 康弘[6]、神山 徹[7]、鈴木 秀彦[8]、山田 学[9]、坂谷 尚哉[6]、本田 親寿[10]、早川 雅彦[6]、吉岡 和夫[2]、松岡 萌[6]、道上 達広[11]、宮本 英昭[2]、菊地 紘[2]、逸見 良道[2]、平林 正稔[12]、平田 直之[13]、平田 成[10]、Ernst Carolyn[14]、Barnouin Olivier[14]、澤田 弘崇[6]、杉田 精司[2] (1.名古屋大学、2.東京大学、3.大阪大学、4.高知大学、5.立教大学、6.宇宙航空研究開発機構、7.産業技術総合研究所、8.明治大学、9.千葉工業大学、10.会津大学、11.近畿大学、12.オーバーン大学、13.神戸大学、14.ジョンズホプキンス大学)

14:15 ~ 14:30

[PPS03-09] Preliminary report on global distribution visible spectra of asteroid Ryugu based on clustering

*本田 理恵[1]、横田 康弘[1,2]、巽 瑛理[3]、Barucci Antonella[12]、Perna Davide[13]、松岡 萌[2]、Domingue Deborah[14]、諸田 智克[4]、亀田 真吾[5]、神山 徹[15]、鈴木 秀彦[6]、山田 学[10]、坂谷 尚哉[2]、本田 親寿[7]、LeCorre Lucille[14]、早川 雅彦[2]、吉岡 和夫[3]、長 勇一郎[3]、山本 幸生[2]、平田 成[7]、平田 直之[8]、中村 智樹[9]、廣井 孝弘[11]、澤田 弘崇[2]、藤井 祐貴[1]、杉田 精司[3]、林 諒[1] (1.高知大学、2.宇宙航空研究開発機構宇宙科学研究所、3.東京大学、4.名古屋大学、5.立教大学、6.明治大学、7.会津大学、8.神戸大学、9.東北大学、10.千葉工業大学、11.ブラウン大学、12.Paris Observatory、13.National Institute for Astrophysics、14.Planetary Science Institute、15.産業技術総合研究所)

14:30 ~ 14:45

[PPS03-10] Visible spectra of small bright spots on asteroid 162173 Ryugu

*杉本 知穂[1]、巽 瑛理[1]、長 勇一郎[1]、吉岡 和夫[1]、澤田 弘崇[2]、横田 康弘[2]、坂谷 尚哉[2]、早川 雅彦[2]、松岡 萌[2]、本田 理恵[3]、諸田 智克[4]、亀田 真吾[5]、山田 学[6]、神山 徹[7]、鈴木 秀彦[8]、本田 親寿[9]、小川 和律[10]、Deborah Domingue[11]、Patrick Michel[12]、杉田 精司[1] (1.東京大学、2.宇宙航空研究開発機構 宇宙科学研究所、3.高知大学、4.名古屋大学、5.立教大学、6.千葉工業大学、7.産業技術総合研究所、8.明治大学、9.会津大学、10.神戸大学、11.惑星科学研究所、12.ニース天文台)

14:45 ~ 15:00

[PPS03-11] Geomorphological characteristics of asteroid Ryugu: implications to its evolutional history

*宮本 英昭[1]、逸見 良道[1]、菊地 紘[1]、小松 吾郎[2]、本田 親寿[3]、道上 達広[4]、諸田 智克[5]、長 勇一郎[1]、バーノイン オリビエ[6]、佐々木 晶[7]、平田 成[3]、平田 直之[8]、本田 理恵[10]、亀田 真吾[11]、巽 瑛理[1]、横田 康弘[12]、神山 徹[13]、鈴木 秀彦[14]、山田 学[15]、坂谷 尚哉[12]、早川 雅彦[12]、吉岡 和夫[1]、松岡 萌[12]、平林 正稔[9]、澤田 弘崇[12]、杉田 精司[1] (1.東京大学、2.ダヌンツィオ大学、3.会津大学、4.近畿大学、5.名古屋大学、6.ジョンズホプキンス大学、7.大阪大学、8.神戸大学、9.オーバーン大学、10.高知大学、11.立教大学、12.宇宙科学研究所、13.産業総合研究所、14.明治大学、15.千葉工業大学)

15:00 ~ 15:15

[PPS03-12] リュウグウ画像テクスチャー解析によるサブメートルスケールのボルダー全球分布解析

*田辺 直也[1]、長 勇一郎[1]、巽 瑛理[1]、諸田 智克[4]、本田 親寿[9]、道上 達広[11]、Patrick Michel[12]、Carolyn Ernst[13]、Olivier Barnouin[13]、吉岡 和夫[1]、澤田 弘崇[2]、横田 康弘[2,3]、坂谷 尚哉[2]、早川 雅彦[2]、松岡 萌[2]、本田 理恵[3]、亀田 真吾[5]、山田 学[6]、神山 徹[7]、鈴木 秀彦[8]、小川 和律[10]、杉田 精司[1] (1.東京大学、2.宇宙航空研究開発機構 宇宙科学研究所、3.高

知大学、4.名古屋大学、5.立教大学、6.千葉工業大学 惑星探査センター、7.産業技術総合研究所、8.明治大学、9.会津大学、10.神戸大学、11.近畿大学、12.ニース天文台、13.ジョンズホプキンス大学応用物理学研究所)

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[P-PS03] Solar System Small Bodies: A New Frontier Arising Hayabusa 2, OSIRIS-REx and Other Projects

コンビーナ:石黒 正晃(ソウル大学物理天文学科)、中本 泰史(東京工業大学)、安部 正真(宇宙航空研究開発機構宇宙科学研究所)、Olivier S Barnouin(Johns Hopkins University Applied Physics Laboratory)、座長:Masanao Abe(Institute of Space and Astronautical Science, JAXA)

15:30 ~ 15:45

[PPS03-13] 162173 リュウグウ表面の岩石の明るさと形状の変化

*佐々木 晶[1]、杉田 精司[2]、巽 瑛理[2]、宮本 英昭[3]、本田 親寿[4]、諸田 智克[5]、平林 正稔[6]、神田 志穂[1]、平田 成[4]、廣井 孝弘[7]、中村 智樹[8]、野口 高明[9]、本田 理恵[10]、道上 達広[11]、渡邊 誠一郎[5]、並木 則行[12]、Patrick Michel[13]、亀田 真吾[14]、神山 徹[15]、鈴木 秀彦[16]、山田 学[17]、菊地 紘[3]、長 勇一郎[2]、吉岡 和夫[18]、早川 雅彦[19]、松岡 萌[19]、野口 里奈[19]、坂谷 尚哉[19]、澤田 弘崇[19]、横田 康弘[19,10]、吉川 真[19] (1.大阪大学大学院理学研究科宇宙地球科学専攻、2.東京大学大学院理学系研究科地球惑星科学専攻、3.東京大学大学院工学系研究科システム創成学専攻、4.会津大学、5.名古屋大学大学院環境学研究科、6.オーバーン大学、7.ブラウン大学、8.東北大学大学院理学研究科地学専攻、9.九州大学基幹教育院、10.高知大学自然科学系理工学部門、11.近畿大学工学部、12.国立天文台 RISE月惑星探査検討室、13.コートダジュール天文台、14.立教大学理学部、15.産業技術総合研究所、16.明治大学理工学部物理学科、17.千葉工業大学惑星探査研究センター、18.東京大学大学院新領域創成科学研究科、19.宇宙航空研究開発機構 宇宙科学研究所)

15:45 ~ 16:00

[PPS03-14] 小惑星162173リュウグウのクレーターと赤道バルジの地形

*並木 則行[1,2]、水野 貴秀[3]、千秋 博紀[4]、野田 寛大[1,2]、松本 晃治[1,2]、平田 成[5]、山田 竜平[5]、石原 吉明[6]、池田 人[3]、荒木 博志[1,2]、山本 圭香[1,2]、阿部 新助[7]、吉田 二美[4]、樋口 有理可[1]、佐々木 晶[10]、押上 祥子[1]、鶴田 誠逸[1]、浅利 一善[1]、田澤 誠一[1]、清水上 誠[1]、宮本 英昭[8]、出村 裕英[5]、木村 淳[10]、大坪 俊通[9] (1.国立天文台、2.総合研究院大学、3.宇宙航空研究開発機構/宇宙科学研究所、4.千葉工業大学、5.会津大学、6.産業技術総合研究所、7.日本大学、8.東京大学、9.一橋大学、10.大阪大学)

16:00 ~ 16:15

[PPS03-15] Observation of 1064 nm normal albedo around equator of the Ryugu using the Hayabusa2 LIDAR

*山田 竜平[1]、山本 圭香[2]、荒木 博志[2]、野田 寛大[2]、千秋 博紀[3]、並木 則行[2]、松本 晃治[2]、吉田 二美[3]、阿部 新助[4]、平田 成[1] (1.会津大学　コンピュータ理工学部、2.国立天文台、3.千葉工業大学、4.日本大学)

16:15 ~ 16:30

[PPS03-16] LIDARデータおよび形状モデルを組み合わせた「はやぶさ2」探査機軌道改良

*松本 晃治[1]、野田 寛大[1]、石原 吉明[2]、千秋 博紀[3]、山本 圭香[1]、平田 成[4]、平田 直之[5]、並木 則行[1]、大坪 俊通[6]、渡邊 誠一郎[7]、水野 貴秀[8]、山本 幸生[8]、池田 人[8]、尾川 順子[8]、菊地 翔太[8]、佐伯 孝尚[8]、津田 雄一[8] (1.国立天文台RISE月惑星探査検討室、2.国立環境研究所、3.千葉工業大学、4.会津大学、5.神戸大学、6.一橋大学、7.名古屋大学、8.宇宙航空研究開発機構)

16:30 ~ 16:45

[PPS03-17] はやぶさ2帰還リュウグウ試料のキュレーションに関する準備状況

*矢田 達[1]、安部 正真[1]、中藤 亜衣子[1]、与賀田 佳澄[1]、坂本 佳奈子[1]、西村 征洋[1]、岡田 達明[1]、中埜 夕希[2]、吉武 美和[1]、熊谷 和也[3]、岩前 絢子[3]、古屋 静萌[1]、橘 省吾[4,1]、圦本 尚義[1,2] (1.宇宙航空研究開発機構、2.北海道大学、3.マリン・ワーク・ジャパン、4.東京大学)

16:45 ~ 17:00

[PPS03-18] Analysis of the grain from the asteroid Ryugu proposed by the Phase 2 curation “Team KOCHI”

*伊藤 元雄[1]、富岡 尚敬[1]、上椙 真之[2]、上杉 健太朗[2]、大東 琢治[3]、山口 亮[4]、今栄 直也[4]、唐牛 譲[5]、白井 直樹[6]、矢田 達[5]、安部 正真[5] (1.海洋研究開発機構　高知コア研究所、2.公益財団法人高輝度光科学研究センター、3.分子科学研究所 UVSOR、4.国立極地研究所、5.宇宙航空研究開発機構、6.首都大学東京)

[E] 口頭発表 | セッション記号 P (宇宙惑星科学)：P-EM 太陽地球系科学・宇宙電磁気学・宇宙環境

9:00 ~ 10:30 | A04 東京ベイ幕張ホール

[P-EM12] Space Weather and Space Climate

コンビーナ:片岡 龍峰(国立極地研究所)、Antti A Pulkkinen(NASA Goddard Space Flight Center)、草野 完也(名古屋大学宇宙地球環境研究所)、坂口 歌織(情報通信研究機構)、座長:片岡 龍峰(国立極地研究所)

9:00 ~ 9:15

[PEM12-25] Variation of carbon-14 in tree rings around the onset of the Spoerer Minimum

★Invited Papers

*宮原 ひろ子[1]、門叶 冬樹[2]、森谷 透[2]、大山 幹成[3]、箱崎 真隆[4]、武山 美麗[2]、櫻井 敬久[2] (1.武蔵野美術大学、2.山形大学、3.東北大学、4.名古屋大学)

9:15 ~ 9:30

[PEM12-26] Current Status of WASAVIES: Warning System for Aviation Exposure to Solar Energetic Particles

★Invited Papers

*佐藤 達彦[1]、片岡 龍峰[2,3]、塩田 大幸[4,5]、久保 勇樹[4]、石井 守[4]、保田 浩志[6]、三宅 晶子[7]、Park InChun[5]、三好 由純[5] (1.原子力機構、2.極地研、3.総研大、4.情報通信研究機構、5.名古屋大学、6.広島大学、7.茨城高専)

9:30 ~ 9:45

[PEM12-27] 太陽高エネルギー粒子(SEP)の発生に関する統計的研究

*木原 孝輔[1]、黄 于蔚[2]、西村 信彦[3]、八代 誠司[4]、新田 就亮[5]、一本 潔[2]、浅井 歩[2] (1.京都大学理学研究科宇宙物理学教室、2.京都大学大学院理学研究科附属天文台、3.名古屋大学宇宙地球環境研究所 、4.米国カトリック大学物理学科、5.ロッキード・マーティン太陽天体物理学研究所)

9:45 ~ 10:00

[PEM12-28] 名古屋多方向ミューオン計で観測された宇宙線強度の長周期変動

*宗像 一起[1]、Rafael Mendonca[2]、加藤 千尋[1]、徳丸 宗利[3] (1.信州大学理学部物理科学科、2.ブラジル宇宙科学研究所、3.名古屋大学ISEE研究所)

10:00 ~ 10:15

[PEM12-29] Solar modulation of galactic cosmic rays during grand minima: A hybrid simulation

*三宅 晶子[1]、松本 倫明[2,3]、片岡 龍峰[4,5]、佐藤 達彦[6]、塩田 大幸[7]、宮原 ひろ子[8]、今田 晋亮[9]、上野 遥[10] (1.茨城工業高等専門学校、2.法政大学、3.プリンストン大学、4.国立極地研究所、5.総合研究大学院大学、6.日本原子力研究開発機構、7.情報通信研究機構、8.武蔵野美術大学、9.名古屋大学、10.宇宙航空研究開発機構)

10:15 ~ 10:30

[PEM12-30] Overview of radio propagation project

*Kornyanat Hozumi[1]、Hiroyuki Nakata[2]、Susumu Saito[3]、Takumi Kondo[1]、Ryo Nakao[2]、Takashi Maruyama[1]、Takuya Tsugawa[1]、Mamoru Ishii[1] (1.National Institute of Information and Communications Technology、2.Graduate School of Engineering, Chiba University, Chiba, Japan、3.National Institute of Maritime, Port and Aviation Technology, Electronic Navigation Research Institute (ENRI), Tokyo, Japan)

[E] 口頭発表 | セッション記号 P (宇宙惑星科学)：P-EM 太陽地球系科学・宇宙電磁気学・宇宙環境

10:45 ~ 12:15 | A04 東京ベイ幕張ホール

[P-EM12] Space Weather and Space Climate

コンビーナ:片岡 龍峰(国立極地研究所)、Antti A Pulkkinen(NASA Goddard Space Flight Center)、草野 完也(名古屋大学宇宙地球環境研究所)、坂口 歌織(情報通信研究機構)、座長:坂口 歌織

10:45 ~ 11:00

[PEM12-31] Dynamic Spectral Characteristics of Equatorial Plasma Bubbles

★Invited Papers

*横山 竜宏[1]、Charles Rino[2]、Charles Carrano[2] (1.京都大学、2.Boston College)

11:00 ~ 11:15

[PEM12-32] Recent advances in space weather monitoring using the Super Dual Auroral Radar Network

★Invited Papers

*Evan G Thomas[1]、Simon G Shepherd[1] (1.Dartmouth College)

11:15 ~ 11:30

[PEM12-33] **A Study of Solar Flare Effects on Radio Wave Propagation using SuperDARN & riometer**

*Shibaji Chakraborty[1]、Joseph Baker[1]、John Michael Ruohoniemi[1]、Nozomu Nishitani[2] (1.Virginia Tech、2.Institute for Space-Earth Environmental Research, Nagoya University)

11:30 ~ 11:45

[PEM12-34] Exploring the use of cell phone GNSS receivers for global monitoring of the ionosphere

*Dawn Kellogg Merriman[1]、Omar A Nava[1]、Jennifer L Meehan[2]、Hsien-Liang R Tseng[1] (1.AFIT、2.NOAA)

11:45 ~ 12:00

[PEM12-35] 2004年11月7-8日に発生した磁気嵐に伴う午後側から夕方側における全球全電子数の極端な増加について

*惣宇利 卓弥[1]、大塚 雄一[1]、新堀 淳樹[1]、津川 卓也[2]、西岡 未知[2] (1.名古屋大学　宇宙地球環境研究所、2.情報通信研究機構)

12:00 ~ 12:15

[PEM12-36] Large scale traveling ionospheric disturbances origin and propagation

*Iurii Cherniak[1,2]、Irina Zakharenkova[2,5]、Paul Prikryl[3,4]、William Schreiner[1] (1.COSMIC Program Office, University Corporation for Atmospheric Research、2.University of Warmia and Mazury in Olsztyn、3.Physics Department, University of New Brunswick、4.Geomagnetic Laboratory, Natural Resources Canada、5.West Department of IZMIRAN)

[E] 口頭発表 | セッション記号 P (宇宙惑星科学)：P-EM 太陽地球系科学・宇宙電磁気学・宇宙環境

13:45 ~ 15:15 | A04 東京ベイ幕張ホール

[P-EM13] 内部磁気圏

コンビーナ:海老原 祐輔(京都大学生存圏研究所)、Danny Summers(Memorial University of Newfoundland)、三好 由純(名古屋大学宇宙地球環境研究所)、齊藤 慎司(名古屋大学　大学院理学研究科)、座長:Danny Summers、三好 由純(名古屋大学宇宙地球環境研究所)

13:45 ~ 14:05

[PEM13-01] Developing an improved understanding of Earth's outer radiation belt electrons with combined observations from Van Allen Probes, MMS, and Arase

★Invited Papers

*Drew L Turner[1]、Ian Cohen[2]、Alexander Boyd[1,3]、Joseph Fennell[1]、Geoff Reeves[3]、Yoshizumi Miyoshi[4] (1.Aerospace Corporation El Segundo、2.Johns Hopkins University Applied Physics Lab、3.Los Alamos National Laboratory、4.Nagoya University)

14:05 ~ 14:25

[PEM13-02] Recent results from Van Allen Probes and future prospects from the CeREs Cubesat

★Invited Papers

*Shrikanth G Kanekal[1]、Daniel N Baker[2]、Ashley Greeley[1]、Lauren Blum[1]、Quintin Schiller[1]、David G Sibeck[1]、Hong Zhao[2]、Xinlin Li[2]、Allison Jaynes[3] (1.NASA Goddard Space Flight Center、2.LASP, University of Colorado, Boulder、3.Univeristy of Iowa)

14:25 ~ 14:40

[PEM13-03] **Optimal Use of Time Lags Between MMS Spacecraft : Application to the Estimation of Wave-Vectors**

*Gerard Marcel CHANTEUR[1,2,3]、Drew L. Turner、Olivier Le Contel[1,2,3]、Alessandro Retino[1,2,3]、Laurent Mirioni[1,2,3] (1.CNRS、2.SORBONNE UNIVERSITE、3.ECOLE POLYTECHNIQUE)

14:40 ~ 14:55

[PEM13-04] Conjugate observation of EMIC waves by Arase and RBSP with associated POES and AARDDVARK detected electron precipitation

*Aaron T. Hendry[1]、Ondrej Santolik[1,2]、Yoshizumi Miyoshi[3]、Yoshiya Kasahara[4]、Yasumasa Kasaba[5]、Ayako Matsuoka[6]、Craig J Rodger[7]、Mark Clilverd[8]、Masafumi Shoji[3]、Shoya Matsuda[6]、Craig Kletzing[9]、Iku Shinohara[6] (1.Dept. of Space Physics, Inst. of Atmospheric Physics, Czech Acad. of Science、2.Fac. of Mathematics and Physics, Charles Univ.、3.Inst. for Space Earth Environmental Research, Nagoya Univ.、4.Graduate School of Natural Science and Technology, Kanazawa Univ.、5.Planetary Plasma and Atmospheric Research Center, Tohoku Univ.、6.Inst. of Space and Astronautical Science, Japan Aerospace Exploration Agency、7.Dept. of Physics, Univ. of Otago、8.British Antarctic Survey (NERC)、9.Dept. of Physics and Astronomy, Univ. of Iowa)

14:55 ~ 15:10

[PEM13-05] Over-darkening pulsating aurora: simultaneous observations with Arase and an all-sky camera in Scandinavia

*細川 敬祐[1]、三好 由純[2]、大山 伸一郎[2]、小川 泰信[3]、栗田 怜[2]、笠原 禎也[4]、尾崎 光紀[4]、笠羽 康正[5]、八木谷 聡[4]、松田 昇也[6]、土屋 史紀[5]、熊本 篤志[5]、篠原 育[6]、藤井 良一[7] (1.電気通信大学大学院情報理工学研究科、2.名古屋大学宇宙地球環境研究所、3.国立極地研究所、4.金沢大学、5.東北大学、6.宇宙航空研究開発機構宇宙科学研究所、7.情報・システム研究機構)

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15:30 ~ 17:00 | A04 東京ベイ幕張ホール

[P-EM13] 内部磁気圏

コンビーナ:海老原 祐輔(京都大学生存圏研究所)、Danny Summers(Memorial University of Newfoundland)、三好 由純(名古屋大学宇宙地球環境研究所)、齊藤 慎司(名古屋大学　大学院理学研究科)、座長:三好 由純(名古屋大学宇宙地球環境研究所)、Danny Summers

15:30 ~ 15:50

[PEM13-06] Deformation of electron pitch angle distributions caused by chorus waves observed by the Arase satellite

★Invited Papers

*栗田 怜[1]、三好 由純[1]、笠原 慧[2]、横田 勝一郎[3]、笠原 禎也[4]、松田 昇也[5]、松岡 彩子[5]、篠原 育[5] (1.名古屋大学宇宙地球環境研究所、2.東京大学、3.大阪大学理学研究科、4.金沢大学総合メディア基盤センター、5.宇宙科学研究所)

15:50 ~ 16:10

[PEM13-07] Electron scattering by isolated chorus elements observed near the magnetospheric equator

★Invited Papers

*笠原 慧[1]、三好 由純[2]、横田 勝一郎[3]、笠原 禎也[4]、松田 昇也[5]、松岡 彩子[5]、桂華 邦裕[1]、堀 智昭[2]、篠原 育[5] (1.東京大学、2.名古屋大学、3.大阪大学、4.金沢大学、5.宇宙科学研究所)

16:10 ~ 16:25

[PEM13-08] れいめい衛星データによる脈動オーロラに関連した低エネルギー電子バンド状降下現象

*坂野井 健[1]、吹澤 瑞貴[1]、三好 由純[2]、海老原 祐輔[3]、浅村 和史[4]、平原 聖文[2] (1.東北大学大学院理学研究科惑星プラズマ・大気研究センター、2.名古屋大学太陽地球環境研究所、3.京都大学生存圏研究所、4.宇宙航空研究開発機構宇宙科学研究所)

16:25 ~ 16:40

[PEM13-09] Origin of energetic electron precipitation with fast fluctuation: Data-driven simulations using the ERG plasma wave observations

*齊藤 慎司[1]、三好 由純[2]、松田 昇也[3]、栗田 怜[2]、笠原 禎也[4]、熊本 篤志[5]、土屋 史紀[5]、松岡 彩子[3] (1.名古屋大学　大学院理学研究科、2.名古屋大学　宇宙地球環境研究所、3.宇宙科学研究所、4.金沢大学、5.東北大学)

16:40 ~ 16:55

[PEM13-10] Conjugated quasi-periodic ELF/VLF emissions between the Arase satellite and both Van Allen Probes

*Claudia Martinez Calderon[1,2]、Frantisek Nemec[3]、Kazuo Shiokawa[2]、Yuto Katoh[1]、Yoshiya Kasahara[4]、Shoya Matsuda[2]、Fuminori Tsuchiya[1]、Atsushi Kumamoto[1]、Mariko Teramoto[2]、Ayako Matsuoka[5]、Yoshizumi Miyoshi[2]、Ondrej Santolik[6,3]、George Hospodarksy[7] (1.Dept. Geophys., Grad. Sch. Sci., Tohoku University、2.Instute for Space-Earth Environmental Research, Nagoya University、3.Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic、4.Kanazawa University、5.Japan Aerospace Exploration Agency、6.Institute of Atmospheric Physics, Prague, Czech Republic、7.Department of Physics and Astronomy, University of Iowa, USA)

[E] 口頭発表 | セッション記号 P (宇宙惑星科学)：P-CG 宇宙惑星科学複合領域・一般

13:45 ~ 15:15 | A03 東京ベイ幕張ホール

[P-CG22] Shock responses of planetary materials elucidated from meteorites and dynamic compression experiments

コンビーナ:関根 利守(Center for High Pressure Science and Technology Advanced Research)、奥地 拓生(岡山大学惑星物質研究所)、座長:関根 利守(HPSTAR & Osaa University)、Ai-Cheng Zhang(Nanjing University)

13:45 ~ 14:00

[PCG22-01] Shock-induced phase transformation in howardite-eucrite-diogenite meteorites

★Invited Papers

*Ai-Cheng Zhang[1,2]、De-Liang Chen[1]、Run-Lian Pang[1] (1.School of Earth Sciences and Engineering, Nanjing University, China、2.CAS Center for Excellence in Comparative Planetary, China)

14:00 ~ 14:15

[PCG22-02] 隕石における結晶格子剪断誘起のケイ酸塩高圧相の準安定的形成

★招待講演

*富岡 尚敬[1]、奥地 拓生[2]、宮原 正明[3] (1.海洋研究開発機構高知コア研究所、2.岡山大学惑星物質研究所、3.広島大学理学部地球惑星システム学科)

14:15 ~ 14:30

[PCG22-03] Can high-pressure polymorphs clarify an ordinary chondrite parent-body breakup?

*宮原 正明[1]、山口 亮[2]、齋藤 優人[1]、吹本 幹太[1]、境 毅[3]、大藤 弘明[3]、富岡 尚敬[4]、兒玉 優[5]、大谷 栄治[6] (1.広島大学大学院理学研究科地球惑星システム学専攻、2.国立極地研究所、3.愛媛大学地球ダイナミクス研究センター、4.JAMSTEC・高知コア研究所、5.マリン・ワーク・ジャパン、6.東北大学大学院理学研究科地学専攻)

14:30 ~ 14:45

[PCG22-04] Linking occurrence and texture of dense silicate minerals in shocked meteorites with laser-shock experimental results of Mg_2SiO_4 analyzed by XFEL probe

*奥地 拓生[1]、Narangoo Purevjav[1]、尾崎 典雅[2]、松岡 健之[2]、瀬戸 雄介[3]、丹下 慶範[4]、薮内 俊毅[5]、富岡 尚敬[6]、関根 利守[7]、兒玉 了祐[2] (1.岡山大学惑星物質研究所、2.大阪大学工学研究科、3.神戸大学理学研究科、4.高輝度光科学研究センター、5.理化学研究所放射光科学研究センター、6.海洋研究開発機構高知コア研究所、7.Center for High Pressure Science and Technology Advanced Research)

14:45 ~ 15:00

[PCG22-05] Laser-shock evolution of organic molecules in carbonaceous meteorite

*薮田 ひかる[1]、藤岡 光[2]、境家 達弘[2]、近藤 忠[2]、大野 宗祐[3]、黒澤 耕介[3]、門野 敏彦[4]、重森 啓介[5]、弘中 陽一郎[5]、山中 高光[6] (1.広島大学大学院理学研究科 地球惑星システム学専攻、2.大阪大学大学院理学研究科 宇宙地球科学専攻、3.千葉工業大学 惑星探査研究センター、4.産業医科大学、5.大阪大学レーザー科学研究所、6.北京高圧科学研究中心)

15:00 ~ 15:15

[PCG22-06] Shock barometer using cathodoluminescence and synchrotron angle-dispersive x-ray diffraction analyses of minerals

★Invited Papers

*鹿山 雅裕[1] (1.東北大学)

[E] 口頭発表 | セッション記号 P (宇宙惑星科学)：P-CG 宇宙惑星科学複合領域・一般

15:30 ~ 17:00 | A03 東京ベイ幕張ホール

[P-CG22] Shock responses of planetary materials elucidated from meteorites and dynamic compression experiments

コンビーナ:関根 利守(Center for High Pressure Science and Technology Advanced Research)、奥地 拓生(岡山大学惑星物質研究所)、座長:奥地 拓生(岡山大学)、Yongjae Lee(Yonsei University)

15:30 ~ 15:45

[PCG22-07] Dynamic Compression at Pohang X-ray Free Electron Laser Facility (PAL-XFEL)

★Invited Papers

*Yongjae Lee[1] (1.Yonsei University, Seoul, Korea)

15:45 ~ 16:00

[PCG22-08] Exploration of extreme melt states of silicate usign high-power laser and XFEL

★Invited Papers

*尾崎 典雅[1] (1.大阪大学)

16:00 ~ 16:15

[PCG22-09] Hugoniot measurements for silicate: Understanding silicate magma under the planetary impacts

*梅田 悠平[1]、尾崎 典雅[1]、関根 利守[2]、Bruno Albertazzi[3]、Alessandra Benuzzi-Mounaix[3]、Riccardo Bolis[3]、Marco Guaruaglini[3]、片桐 健登[1]、兒玉 了祐[1]、Michel Koeing[3]、宮西 宏併[4]、森岡 信太郎[1]、西川 豊人[1]、大井 修吾[5]、Alessandra Ravasio[3]、坂和 洋一[4]、佐野 孝好[4]、佐藤 友子[6] (1.大阪大学大学院工学研究科、2.HPSTAR、3.エコールポリテクニーク、4.大阪大学レーザー科学研究所、5.滋賀大学、6.広島大学大学院理学研究科)

16:15 ~ 16:30

[PCG22-10] An experimental design to determine iron melting at the Earth’s core conditions via in-situ X-ray diffraction technique at high power laser facility

★Invited Papers

*Hao Liu[1] (1.Laser fusion research center)

16:30 ~ 16:45

[PCG22-11] Study on transport properties of liquid iron and iron alloy under high temperature and high pressure using the laser shock technique

*宮西 宏併[1]、尾崎 典雅[2]、大村 訓史[3]、Marion Harmand[4]、Andy Krygier[5]、西川 豊人[2]、梅田 悠平[2]、重森 啓介[1]、坂和 陽一[1]、佐野 孝好[1]、兒玉 了祐[1,2] (1.大阪大学レーザー科学研究所、2.大阪大学工学研究科、3.広島工業大学工学部、4.IMPMC, Sorbonne Université、5.LLNL)

16:45 ~ 17:00

[PCG22-12] Laser shock compression in LFRC

*Liang Sun[1] (1.Laser Fusion Research Center, CAEP)

[E] 口頭発表 | セッション記号 A (大気水圏科学)：A-AS 大気科学・気象学・大気環境

13:45 ~ 15:15 | 104 1F

[A-AS03] 大規模な水蒸気場と組織化した雲システム

コンビーナ:三浦 裕亮(国立大学法人 東京大学大学院 理学系研究科 地球惑星科学専攻)、濱田 篤(富山大学)、横井 覚(海洋研究開発機構)、佐藤 正樹(東京大学大気海洋研究所)、座長:三浦 裕亮

13:45 ~ 14:00

[AAS03-01] Boundary-Layer Control on Convective Self-Aggregation

★Invited Papers

*Da YANG[1,2] (1.University of California, Davis、2.Lawrence Berkeley National Laboratory)

14:00 ~ 14:15

[AAS03-02] 高解像度放射対流平衡実験における積雲アンサンブルの統計的性質

*柳瀬 友朗[1,2]、竹見 哲也[2] (1.京都大学大学院理学研究科、2.京都大学防災研究所)

14:15 ~ 14:30

[AAS03-03] **The role of interactive SST in the cloud-resolving simulations of aggregated convection**

★Invited Papers

*Chien-Ming Wu[1]、Yan-Ting Chen[1] (1.National Taiwan University)

14:30 ~ 14:45

[AAS03-04] **Role of coastal convection to moisture buildup during the South China Sea summer monsoon onset**

*Wei-Ting Chen[1]、Wei-Ming Tsai[1,2]、Chien-Ming Wu[1]、Peng-Jen Chen[1] (1.National Taiwan University、2.University of Miami)

14:45 ~ 15:00

[AAS03-05] Resolution dependencies of tropical convection in a global cloud/cloud-system resolving model

★Invited Papers

*宮川 知己[1]、三浦 裕亮[2] (1.東京大学大気海洋研究所、2.東京大学大学院理学系研究科)

15:00 ~ 15:15

[AAS03-06] 海洋大陸西部における対流活動が大規模場に及ぼす影響：YMCスマトラ集中観測期間の数値シミュレーション

*那須野 智江[1] (1.国立研究開発法人　海洋研究開発機構)

[E] 口頭発表 | セッション記号 A (大気水圏科学)：A-AS 大気科学・気象学・大気環境

15:30 ~ 17:00 | 104 1F

[A-AS03] 大規模な水蒸気場と組織化した雲システム

コンビーナ:三浦 裕亮(国立大学法人 東京大学大学院 理学系研究科 地球惑星科学専攻)、濱田 篤(富山大学)、横井 覚(海洋研究開発機構)、佐藤 正樹(東京大学大気海洋研究所)、座長:横井 覚

15:30 ~ 15:45

[AAS03-07] A Mechanism for the Maintenance of Sharp Tropical Margins

★Invited Papers

*増永 浩彦[1]、Brian Mapes[2] (1.名古屋大学、2.マイアミ大学)

15:45 ~ 16:00

[AAS03-08] Observational Evidence of Mixed Rossby-Gravity Waves as a Driving Force for the MJO Convective Initiation and Propagation

*高須賀 大輔[1,2]、佐藤 正樹[1]、横井 覚[2] (1.東京大学大気海洋研究所、2.海洋研究開発機構)

16:00 ~ 16:15

[AAS03-09] A characteristic of the MJO as a part of enhanced large-scale zonal circulation

*末松 環[1]、三浦 裕亮[2] (1.Atmosphere and Ocean Reaserch Institute, The University of Tokyo、2.School of Science, The University of Tokyo)

16:15 ~ 16:30

[AAS03-10] **The role of the moisture on the occurrences and distribution of the Amazonian mesoscale convective systems**

*Amanda Rehbein[1,2]、Masaki Satoh[2]、Tercio Ambrizzi[1] (1.Univ. of Sao Paulo、2.Univ. of Tokyo)

16:30 ~ 16:45

[AAS03-11] Interdecadal Change of the Impact of Eurasian Snow on Spring Precipitation Over Southern China

*Dingrui Cao[1] (1.Zhejiang University)

16:45 ~ 17:00

[AAS03-12] 日本の暖候期の豪雨に影響するAtmospheric Riverとその循環場の解析

末藤 菜保[1]、*谷田貝 亜紀代[1]、高藪 縁[2] (1.弘前大学大学院理工学研究科、2.東京大学大気海洋研究所)

[E] 口頭発表 | セッション記号 A (大気水圏科学)：A-HW 水文・陸水・地下水学・水環境

13:45 ~ 15:15 | 103 1F

[A-HW23] 水循環・水環境

コンビーナ:町田 功(産業技術総合研究所地質調査総合センター)、山崎 大(東京大学生産技術研究所)、林 武司(秋田大学教育文化学部)、福士 圭介(金沢大学環日本海域環境研究センター)、座長:町田 功(産業技術総合研究所地質調査総合センター)

13:45 ~ 14:00

[AHW23-01] 降雨流出過程に関する山地斜面での観測における斜面内圧（間隙空気圧）の測定方法の検討
★招待講演

*岩上 翔[1]、野口 正二[1]、清水 貴範[1]、久保田 多余子[1]、飯田 真一[1]、荒木 誠[1] (1.国立研究開発法人 森林研究・整備機構 森林総合研究所)

14:00 ~ 14:15

[AHW23-02] **A method to quantify the influence of total water storage change on climate elasticity of streamflow**

*Yin Tang[1] (1.Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Science)

14:15 ~ 14:30

[AHW23-03] **Trade-off analysis of discharge-desiltation-turbidity and sediment simulation of a combined reservoir–river system under multi-phase and multi-layer conjunctive releasing operation**

*Chien-Lin Huang[1]、Nien-Sheng Hsu[1]、Gene Jiing-Yun You[1] (1.National Taiwan University, Taiwan)

14:30 ~ 14:45

[AHW23-04] Gradient change of soil moisture effect on next-day precipitation identified via a Random Forest-Granger causality model

*Lu Li[1]、Wei ShangGuan[1]、Shu Peng Zhang[1]、Jin Jing Pan[1]、Nan Wei[1]、Yong Jiu Dai[1] (1.Guangdong Province Key Laboratory for Climate Change and Natural Disaster Studies, School of Atmospheric Sciences, Sun Yat-sen University)

14:45 ~ 15:00

[AHW23-05] **Using data-driven methods to explore the predictability of surface soil moisture with FLUXNET site data**

*jinjing Pan[1] (1.Guangdong Province Key Laboratory for Climate Change and Natural Disaster Studies, School of Atmospheric Sciences, Sun Yat-sen University.)

15:00 ~ 15:15

[AHW23-23] Global Analyis of the Hydrological Sensitivity to Climate Variability

*Marisol Dominguez[1]、Hugo Alberto Gutierrez-Jurado[1] (1.University of Texas at El Paso)

[E] 口頭発表 | セッション記号 A (大気水圏科学)：A-HW 水文・陸水・地下水学・水環境

15:30 ~ 17:00 | 103 1F

[A-HW23] 水循環・水環境

コンビーナ:町田 功(産業技術総合研究所地質調査総合センター)、山崎 大(東京大学生産技術研究所)、林 武司(秋田大学教育文化学部)、福士 圭介(金沢大学環日本海域環境研究センター)、座長:渡辺 恵

15:30 ~ 15:45

[AHW23-06] **A review on the global soil property maps for Earth system model**

Yongjiu Dai[1]、*Wei Shangguan[1]、Dagang Wang[2]、Nan Wei[1]、Qinchuan Xin[2]、Hua Yuan[1]、Shupeng Zhang[1]、Shaofeng Liu[1]、Fapeng Yan[3]、Xingji Lu[1] (1. Guangdong Province Key Laboratory for Climate Change and Natural Disaster Studies, School of Atmospheric Sciences, Sun Yat-sen University、2.School of Geography and Planning, Sun Yat-sen University、3.College of Global Change and Earth System Science, Beijing Normal University)

15:45 ~ 16:00

[AHW23-07] **Estimating near surface soil moisture at a high spatial resolution using an in-situ data based model**

*Indishe Prabath Senanayake[1]、In-Young Yeo[1,2]、Natthachet Tangdamrongsub[3,4]、Garry R Willgoose[1]、Gregory R Hancock[5]、Tony Wells[1]、Bin Fang[6]、Venkataraman Lakshmi[6]、Jeffrey P Walker[7] (1.School of Engineering, Faculty of Engineering and Built Environment, The University of Newcastle, Callaghan, NSW 2308, Australia.、2.Department of Geographical Sciences, University of Maryland, College Park, MD 20742, USA.、3.Earth System Science Interdisciplinary Center, University of Maryland, College Park, Maryland, USA.、4.Hydrological Sciences Laboratory, NASA Goddard Space Flight Center, Greenbelt, Maryland, USA.、5.School of Environmental and Life Sciences, Faculty of Science, The University of Newcastle, Callaghan, NSW 2308, Australia.、6.School of Earth Ocean and Environment, University of South Carolina, Columbia, SC 29223, United States.、7.Department of Civil Engineering, Monash University, Clayton, Victoria 3800, Australia.)

16:00 ~ 16:15

[AHW23-08] Representation of dams in global flood inundation simulations by coupling the global hydrological model H08 and the global hydrodynamic model CaMa-Flood

*Julien Eric Boulange[1]、Naota Hanasaki[1] (1.National Institute for Environmental Studies)

16:15 ~ 16:30

[AHW23-09] An investigation into a potential long subglacial river beneath the Greenland ice sheet using SICOPOLIS simulations.

*Christopher Chambers[1]、Ralf Greve[1]、Bas Altena[2]、Pierre-Marie Lefeuvre[2] (1.Hokkaido University、2.University of Oslo)

16:30 ~ 16:45

[AHW23-10] **Changes in Annual Rainfall patterns in the Democratic Republic of Congo: Congo river basin**

*Chetan Sharma[1]、Chandra Shekhar Prasad Ojha[1] (1.Indian Institute of Technology Roorkee)

16:45 ~ 17:00

[AHW23-11] Seasonality in the extreme precipitation events linked to temperature over Japan

*Sridhara Nayak[1]、Tetsuya Takemi[1] (1.Disaster Prevention Research Institute, Kyoto University)

[E] 口頭発表 | セッション記号 A (大気水圏科学)：A-CG 大気海洋・環境科学複合領域・一般

13:45 ~ 15:15 | 301A 3F

[A-CG32] Global Carbon Cycle Observation and Analysis

コンビーナ:市井 和仁(千葉大学)、Patra Prabir(Research Institute for Global Change, JAMSTEC)、Forrest M. Hoffman(Oak Ridge National Laboratory)、Makoto Saito(National Institute of Environmental Studies)、座長:市井 和仁

13:45 ~ 14:00

[ACG32-01] A high-resolution fossil fuel CO2 emission gridded dataset for tracer transport simulations and flux inversions: An overview, evaluations, applications and future perspectives

★Invited Papers

*Tomohiro Oda[1,2]、Shamil Maksyutov [3]、Miguel O. Roman [2,4]、Zhousen Wang [4]、Thomas Lauvaux[6,5]、Sha Feng [5]、Rostyslav Bun [7,8]、James Wang [2,1]、Randy Kawa [1]、Lesley Ott[1]、Steven Pawson[1] (1.NASA Goddard Space Flight Center, Greenbelt, MD, USA 、2.Universities Space Research Association, Columbia, MD, USA 、3.Center for Global Environmental Research, National Institute for Environmental Studies, Tsukuba, Ibaraki, Japan 、4.Terrestrial Information Systems Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD, USA 、5.Department of Meteorology and Atmospheric Science, Penn. State University, State College, PA, USA 、6.Laboratoire des sciences du climat et de l'environnement, Gif sur Yvette, France、7.Lviv Polytechnic National University, Lviv, Ukraine 、8.University of Dąbrowa Górnicza, Górnicza, Poland)

14:00 ~ 14:15

[ACG32-02] **グローバル二酸化炭素排出インベントリーの不確実性の低減に向けて**

*叢 日超[1]、齊藤 誠[1]、平田 竜一[1]、伊藤 昭彦[1] (1.国立環境研究所　地球環境研究センター)

14:15 ~ 14:30

[ACG32-03] Evaluation of MIROC4-ACTM reanalysis of GHGs concentrations using aircraft

*Jagat Bisht[1]、Prabir Patra[1]、Naveen Chandra[1]、Sergey Gromov[2]、Taku Umezawa[3]、Andreas Zahn[4]、cARL A. M. Brenninkmeijer[5] (1.Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Yokohama, Japan、2.Max Planck Institute for Chemistry, Mainz, Germany、3.National Institute for Environmental Studies, Tsukuba, Japan、4.Karlsruhe Institute of Technology (KIT), Institute for Meteorology and Climate Research, Karlsruhe, Germany、5.Max Planck Institute for Chemistry, Air Chemistry Division, Mainz, Germany)

14:30 ~ 14:45

[ACG32-04] **Carbon flux estimation using NICAM-TM 4D-Var and GOSAT data towards GOSAT-2 Level 4 product**

*佐伯 田鶴[1]、丹羽 洋介[1]、齊藤 誠[1] (1.国立研究開発法人 国立環境研究所)

14:45 ~ 15:00

[ACG32-05] **Attribution of the ambiguity in methane's growth rate shifts during 1988-2016.**

*Naveen Chandra[1]、Prabir Patra[1] (1.Japan Agency for Marine Earth Science and Technology)

15:00 ~ 15:15

[ACG32-06] **Ocean uptake and land use change emissions suppressed atmospheric CO_2 growth in the 2015/16 El Niño**

*近藤 雅征[1]、Landschützer Peter [2]、Iida Yousuke [3]、Houghton Richard [4]、Sitch Stephen [5] (1.千葉大学　環境リモートセンシング研究センター、2.Max Planck Institute for Meteorology、3.Global Environment and Marine Department, Japan Meteorological Agency、4.Woods Hole Research Center、5.University of Exeter)

[E] 口頭発表 | セッション記号 A (大気水圏科学)：A-CG 大気海洋・環境科学複合領域・一般

15:30 ~ 17:00 | 301A 3F

[A-CG32] Global Carbon Cycle Observation and Analysis

コンビーナ:市井 和仁(千葉大学)、Patra Prabir(Research Institute for Global Change, JAMSTEC)、Forrest M. Hoffman(Oak Ridge National Laboratory)、Makoto Saito(National Institute of Environmental Studies)、座長:Prabir Patra

15:30 ~ 15:45

[ACG32-07] Observing vegetation seasonal dynamics in Japan with Himawari-8 hypertemporal data

*Tomoaki Miura[1,2]、Shin Nagai[2]、Kazuhito Ichii[3]、Hiroki Yoshioka[4] (1.University of Hawaii at Manoa、2.Japan Agency for Marine-Earth Science and Technology、3.Center for Environmental Remote Sensing, Chiba University、4.Aichi Prefectural University)

15:45 ~ 16:00

[ACG32-08] Carbon and Water Fluxes at High spatial Resolutions through Down-Scaling

*Jiquan Chen[1]、Pietro Sciusco[1]、Ranjeet John[1]、Zutao Ouyang[1] (1.Michigan State University)

16:00 ~ 16:15

[ACG32-09] **Connecting Satellite Based Spectral Modelling Approach and Forest Inventory to Model Biomass and Carbon Stocks in Natural and Planted Forest over part of Semi-arid zone, India**

*SWATI UNIYAL[1]、Siti Raju Rao (1.Andhra University)

16:15 ~ 16:30

[ACG32-10] **Allocation of forest net primary production varies by forest age and air temperature**

*Xiang Song[1]、Xiaodong Zeng[1]、Dongxiao Tian[2] (1.IAP, CAS、2.Beijing Meteorological Information Center)

16:30 ~ 16:45

[ACG32-11] Analyzing Model Biases in Terrestrial Carbon Cycle Submodels in Earth System Models and Offline Models

*市井 和仁[1]、村上 和隆[2]、高山 宏明[3]、羽島 知洋[3]、立入 郁[3] (1.千葉大学、2.国立環境研究所、3.海洋研究開発機構)

16:45 ~ 17:00

[ACG32-12] Assessing terrestrial biogeochemical feedbacks in a strategically geoengineered climate

*Forrest M. Hoffman[1,2]、Cheng-En Yang[2,1]、Joshua S. Fu[2,1]、Simone Tilmes[3]、Lili Xia[4]、Douglas G. MacMartin[5]、Jadwiga H. Richter[3]、Michael Mills[3]、Ben Kravitz[6] (1.Oak Ridge National Laboratory、2.University of Tennessee、3.National Center for Atmospheric Research、4.Rutgers University、5.Cornell University、6.Pacific Northwest National Laboratory)

[E] 口頭発表 | セッション記号 H (地球人間圏科学)：H-DS 防災地球科学

9:00 ~ 10:30 | 304 3F

[H-DS09] 地すべりおよび関連現象

コンビーナ:千木良 雅弘(京都大学防災研究所)、王 功輝(京都大学防災研究所)、今泉 文寿(静岡大学農学部)、座長:今泉 文寿

9:00 ~ 9:15

[HDS09-01] Mechanical behavior modulated by shear surface morphology of simulated shear zone

*Yao Jiang[1]、Gonghui Wang[2]、Toshitaka Kamai[2] (1.Institute of Mountain Hazards and Environment, Chinese Academy of Sciences, China、2.Research Center on Landslide, Disaster Prevention Research Institute, Kyoto University, Japan)

9:15 ~ 9:30

[HDS09-02] On the Pre-failure Shear Behavior of Clayey Soil

*Chengrui Chang[1]、Gonghui Wang[1] (1.Disaster Prevention Research Institute, Kyoto University)

9:30 ~ 9:45

[HDS09-03] **GeoGuard: low-cost GNSS sensors for the continuous monitoring of landslides and structures**

*Andrea Gatti[1]、Giulio Tagliaferro[1]、Eugenio Realini[1]、Stefano Caldera[1] (1.Geomatics Research & Development srl)

9:45 ~ 10:00

[HDS09-04] **Landslide Susceptibility Analysis in the Chenyulan River Watershed, Taiwan**

*Po-Tsun Yeh[1]、Kuang-Tsung Chang[1] (1.National Chung Hsing University, Taiwan)

10:00 ~ 10:15

[HDS09-05] Investigating the Relationship Between Tree Height and Landslide Occurrence in the Ikawa Catchment, Central Japan

*Jamie Rhys Evans[1]、Fumitoshi Imaizumi[1] (1.Faculty of Agriculture, Shizuoka University)

10:15 ~ 10:30

[HDS09-06] チベット高原南縁と東縁における遷急点遡及による地すべり

*千木良 雅弘[1]、鄒 青穎[2]、チョウ シーユアン[4]、ウー シヨン[3] (1.京都大学防災研究所、2.弘前大学、3.西南交通大学、4.京都大学大学院理学研究科)

[E] 口頭発表 | セッション記号 H (地球人間圏科学)：H-DS 防災地球科学

10:45 ~ 12:15 | 304 3F

[H-DS09] 地すべりおよび関連現象

コンビーナ:千木良 雅弘(京都大学防災研究所)、王 功輝(京都大学防災研究所)、今泉 文寿(静岡大学農学部)、座長:王 功輝、土井 一生

10:45 ~ 11:15

[HDS09-07] Landslides caused by the 2018 Hokkaido Eastern Iburi Earthquake

★Invited Papers

*林 真一郎[1]、小山内 信智[1]、山田 孝[1]、桂 真也[1]、古市 剛久[1]、柳井 清治[2]、村上 泰啓[3]、宮崎 知与[4]、谷岡 勇市郎[1]、瀧口 茂隆[5]、宮崎 真由美[6] (1.北海道大学、2.石川県立大学、3.国立研究開発法人土木研究所寒地土木研究所、4.株式会社シン技術コンサル、5.国土交通省、6.株式会社パスコ)

11:15 ~ 11:45

[HDS09-08] On the coseismic landslides occurring on tephra slopes during the 2018 Hokkaido Eastern Iburi Earthquake

★Invited Papers

*王 功輝[1]、古谷 元[2] (1.京都大学防災研究所、2.富山県立大学)

11:45 ~ 12:00

[HDS09-09] Seismological and geotechnical surveys on the landslides induced by the 2018 Hokkaido Eastern Iburi earthquake

*土井 一生[1]、大澤 光[2]、松浦 純生[1] (1.京都大学防災研究所、2.筑波大学山岳科学センター)

[E] 口頭発表 | セッション記号 H (地球人間圏科学)：H-DS 防災地球科学

13:45 ~ 15:15 | 304 3F

[H-DS09] 地すべりおよび関連現象

コンビーナ:千木良 雅弘(京都大学防災研究所)、王 功輝(京都大学防災研究所)、今泉 文寿(静岡大学農学部)、座長:今泉 文寿、千木良 雅弘

13:45 ~ 14:15

[HDS09-10] Initiation conditions of debris flows in Ohsawa landslide, Mt. Fuji

★Invited Papers

*今泉 文寿[1]、山本 一樹[1]、池田 敦[4]、逢坂 興宏[1]、杉本 宏之[2]、鈴木 聡[2]、佐藤 慎一[2]、柏原 佳明[3]、西村 直記[3] (1.静岡大学農学部、2.国土交通省富士砂防事務所、3.アジア航測、4.筑波大学生命環境系)

14:15 ~ 14:30

[HDS09-11] 四万十付加体中の重力斜面変形と深層崩壊の発生に対する断層粘土を含む衝上断層の役割

*荒井 紀之[1]、千木良 雅弘[1] (1.京都大学防災研究所)

14:30 ~ 14:45

[HDS09-12] Control effect of huge faults on the structure of surrounding regional rock mass in the whole mountain: implications for the distribution pattern of coseismic landslides

*Chao HUANG[1,2]、Yusheng LI[1]、Chunhao WU[3]、Shujian YI[1,3]、Kai LIU[1,4]、Gonghui WANG[2] (1.State Key Laboratory of Geohazard Prevention and Geoenvironment Protection, Chengdu University of Technology, China、2.Disaster Prevention Research Institute, Kyoto University, Japan、3.Institute of Mountain Hazards and Environment, Chinese Academy of Sciences, China、4.China Railway Eryuan Engineering Group CO. LTD, China)

[E] 口頭発表 | セッション記号 H (地球人間圏科学)：H-TT 計測技術・研究手法

9:00 ~ 10:30 | 302 3F

[H-TT18] 環境トレーサビリティー手法の開発と適用

コンビーナ:陀安 一郎(総合地球環境学研究所)、大手 信人(京都大学大学院情報学研究科社会情報学専攻)、Gabriel J Bowen(University of Utah)、座長:Nobuhito Ohte(Kyoto University)

9:00 ~ 9:15

[HTT18-01] Environmental traceability methodology by multi-isoscapes

*陀安 一郎[1]、藤吉 麗[1]、藪崎 志穂[1]、SHIN Ki-Cheol[1]、中野 孝教[1]、谷口 真人[1] (1.総合地球環境学研究所)

9:15 ~ 9:45

[HTT18-02] Exploring physical and biological connections using isoscapes

★Invited Papers

*Gabriel J Bowen[1] (1.University of Utah)

9:45 ~ 10:00

[HTT18-03] Spatial and temporal variations in stable isotopes and soluble ions on high mountain snow surface of Mt. Tateyama, Toyama Prefecture, Japan

*竹内 望[1]、杉山 涼[1] (1.千葉大学)

10:00 ~ 10:15

[HTT18-04] Using Sr isotopes to determine the contribution of volcanic ash to Sr and Ca in stream waters in a chert watershed.

*越川 昌美[1]、渡邊 未来[1]、村田 智吉[1]、高松 武次郎[1]、三浦 真吾[1]、SHIN Ki-Cheol[2]、中野 孝教[2] (1.独立行政法人国立環境研究所、2.総合地球環境学研究所)

10:15 ~ 10:30

[HTT18-05] Influences of soil dust, sea salt and anthropogenic activities on ionic and Sr isotopic compositions of wet deposition in Iran

*横尾 頼子[1]、浅井 公輔[1]、堀井 彩衣[1]、安間 了[2]、Mehrabani Shiva[3]、申 基澈[4] (1.同志社大学理工学部、2.徳島大学、3.Kurdistan University、4.総合地球環境学研究所)

[E] 口頭発表 | セッション記号 H (地球人間圏科学)：H-TT 計測技術・研究手法

10:45 ~ 12:15 | 302 3F

[H-TT18] 環境トレーサビリティー手法の開発と適用

コンビーナ:陀安 一郎(総合地球環境学研究所)、大手 信人(京都大学大学院情報学研究科社会情報学専攻)、Gabriel J Bowen(University of Utah)、座長:Gabriel Bowen(The University of Utah)

10:45 ~ 11:00

[HTT18-06] Long-term increasing trend of line-conditioned excess in groundwater

*勝山 正則[1] (1.京都大学農学研究科)

11:00 ~ 11:15

[HTT18-07] Geochemistry of river water in the Okayama and Tottori Prefectures, Japan

*山下 勝行[1]、亀井 隆博[1]、岸本 悠河[1]、森 雅彦[1]、大井 あや[2]、大西 彩月[2]、栗原 洋子[2]、千葉 仁[1]、中野 孝教[3]、SHIN Ki-Cheol[4] (1.岡山大学大学院自然科学研究科、2.岡山大学理学部、3.大野市、4.総合地球環境学研究所)

11:15 ~ 11:30

[HTT18-08] Study on groundwater flow system at Oshino Village in Yamanashi Prefecture – Report 5. Estimation of the residence time in spring water and groundwater at Oshino Village.

*藪崎 志穂[1]、谷口 真人[1]、陀安 一郎[1]、秋道 智彌[1]、大森 昇[2]、後藤 健[2]、渡邉 宗一郎[2]、渡辺 仁[2] (1.総合地球環境学研究所、2.忍野村役場)

11:30 ~ 11:45

[HTT18-09] The hydrogen and oxygen isotopic compositions of water in the Chikusa River

*大串 健一[1]、藪崎 志穂[2]、陀安 一郎[2]、藤吉 麗[2]、中野 孝教[2]、SHIN Ki-Cheol[2]、横山 正[3]、三橋 弘宗[4]、伊藤 真之[1]、八杉 和輝[1] (1.神戸大学、2.総合地球環境学研究所、3.兵庫県立赤穂特別支援学校、4.兵庫県立大学)

11:45 ~ 12:00

[HTT18-10] Dynamics of sulfate and nitrate inferred from stable isotope techniques in Chikusa river watershed, Hyogo Prefecture

*藤吉 麗[1]、陀安 一郎[1]、藪崎 志穂[1]、原口 岳[1]、由水 千景[1]、大串 健一[2]、古川 文美子[2]、伊藤 真之[2]、山本 雄大[3]、横山 正[4]、三橋 弘宗[5] (1.総合地球環境学研究所、2.神戸大学、3.名古屋大学、4.兵庫県立赤穂特別支援学校、5.兵庫県立大学)

12:00 ~ 12:15

[HTT18-11] Chemistry and sulfur and oxygen isotope ratios of sulfate ion of water soluble component of suspended particulate matter at Okayama city.

*千葉 仁[1]、山本 翼[1] (1.岡山大学自然科学研究科)

[E] 口頭発表 | セッション記号 H (地球人間圏科学)：H-TT 計測技術・研究手法

13:45 ~ 15:15 | 302 3F

[H-TT18] 環境トレーサビリティー手法の開発と適用

コンビーナ:陀安 一郎(総合地球環境学研究所)、大手 信人(京都大学大学院情報学研究科社会情報学専攻)、Gabriel J Bowen(University of Utah)、座長:陀安 一郎(総合地球環境学研究所)

13:45 ~ 14:00

[HTT18-12] 登山家動物たちの種子散布は植物が温暖から逃れるのに有効か？

*直江 将司[1]、陀安 一郎[2] (1.国立研究開発法人　森林研究・整備機構　森林総合研究所、2.大学共同利用機関法人　人間文化研究機構 総合地球環境学研究所)

14:00 ~ 14:15

[HTT18-13] Spatial distribution of nitrogen stable isotope ratio in deer feces in an agro-environment, Osaka

*原口 岳[1]、幸田 良介[2]、陀安 一郎[1] (1.大学共同利用機関法人　人間文化研究機構　総合地球環境学研究所、2.大阪府立環境農林水産総合研究所)

14:15 ~ 14:30

[HTT18-14] 付着藻類の炭素窒素同位体比からみる富山県東部森林域から河川への栄養塩供給

*張 勁[1]、増田 亮介[1]、片境 紗希[1]、太田 民久[1]、稲村 修[2]、中川 書子[3] (1.富山大学、2.魚津水族館、3.名古屋大学)

14:30 ~ 14:45

[HTT18-15] Investigation on the possibility of the identification of air pollutant sources using stable isotope ratios of lead and strontium

*櫻井 伸治[1]、中桐 貴生[1]、田中 滉介[1]、堀野 治彦[1]、SHIN Ki-Cheol[2]、陀安 一郎[2]、藪崎 志穂[2] (1.大阪府立大学、2.総合地球環境学研究所)

14:45 ~ 15:00

[HTT18-16] Magnesium and zinc stable isotopes in stream ecology

*Kai Nils Nitzsche[1]、Yoshikazu Kato[1]、Ki-Cheol Shin[1]、Hiromitsu Kamauchi[1]、Ichiro Tayasu[1] (1.Research Institute for Humanity and Nature)

15:00 ~ 15:15

[HTT18-17] A mechanitic metabolic model of nitrogen stable isotope dynamics in trophic processes

*石井 励一郎[1]、相田 真希[2]、和田 英太郎 (1.総合地球環境学研究所、2.海洋研究開発機構)

[E] 口頭発表 | セッション記号 H (地球人間圏科学)：H-CG 地球人間圏科学複合領域・一般

15:30 ~ 17:00 | 302 3F

[H-CG28] Implementing Integrated Research for Sustainable Future

コンビーナ:氷見山 幸夫(北海道教育大学名誉教授)、近藤 昭彦(千葉大学環境リモートセンシング研究センター)、櫻井 武司(国立大学法人東京大学大学院農学生命科学研究科)、阿部 健一(総合地球環境学研究所)、座長:Ernan Rustiadi(Bogor Agricultural University)、王 勤学(国立環境研究所)、takeshi sakurai

15:30 ~ 15:45

[HCG28-01] Implementing Integrated Research for Sustainable Future - a human geoscience perspective

*氷見山 幸夫[1] (1.北海道教育大学名誉教授)

15:45 ~ 16:00

[HCG28-02] **Application of environmental carrying capacity analysis and land cover change scenarios in collaborative spatial planning process: The Jakarta Megacity Case**

★Invited Papers

*ERNAN RUSTIADI[1]、Andrea Emma Pravitasari[2]、Diar Shiddiq[1]、Laode Syamsul Iman[1]、Setyardi Pratika Mulya[2]、Mia Ermyanila[1]、Nur Etika Karyati[1] (1.Center for Regional System Analysis, Planning and Development, Bogor Agricultural University 、2.Department of Soil Science and Land Resource, Faculty of Agriculture, Bogor Agricultural University)

16:00 ~ 16:15

[HCG28-03] Does the Market Economy Save the Local Natural Resources While Improving Human Welfare? The Case of 101 Natural Forests in the Middle Hills of Nepal

*櫻井 武司[1]、橘 永久[2]、Rayamajhi Santosh[3] (1.東京大学、2.千葉大学、3.Tribhuvan University)

16:15 ~ 16:30

[HCG28-04] Academic-public-private partnerships for sustainable herding under increasing frequency of climate hazards

*篠田 雅人[1] (1.名古屋大学大学院環境学研究科)

16:30 ~ 16:45

[HCG28-05] 現代北京市における公墓を主体とする死後の土地利用と市民の葬送

*土居 晴洋[1]、柴 彦威[2]、徐 培瑋[3] (1.大分大学教育学部、2.北京大学、3.北京師範大学)

16:45 ~ 17:00

[HCG28-06] Restoration and sustainable land management of degraded landscapes in Asia and Africa

★Invited Papers

*大黒 俊哉[1] (1.東京大学大学院農学生命科学研究科)

[E] 口頭発表 | セッション記号 S (固体地球科学)：S-SS 地震学

13:45 ~ 15:15 | コンベンションホールB 2F

[S-SS06] Nankai Trough Seismogenic Zone Experiment: Logging and sampling the seismogenic megathrust

コンビーナ:金川 久一(千葉大学大学院理学研究科)、Demian M Saffer(Pennsylvania State University)、木下 正高(東京大学地震研究所)、座長:金川 久一(千葉大学大学院理学研究科)、Saffer Demian(Department of Geosciences, Pennsylvania State University)、木下 正高(東京大学地震研究所)

13:45 ~ 14:00

[SSS06-01] Geoscientific information about plate boundary along the Nankai Trough provided by the GNSS-A

★Invited Papers

*横田 裕輔[1]、石川 直史[2] (1.東京大学生産技術研究所、2.海上保安庁海洋情報部)

14:00 ~ 14:15

[SSS06-02] Deep Drilling at the Nankai Trough: IODP NanTroSEIZE Expedition 358 Summary and First Results

★Invited Papers

*Harold Tobin[1]、Takehiro Hirose[7]、Matt Ikari[5]、Kyuichi Kanagawa[10]、Gaku Kimura[3]、Masataka Kinoshita[8]、Hiroko Kitajima[6]、Demian M Saffer[4]、Asuka Yamaguchi[9]、Lena Maeda[2]、Nobu Eguchi[2]、Sean Toczko[2] (1.Department of Earth and Space Sciences, University of Washington、2.JAMSTEC-CDEX、3.Tokyo Un. of Marine Science-Technology、4.Penn State University、5.MARUM Un. of Bremen、6.Texas A&M University、7.JAMSTEC-KCC、8.Un. of Tokyo Earthquake Research Institute、9.Un. of Tokyo AORI、10.Chiba University)

14:15 ~ 14:30

[SSS06-03] Coexistence of soft and hard sediments at deep Nankai accretionary prism, NanTro SEIZE Project, IODP Exp.358

*坂口 有人[1,2]、Michael Strasser[3]、浜橋 真理[4,5]、廣瀬 丈洋[2]、北島 弘子[6]、Expedition 358 Scientists IODP (1.山口大学、2.海洋研究開発機構、3.University of Innsbruck、4.東京大学、5.Nanyang Technological University、6.Texas A&M University)

14:30 ~ 14:45

[SSS06-04] Active and passive seismic experiment during the IODP Exp. 358 deep riser drilling in the Nankai Trough, Japan

*木村 俊則[1]、利根川 貴志[1]、白石 和也[1]、荒木 英一郎[1]、中村 恭之[1]、海宝 由佳[1]、藤江 剛[1]、三浦 誠一[1]、小平 秀一[1]、櫻井 紀旭[1]、真田 佳典[1]、木戸 ゆかり[1]、木下 正高[2]、高橋 成実[3,1]、町田 祐弥[1]、西田 周平[1] (1.国立研究開発法人海洋研究開発機構、2.東京大学地震研究所、3.国立研究開発法人防災科学技術研究所)

14:45 ~ 15:00

[SSS06-05] Microfabric analysis of damaged zone of principal shear zone in the frontal megathrust in the Nankai Trough

*木村 学[1]、山口 飛鳥[2]、濱田 洋平[3]、矢部 優[4] (1.東京海洋大学 海洋資源環境学部、2.東京大学 大気海洋研究所、3.海洋研究開発機構 高知コア研究所、4.海洋研究開発機構)

15:00 ~ 15:15

[SSS06-06] Seismic Imaging of Mud Diapirs in Northern Kumano Basin, Nankai Trough

*Gregory F Moore[1]、Miho Asada[2]、Shuichi Kodaira[2]、Achim Kopf[3] (1.University of Hawaii at Manoa、2.JAMSTEC、3.MARUM)

[E] 口頭発表 | セッション記号 S (固体地球科学)：S-IT 地球内部科学・地球惑星テクトニクス

9:00 ~ 10:30 | A10 東京ベイ幕張ホール

[S-IT21] 核-マントルの相互作用と共進化

コンビーナ:河合 研志(東京大学大学院理学系研究科地球惑星科学専攻)、飯塚 毅(東京大学)、太田 健二(東京工業大学大学院理工学研究科地球惑星科学専攻)、土屋 卓久(愛媛大学地球深部ダイナミクス研究センター)、座長:河合 研志、Sebastian Ritterbex

9:00 ~ 9:15

[SIT21-19] Seismological Explorations of Earth's Outer Core: Normal Mode and Body Wave Analyses

★Invited Papers

*Jessica C E Irving[1]、Sanne Cottaar[2]、Vedran Lekic[3]、Wenbo Wu[4] (1.Princeton University、2.University of Cambridge、3.University of Maryland, College Park、4.California Institute of Technology)

9:15 ~ 9:30

[SIT21-20] ディスカッション

*河合 研志[1] (1.東京大学)

9:30 ~ 9:45

[SIT21-21] On the 1-D radial convective structure of the Earth’s core inferred from a coupled core-mantle evolution model

*中川 貴司[1] (1.香港大学地球科学専攻)

9:45 ~ 10:00

[SIT21-22] Structural and transport properties of liquid iron-light-element mixtures under outer core conditions

*大村 訓史[1]、土屋 卓久[2] (1.広島工業大学、2.愛媛大学)

10:00 ~ 10:15

[SIT21-23] Development of New Technology for Geoneutrino Directional Measurement

*渡辺 寛子[1] (1.東北大学ニュートリノ科学研究センター)

10:15 ~ 10:30

[SIT21-24] Investigation of multi light elements in iron-silicate-water system using high pressure and temperature neutron experiments: Implications for the Earth's evolution

★Invited Papers

*飯塚 理子[1]、後藤 弘匡[2]、福山 鴻[1]、鍵 裕之[1] (1.東京大学大学院理学系研究科地殻化学実験施設、2.東京大学物性研究所)

[E] 口頭発表 | セッション記号 S (固体地球科学)：S-IT 地球内部科学・地球惑星テクトニクス

10:45 ~ 12:15 | A10 東京ベイ幕張ホール

[S-IT21] 核-マントルの相互作用と共進化

コンビーナ:河合 研志(東京大学大学院理学系研究科地球惑星科学専攻)、飯塚 毅(東京大学)、太田 健二(東京工業大学大学院理工学研究科地球惑星科学専攻)、土屋 卓久(愛媛大学地球深部ダイナミクス研究センター)、座長:辻野 典秀、上木 賢太

10:45 ~ 11:00

[SIT21-25] Low hydrogen contents in the cores of terrestrial planets

★Invited Papers

*Vincent Clesi[1]、Mohamed Ali Bouhifd[2]、Nathalie Bolfan-Casanova[2]、Geeth Manthilake[2]、Federica Schiavi[2]、Caroline Raepsaet[3]、Hélène Bureau[4]、Hicham Khodja[3]、Denis Andrault[2] (1.Laboratoire de Geologie de Lyon - Terre, Planètes, Environnement, Université Claude Bernard Lyon 1, CNRS, ENS-Lyon, 69622 Villeurbanne, France.、2.Laboratoire Magmas et Volcans, Université Clermont Auvergne, CNRS UMR 6524, OPGC–IRD, Campus Universitaire des Cézeaux, 6 Avenue Blaise Pascal, 63178 Aubière Cedex, France.、3.Laboratoire d'Etude des Eléments Légers, NIMBE, CEA, CNRS, Université Paris-Saclay, CEA Saclay, 91191 Gif sur Yvette Cedex, France.、4.Institut de Minéralogie et de Physique de la Matière et de Cosmochimie, Sorbonne Universités, UMR CNRS-UPMC 7590, 4 place Jussieu, 75252 Paris, France.)

11:00 ~ 11:15

[SIT21-26] Discussion

*土屋 卓久[1] (1.愛媛大学地球深部ダイナミクス研究センター)

11:15 ~ 11:30

[SIT21-27] Fe_2S: the most iron-rich Fe-S compound at pressures of the inner core

*舘野 繁彦[1,2]、小澤 春香[2,3]、廣瀬 敬[1,4]、鈴木 敏弘[5] (1.東京工業大学地球生命研究所、2.岡山大学惑星物質研究所、3.日本原子力研究開発機構原子力基礎工学研究センター 、4.東京大学地球惑星科学専攻、5.東京大学地殻化学実験施設)

11:30 ~ 11:45

[SIT21-28] First-principles Investigation of Iron Diffusion Properties with Implications to Inner Core Plasticity

★Invited Papers

*Sebastian Ritterbex[1]、Taku Tsuchiya[1] (1.GRC Ehime University)

11:45 ~ 12:00

[SIT21-29] Dependence of the dipole component dominancy on the Rayleigh number and inner core size in geodynamo simulations

*西田 有輝[1]、加藤 雄人[1]、松井 宏晃[2]、松島 政貴[3]、熊本 篤志[1] (1.東北大学大学院理学研究科地球物理学専攻、2.Dept. of Earth and Planetary Sciences, University of California, Davis、3.東京工業大学理学院地球惑星科学系)

12:00 ~ 12:15

[SIT21-30] Elasticity of Fe-Si Alloy

*土屋 卓久[1]、福永 優[1] (1.愛媛大学地球深部ダイナミクス研究センター)

[E] 口頭発表 | セッション記号 S (固体地球科学)：S-MP 岩石学・鉱物学

13:45 ~ 15:15 | A08 東京ベイ幕張ホール

[S-MP29] Oceanic and Continental Subduction Processes

コンビーナ:Hafiz Ur REHMAN(Department of Earth and Environmental Sciences, Graduate School of Science and Engineering, Kagoshima University)、辻森 樹(東北大学)、Chin-Ho Tsai(Department of Natural Resources and Environmental Studies, National Dong Hwa University)、岡本 和明(埼玉大学教育学部地学)、座長:Hafiz REHMAN(Kagoshima University)、Tatsuki Tsujimori

13:45 ~ 14:00

[SMP29-01] Pb-isotope of Fe-Ni alloy associated with serpentinite: Geochemical constraints on the fluid-mediated hyper-reducing environment in mantle wedge

★Invited Papers

*掛札 真由[1]、辻森 樹[1]、山下 勝行[2]、飯塚 義之[3] (1.東北大学、2.岡山大学大学院自然科学研究科、3.中央研究院地球科学研究所)

14:00 ~ 14:15

[SMP29-02] PETROCHEMISTRY AND AGE DETERMINATION OF THE NEWLY DISCOVERED ECLOGITE IN THE WESTERN MONGOLIA

*苗村 康輔[1]、チョイドンジャムツ エルデンジャルガル[4]、加藤 丈典[5]、ジャフハラン オトゴンクゥ[3]、道林 克禎[2] (1.名古屋大学博物館、2.名古屋大学環境学研究科、3.中国地質科学院、4.モンゴル科学アカデミー、5.名古屋大学宇宙地球環境研究所)

14:15 ~ 14:45

[SMP29-03] **Continental subduction, "*Intraslab UHP Metasomatism*", and the formation of metamorphic diamond**

★招待講演

*小笠原 義秀[1] (1.Department of Earth Sciences, Waseda University)

14:45 ~ 15:00

[SMP29-04] Ultrahigh-pressure pseudotachylyte in a marble

★Invited Papers

*西山 忠男[1]、藤本 智也[1] (1.熊本大学先端科学研究部理学系地球環境科学講座)

15:00 ~ 15:15

[SMP29-05] Dehydration and Deformation process of subducted large Oceanic Pleateau -case study of the Mikabu blueschist-

*岡本 和明[1] (1.埼玉大学教育学部地学)

[E] 口頭発表 | セッション記号 S (固体地球科学)：S-MP 岩石学・鉱物学

15:30 ~ 17:00 | A08 東京ベイ幕張ホール

[S-MP29] Oceanic and Continental Subduction Processes

コンビーナ:Hafiz Ur　REHMAN(Department of Earth and Environmental Sciences, Graduate School of Science and Engineering, Kagoshima University)、辻森 樹(東北大学)、Chin-Ho Tsai(Department of Natural Resources and Environmental Studies, National Dong Hwa University)、岡本 和明(埼玉大学教育学部地学)、座長:Tsai Chin-HO(National Dong Hwa University)、Hafiz REHMAN(Kagoshima University)

15:30 ~ 15:45

[SMP29-06] Unusually high Nb/Ta ratio of fluid-precipitated jadeites from New Idria serpentinite body, California: Implications for extreme fractionation in slab fluids

*高橋 菜緒子[1]、辻森 樹[2]、常 青[3]、木村 純一[3] (1.東北大学大学院理学研究科、2.東北大学東北アジア研究センター、3.海洋研究開発機構・地球内部物質循環研究分野)

15:45 ~ 16:00

[SMP29-07] The collision process interpreted using the systematic change of metamorphic pattern along theQinling–Dabie–Odesan collisional belt between the North and South Korea-China Cratons

★Invited Papers

*Chang Whan Oh[1,2] (1.Department of Earth and Environmental Sciences, Chonbuk National University, Jeonju, Republic of Korea、2.Environmental Science System Research Center, Chonbuk National University,Jeonju, Republic of Korea)

16:00 ~ 16:15

[SMP29-08] Contrasting collision processes between northwest and central Himalaya: examination from the "Lesser Himalayan granites” in Pakistan

*小笠原 正継[1]、福山 繭子[2]、Siddiqui Rehanul[3] (1.産業技術総合研究所地質調査総合センター地質情報研究部門、2.秋田大学理工学研究科、3.Balochistan University of Information Technology, Engineering and Management Sciences)

16:15 ~ 16:30

[SMP29-09] New petrologic indications of subduction metamorphism in the Yuli belt, eastern Taiwan

*Chin-Ho Tsai[1]、Chih-Ying Yeh[1]、Dominikus Deka Dewangga[1]、Yui Kouketsu[2]、Masaki Enami[3] (1.Department of Natural Resources & Environmental Studies, National Dong Hwa Univ.、2.Department of Earth & Planetary Sciences, Nagoya Univ.、3.Institute for Space-Earth Environmental Research, Nagoya Univ.)

16:30 ~ 16:45

[SMP29-10] **The importance of Mn-nodules on the sea floor during subduction for the formation of ophiolitic diamond**

*Richard Wirth[1] (1.Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences 3.5 Surface Geochemistry)

16:45 ~ 17:00

[SMP29-11] **Along-strike variability of primitive magmas inferred from olivine-hosted melt inclusions, southernmost Andean Southern Volcanic Zone, Chile**

*Derek Weller[1,2]、Charles R Stern[2] (1.Earthquake Research Institute、2.University of Colorado)

[E] 口頭発表 | セッション記号 S (固体地球科学)：S-MP 岩石学・鉱物学

13:45 ~ 15:15 | A07 東京ベイ幕張ホール

[S-MP30] 地殻-マントル・コネクション

コンビーナ:田村 芳彦(海洋研究開発機構　海域地震火山部門)、石塚 治(産業技術総合研究所活断層火山研究部門)、Chris Conway(Geological Survey of Japan)、座長:田村 芳彦(JAMSTEC)、Chris Conway、森下 知晃(金沢大学)

13:45 ~ 14:00

[SMP30-01] **Noble gas and carbon isotopic compositions of petit-spot lavas from southeast of Marcus Island**

★Invited Papers

*山本 順司[1]、河野 哲馬[2]、高畑 直人[3]、佐野 有司[3] (1.北海道大学総合博物館、2.北海道大学大学院理学院、3.東京大学大気海洋研究所)

14:00 ~ 14:15

[SMP30-02] A series of cummingtonite-bearing rhyolites in Niijima, Izu-Bonin arc, Japan: petrological and geochemical constraints

★Invited Papers

*荒川 洋二[1]、遠藤 大介[2]、大鹿 淳也[3]、新村 太郎[4]、池端 慶[1] (1.筑波大学　生命環境系 地球進化科学専攻、2.島根県立三瓶博物館サヒメル、3.中国地質大学（武漢）地球資源学部、4.熊本学園大学　経済学部)

14:15 ~ 14:30

[SMP30-03] **Generation of primary andesitic magma in oceanic arcs: Evidence from Kibblewhite Volcano, Kermadec Arc**

★Invited Papers

*平井 康裕[1,2]、田村 芳彦[2]、Kaj Hoernle[3]、Christian Timm[4]、Folkmar Hauff[3]、Reinhard Werner[3]、Bogdan Vaglarov[2]、常 青[2]、宮崎 隆[2]、木村 純一[2] (1.金沢大学大学院 自然科学研究科、2.海洋研究開発機構、3.ゲオマール海洋研究所、4.GNSサイエンス)

14:30 ~ 14:45

[SMP30-04] Petrogenesis of high-Mg# andesite lavas from Ruapehu volcano, New Zealand

*Chris Conway[1]、Katy Chamberlain[2]、Yumiko Harigane[1]、Daniel Morgan[3] (1.Geological Survey of Japan、2.Univ. Derby、3.Univ. Leeds)

14:45 ~ 15:00

[SMP30-05] Hydrous felsic magma generated by unmixing of slab-derived supercritical liquid: evidence from Rishiri Volcano, Kuril Arc

★Invited Papers

*谷内 元[1]、栗谷 豪[2,3]、横山 哲也[4,3]、中村 栄三[3]、中川 光弘[2] (1.北海道大学大学院理学院自然史科学専攻、2.北海道大学大学院理学研究院地球惑星科学部門、3.岡山大学惑星物質研究所、4.東京工業大学理学院地球惑星科学系)

15:00 ~ 15:15

[SMP30-06] Genesis of recent mafic volcanism in the Taupo Volcanic Zone, New Zealand: insights into the birth and death of cataclysmic caldera-forming systems?

*Georg F Zellmer[1]、Jun-Ichi Kimura[2]、Claudine Stirling[3]、Gert Lube[1]、Phil A Shane[4] (1.Volcanic Risk Solutions, Massey University, Tennent Drive, Palmerston North 4410, New Zealand、2.Department of Solid Earth Geochemistry, Japan Agency for Marine-Earth Science and Technology [JAMSTEC], Natsushima-cho 2-15, Yokosuka 237-0061, Japan、3.Department of Chemistry, University of Otago, Dunedin 9054, New Zealand、4.School of Environment, University of Auckland, Auckland 1142, New Zealand)

[E] 口頭発表 | セッション記号 S (固体地球科学)：S-MP 岩石学・鉱物学

15:30 ~ 17:00 | A07 東京ベイ幕張ホール

[S-MP30] 地殻-マントル・コネクション

コンビーナ:田村 芳彦(海洋研究開発機構　海域地震火山部門)、石塚 治(産業技術総合研究所活断層火山研究部門)、Chris Conway(Geological Survey of Japan)、座長:Chris Conway、田村 芳彦(JAMSTEC)

15:30 ~ 15:45

[SMP30-07] **Introducing an oceanic core complex in the Shikoku Basin: Mado Megamullion**

★Invited Papers

*小原 泰彦[1,2]、沖野 郷子[3]、秋澤 紀克[3]、藤井 昌和[4]、針金 由美子[5]、平野 直人[6]、平内 健一[7]、石塚 治[5]、町田 嗣樹[8]、道林 克禎[9]、Sanfilippo Alessio[10]、Snow Jonathan[11]、山下 浩之[12] (1.海上保安庁海洋情報部、2.海洋研究開発機構、3.東京大学大気海洋研究所、4.国立極地研究所、5.産業技術総合研究所、6.東北大学、7.静岡大学、8.千葉工業大学、9.名古屋大学、10.パビア大学、11.ヒューストン大学、12.神奈川県立生命の星・地球博物館)

15:45 ~ 16:00

[SMP30-08] Spatial variation of petrological and geochemical characteristics of mantle peridotites in Mado Megamullion, Shikoku Basin

*秋澤 紀克[1]、町田 嗣樹[2]、沖野 郷子[1]、小原 泰彦[3] (1.東京大学　大気海洋研究所、2.千葉工業大学　次世代海洋資源研究センター、3.海上保安庁　海洋情報部)

16:00 ~ 16:15

[SMP30-09] **Magmatism-hydrothermalism interaction along the crust-mantle transition below oceanic spreading centres**

★Invited Papers

*Mathieu Rospabe[1,2]、Mathieu Benoit[1]、Georges Ceuleneer[1] (1.GET, OMP, Univ. of Toulouse, CNRS, IRD, F-31400 Toulouse, France、2.JAMSTEC, Yokosuka 237-0061, Japan.)

16:15 ~ 16:30

[SMP30-10] **Serpentinization and carbonation of dunites in the western part of the Isua Supracrustal Belt, Southwestern Greenland**

*Juan Miguel Ramirez Guotana[1]、Tomoaki Morishita[1]、Akihiro Tamura[1]、Ikuya Nishio[1]、Kenichiro Tani[2]、Yumiko Harigane[3]、Kristoffer Szilas[4]、D. Graham Pearson[5] (1.Kanazawa University、2.National Museum of Nature and Science, Japan、3.Institute of Geology and Geoinformation Geological Survey of Japan/AIST、4.University of Copenhagen、5.University of Alberta)

16:30 ~ 16:45

[SMP30-11] **Petrogenesis of fertile abyssal peridotites of the Pujada Ophiolite, SE Mindanao, Philippines**

*Valerie Shayne Vargas Olfindo[1]、Betchaida Duetes Payot[1]、Gabriel Theophilus Valera[1]、Shoji Arai[2]、Tomoyuki Shibata[4]、Masako Yoshikawa[3] (1.Rushurgent Working Group, National Institute of Geological Sciences, University of the Philippines、2.Department of Earth Sciences, Kanazawa University, Kakuma, Kanazawa, Ishikawa 920-1192, Japan、3.Institute for Geothermal Sciences, Graduate School of Science, Kyoto University, Beppu 874-0903, Japan、4.Department of Earth and Planetary Systems Science, Hiroshima University, Hiroshima 739-8526, Japan)

16:45 ~ 17:00

[SMP30-12] 飛騨変成帯中に産する超苦鉄質岩：島弧深部起源岩石の例として

小楠 陽平[1]、*森下 知晃[1]、田村 明弘[1] (1.金沢大学)

[E] 口頭発表 | セッション記号 S (固体地球科学)：S-MP 岩石学・鉱物学

10:45 ~ 12:15 | A08 東京ベイ幕張ホール

[S-MP31] Supercontinents and Crustal Evolution

コンビーナ:Satish-Kumar Madhusoodhan(Department of Geology, Faculty of Science, Niigata University)、外田 智千(国立極地研究所)、Sajeev Krishnan(Centre for Earth Sciences, Indian Institute of Science)、小山内 康人(九州大学大学院比較社会文化研究院地球変動講座)、座長:M. Satish-Kumar(Niigata University)、外田 智千(国立極地研究所)

10:45 ~ 11:00

[SMP31-01] Tectonic development of the East Indian cratonic margin and its status in Columbia Supercontinent

★Invited Papers

*Kaushik Das[1] (1.Hiroshima University)

11:00 ~ 11:15

[SMP31-02] **Continental crust formation and metamorphism during the Neoarchean–Paleoproterozoic: an example from the Nilgiri Block, southern India**

★Invited Papers

*VINOD O SAMUEL[1] (1.Yonsei University)

11:15 ~ 11:30

[SMP31-03] Preliminary paleomagnetic studies on the mafic dykes in Western Dharwar craton, South India.

*Silpa Ammini Sasidharan[1]、Madhusoodhan Satish-Kumar[2]、Naoto Ishikawa[3]、Krishnan Sajeev[4] (1.Graduate School of Science and Technology, Niigata University、2.Department of Geology, Faculty of Science, Niigata University、3.Graduate School of Human and Environmental Studies, Kyoto University, Kyoto, Japan、4.Centre for Earth Sciences, Indian Institute of Science, Bangalore, India)

11:30 ~ 11:45

[SMP31-04] Syn-metamorphic boron-bearing fluid infiltrations deduced from tourmaline in the Main Central Thrust zone, eastern Nepal Himalayas

★Invited Papers

*河上 哲生[1]、酒井 治孝[1]、佐藤 活志[1] (1.京都大学大学院理学研究科)

11:45 ~ 12:00

[SMP31-05] **レッサーヒマラヤの現地性堆積物層下部（1.9-1.75 Ga）に産出する火成岩の岩石学的特徴：広域的組成変化とテクトニック場の推定**

*新城 竜一[1]、安室 朝基[1]、大浦 晃平[1]、大城 和哉[1]、田原 史朗[1]、酒井 治孝[2] (1.琉球大学理学部物質地球科学科、2.京都大学大学院理学研究科)

12:00 ~ 12:15

[SMP31-06] Petrogenesis and tectonic implications of orbicular granodiorite from Yangtze cratonic nucleus

*Yihe Li[1] (1.China University of Geosciences Wuhan)

[E] 口頭発表 | セッション記号 S (固体地球科学)：S-CG 固体地球科学複合領域・一般

9:00 ~ 10:30 | A07 東京ベイ幕張ホール

[S-CG49] ハードロック掘削科学〜陸上掘削から深海底掘削、そしてオマーン〜

コンビーナ:道林 克禎(名古屋大学大学院環境学研究科地球環境科学専攻地質・地球生物学講座岩石鉱物学研究室)、高澤 栄一(新潟大学理学部地質科学科)、秋澤 紀克(東京大学　大気海洋研究所　海洋底科学部門)、座長:高澤 栄一(新潟大学)、秋澤 紀克(東京大学　大気海洋研究所)

9:00 ~ 9:15

[SCG49-06] Melt transport and compositional heterogeneity of the mantle: a case study of peridotite, dunite, and wehrlite from Atlantis Massif

*秋澤 紀克[1]、Gretchen L. Früh-Green[2]、田村 明弘[3]、田村 千織[1]、森下 知晃[3] (1.東京大学　大気海洋研究所、2.ETH 地球科学科、3.金沢大学　理工研究域)

9:15 ~ 9:30

[SCG49-07] **Lower crustal accretion processes revealed from the study of gabbroic cores in Holes GT1A and GT2A, the ICDP Oman Drilling Project**

*Sayantani Chatterjee[1]、Eiichi TAKAZAWA[1]、Katsuyoshi Michibayashi[2]、Peter B Kelemen[3]、Damon A.H. Teagle[4]、Oman Drilling Project Phase I Science Party (1.Department of Geology, Faculty of Sciences, Niigata University, Japan、2.Department of Earth and Environmental Sciences, Nagoya University, Japan、3.Lamont Doherty Earth Observatory, Columbia University, USA、4.Southampton Marine and Maritime Institute, University of Southampton, United Kingdom)

9:30 ~ 9:45

[SCG49-08] オマーンに産するリストベナイトの岩石学: 沈み込み帯の炭素循環の解明に向けて

*髙橋 藤馬[1]、森下 知晃[2]、佐藤 宏樹[3]、Guotana Juan[2]、川本 竜彦[4]、Peter Kelemen[5]、Jude Coggon[6]、Michelle Harris[7]、Juerg Matter[6]、道林 克禎[8]、高澤 栄一[9]、Damon Teagle[6]、The Oman Drilling Project Phase 1 science Party (1.国立大学法人金沢大学理工学域自然システム学類地球学コース、2.国立大学法人金沢大学自然科学研究科自然システム学専攻、3.国立大学法人京都大学理学部、4.国立大学法人静岡大学理学部地球化学科、5.Lamont-Doherty Earth Observatory, Columbia university、6.School of Ocean and Earth Science, National Oceanography Center Southampton, University of Southampton、7.School of Geography, Earth and Environmental Sciences, Plymouth University、8.国立大学法人名古屋大学理学部地球惑星学科、9.国立大学法人新潟大学自然科学研究所)

9:45 ~ 10:00

[SCG49-09] PGE and Os isotope variation in the gabbros and peridotites from the Oman DP drilling cores in the Samail ophiolite, Oman

*仙田 量子[1,2]、鈴木 勝彦[2]、森下 知晃[3]、高澤 栄一[4]、道林 克禎[5]、Kelemen Peter[6]、Teagle Damon[7]、Coggon Jude[7]、Godard Marguerite[8]、The Oman DP Science Party (1.九州大学比較社会文化研究院、2.国立研究開発法人海洋研究開発機構・海底資源研究開発センター 、3.金沢大学理工研究域自然システム学系 、4.新潟大学理学部地質科学科、5.名古屋大学大学院環境学研究科、6.コロンビア大学、7.サウザンプトン大学、8.モンペリエ大学)

10:00 ~ 10:15

[SCG49-10] オマーンオフィオライト・ワジタイン岩体のCM1およびCM2サイトにおける地殻-マントル境界の掘削結果の概要

*高澤 栄一[1]、Damon Teagle[2]、道林 克禎[3]、田村 芳彦[4]、Jude Coggon[2]、Juerg Matter[2]、Peter Kelemen[5]、Oman Drilling Project Phase 2 Science Party (1.新潟大学理学部地質科学プログラム、2.サウサンプトン大学、3.名古屋大学、4.海洋研究開発機構、5.コロンビア大学)

10:15 ~ 10:30

[SCG49-11] オマーン掘削プロジェクトPhase2　マントルセクションから得られた掘削コア試料の岩石学的観察

*市山 祐司[1]、Oman Drilling Project Phase 2 Scientific Party (1.千葉大学)

[E] 口頭発表 | セッション記号 S (固体地球科学)：S-CG 固体地球科学複合領域・一般

10:45 ~ 12:15 | A07 東京ベイ幕張ホール

[S-CG49] ハードロック掘削科学〜陸上掘削から深海底掘削、そしてオマーン〜

コンビーナ:道林 克禎(名古屋大学大学院環境学研究科地球環境科学専攻地質・地球生物学講座岩石鉱物学研究室)、高澤 栄一(新潟大学理学部地質科学科)、秋澤 紀克(東京大学　大気海洋研究所　海洋底科学部門)、座長:森下 知晃(金沢大学)、道林 克禎

10:45 ~ 11:00

[SCG49-12] ちきゅう船上のXCTデータによる超マフィック岩の構造解析

*道林 克禎[1]、柿畑 優季[1]、片山 郁夫[2]、岡本 敦[3]、岡崎 啓史[4]、Peter Kelemen[5]、高澤 栄一[6]、Damon Teagle[7]、Oman Drilling Project Phase 2 Science Party[8] (1.名古屋大学大学院環境学研究科、2.広島大学、3.東北大学、4.JAMSTEC 高知コアセンター、5.コロンビア大学、6.新潟大学、7.サウサンプトン大学、8.ICDP)

11:00 ~ 11:15

[SCG49-13] Petrophysical characteristics of serpentinized peridotites of Hole BA1B, BA3A and BA4A

*柿畑 優季[1]、道林 克禎[2]、Laura Crispini[3]、Bjorn Jamtveit[4]、Samuel Barbier[5]、Joe Aslin[6]、Manuel Menzel[7]、Marguerite Godard[8] (1.静岡大学大学院総合科学技術研究科、2.名古屋大学大学院環境学研究科、3.ジェノバ大学、4.オスロ大学、5.リヨン第1大学、6.リバプール大学、7.アンダルシア地球科学研究所、8.モンペリエ大学)

11:15 ~ 11:30

[SCG49-14] Physical properties of the Moho TZ: Implications from ICDP Oman Drilling Project Phase I & II on-board measurements

*阿部 なつ江[1,12]、岡崎 啓史[1]、片山 郁夫[2]、畠山 航平[2]、赤松 祐哉[2]、Ildefonse Benoit[3]、Ole Ulven[4]、Hong Gilbert[5]、Zhu Wenlu[6]、Cordonnier Benoit[4]、道林 克禎[7]、高澤 栄一[8]、Harris Michell[10]、Teagle Damon[11]、ケレメン ピーター[9]、Godard Marguerite[3]、Matter Jurg[11]、Coggon Jude[11]、Scientific Party Oman Drilling Project (1.国立研究開発法人海洋研究開発機構、2.広島大学、3.モンペリエ大学、4.オスロ大学、5.ソウル大学、6.メリーランド大学、7.名古屋大学、8.新潟大学、9.コロンビア大学、10.プリマス大学、11.サウザンプトン大学、12.金沢大学)

11:30 ~ 11:45

[SCG49-15] **Oman Drilling Project Phase IIから採取されたハルツバージャイトの高圧条件下における地震波異方性**

*畠山 航平[1]、片山 郁夫[1]、阿部 なつ江[2]、The Oman Drilling Project Phase II Science Party (1.広島大学大学院理学研究科地球惑星システム学専攻、2.国立研究開発法人海洋研究開発機構)

11:45 ~ 12:00

[SCG49-16] 海洋底の拡大モードと海洋地殻構造の解明〜ハワイ沖モホール候補地における深海掘削

*海野 進[1]、森下 知晃[1]、山下 幹也[2]、石塚 治[3] (1.金沢大学理工研究域自然システム学系、2.（独）海洋研究開発機構、3.産総研・地質調査総合センター)

[E] 口頭発表 | セッション記号 B (地球生命科学)：B-CG 地球生命科学複合領域・一般

9:00 ~ 10:30 | 201A 2F

[B-CG06] 地球惑星科学　生命圏フロンティアセッション

コンビーナ:高野 淑識(海洋研究開発機構)、鈴木 庸平(東京大学大学院理学系研究科)、加藤 真悟(国立研究開発法人理化学研究所)、福士 圭介(金沢大学環日本海域環境研究センター)、座長:諸野 祐樹(JAMSTEC)、金子 雅紀(産業技術総合研究所)、加藤 真悟(理化学研究所)

9:00 ~ 9:15

[BCG06-01] 宇宙への開放系としての地球システムと、生命惑星をつくる五層構造

*丸山 茂徳[1] (1.東京工業大学地球生命研究所)

9:15 ~ 9:30

[BCG06-02] Holocene Antarctic subglacial weathering and ice-sheet history reconstructed using the $^{10}Be/^{9}Be$ ratios of lake Maruwan Oike sediments

*Adam David Sproson[1]、Yusuke Yokoyama[1,2]、Yoshinori Takano[2]、Yosuke Miyairi[1]、Takahiro AZE[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo、2.Department of Biogeochemistry, Japan Agency for Marine Science and Technology)

9:30 ~ 9:45

[BCG06-03] Chemical speciation and solubility of heavy elements (lead, zinc, copper, arsenic and cadmium) in contaminated soil from Kamegai mine tailing, Toyama, Japan

*Baasansuren Gankhurel[1]、Keisuke Fukushi[2]、Akitoshi Akehi[1]、Yoshio Takahashi[3]、Kazuo Kawasaki[4] (1.Graduate School of Natural Science and Technology, Kanazawa University、2.Instutute of Nature and Environmental Technology, Kanazawa University、3.Department of Earth and Planetary Science, The University of Tokyo、4.Graduate School of Science and Engineering for Research, Toyama University)

9:45 ~ 10:00

[BCG06-04] High-mass resolution molecular imaging of organic compounds on the Murchison meteorite.

★Invited Papers

*橋口 未奈子[1]、奈良岡 浩[1,2] (1.九州大学惑星微量有機化合物研究センター、2.九州大学大学院理学研究院)

10:00 ~ 10:15

[BCG06-05] Fe(II) oxidation processes at the surface of bacterially colonized iron deposits

★Invited Papers

*白石 史人[1]、中尾 鴻兵[1]、高島 千鶴[2]、狩野 彰宏[3]、板井 啓明[3] (1.広島大学、2.佐賀大学、3.東京大学)

10:15 ~ 10:30

[BCG06-06] Heme: The distribution and dynamics of a ubiquitous iron-tetrapyrrole molecule

*伊左治 雄太[1]、高野 淑識[1]、小川 奈々子[1]、大河内 直彦[1] (1.海洋研究開発機構)

[E] 口頭発表 | セッション記号 B (地球生命科学)：B-CG 地球生命科学複合領域・一般

10:45 ~ 12:15 | 201A 2F

[B-CG06] 地球惑星科学　生命圏フロンティアセッション

コンビーナ:高野 淑識(海洋研究開発機構)、鈴木 庸平(東京大学大学院理学系研究科)、加藤 真悟(国立研究開発法人理化学研究所)、福士 圭介(金沢大学環日本海域環境研究センター)、座長:高野 淑識(JAMSTEC)、福士 圭介、鈴木 庸平(東京大学)

10:45 ~ 11:00

[BCG06-07] クロロフィル色素の生合成酵素の多様性と進化

★招待講演

*塚谷 祐介[1] (1.国立研究開発法人海洋研究開発機構)

11:00 ~ 11:20

[BCG06-08] **Microdolomites are not MDACs: microbially-derived carbon source for microcrystalline dolomite found within massive gas hydrates and implications for the shallow marine carbon cycle**

★Invited Papers

*Glen Snyder[1]、Ryo Matsumoto[1]、Naizhong Zhang[1]、Yoshihiro Kakizaki[2]、Yohey Suzuki[2]、Yuji Sano[3]、Naoto Takahata[3]、Kentaro Tanaka[3]、Takumi Imajo[5]、Stephen Bowden[4] (1.Gas Hydrate Research Laboratory, Meiji University、2.University of Tokyo、3.AORI, University of Tokyo、4.University of Aberdeen, Scotland、5.Tokyo University of Marine Science and Technology)

11:20 ~ 11:35

[BCG06-09] **Discriminative biogeochemical signatures of methanotrophs inhabiting different chemosynthetic fields in an active mud volcano of the Canadian Beaufort Sea**

*Dong-Hun Lee[1]、Yung Mi Lee[2]、Jung-Hyun Kim[2]、Young Keun Jin[2]、Charles Paull[3]、Helge Niemann[4,5]、Ji-Hoon Kim[6]、Kyung-Hoon Shin[1] (1.Hanyang Univ.、2.KOPRI、3.MBARI、4.NIOZ and Utrecht Univ.、5.CAGE, UiT 、6.KIGAM)

11:35 ~ 11:50

[BCG06-10] メタン生成アーキアのコア脂質主成分2-ヒドロキシアーキオールのアルキル鎖側の水酸基の絶対立体配置決定

*山内 敬明[1]、金子 雅紀[2] (1.九州大学大学院理学研究院地球惑星科学部門、2.産業総合研究所)

11:50 ~ 12:10

[BCG06-11] Mineral-Microbe interaction – Identification of extracellular electron transfer mechanisms by using MetaOmics approach

★Invited Papers

*石井 俊一[1]、鈴木 志野[1]、Kenneth Nealson[2] (1.国立研究開発法人海洋研究開発機構、2.南カリフォルニア大)

12:10 ~ 12:15

[BCG06-12] Interactive discussion with the invited speakers

*高野 淑識[1] (1.海洋研究開発機構)

[E] 口頭発表 | セッション記号 M (領域外・複数領域)：M-IS ジョイント

13:45 ~ 15:15 | 101 1F

[M-IS05] New technologies to monitor thunderstorm and severe weather activities

コンビーナ:佐藤 光輝(北海道大学 大学院理学研究院)、高橋 幸弘(北海道大学・大学院理学院・宇宙理学専攻)、久保田 尚之(北海道大学)、山下 幸三(足利大学工学部)、座長:佐藤 光輝(北海道大学)、山下 幸三(足利工業大学工学部)

13:45 ~ 14:00

[MIS05-01] Quasi real-time observation of typhoon and thunderstorms by the system of micro-satellites and ground-based lightning sensors

*高橋 幸弘[4,1]、佐藤 光輝[1,4]、久保田 尚之[4]、山下 幸三[2]、石田 哲朗[4]、Castro Ellison[3]、プルワディ プルワディ[1]、坪木 和久[5]、山田 広幸[6]、篠田 太郎[5]、Estrebillo Loren Joy[1]、Pulutan Doreena Karmina[1] (1.北海道大学・大学院理学院、2.足利大学・工学部、3.フィリピン大学ディリマン校、4.北海道大学・大学院理学研究院、5.名古屋大学・宇宙地球環境研究所、6.琉球大学)

14:00 ~ 14:15

[MIS05-02] **Towards the Implementation of the Understanding Lightning and Thunderstorms for Extreme Weather Monitoring and Information Sharing in the Philippines (ULAT) Project**

★Invited Papers

*Glenn Vincent C. Lopez[1] (1.Advanced Science and Technology Institute)

14:15 ~ 14:30

[MIS05-03] **Airborne observation of Super Typhoon Trami in 2018 for understanding the intensity of tropical cyclone in the Philippine Sea**

★Invited Papers

*久保田 尚之[1]、坪木 和久[2]、山田 広幸[3]、高橋 幸弘[1]、篠田 太郎[2]、大東 忠保[4]、山口 宗彦[5]、伊藤 耕介[3]、中澤 哲夫[5]、長浜 則夫[6]、清水 健作[6]、佐藤 光輝[1] (1.北海道大学、2.名古屋大学、3.琉球大学、4.防災科学研究所、5.気象研究所、6.明星電気)

14:30 ~ 14:45

[MIS05-04] Relation between Lightning and Typhoon Activities (Typhoon LAN) in the Western Pacific Region

*佐藤 光輝[1]、高橋 幸弘[1]、久保田 尚之[1]、山下 幸三[2]、浜田 純一[3]、Marciano Joel[4] (1.北海道大学 大学院理学研究院、2.足利大学 工学部、3.首都大学東京 都市環境学部、4.先端科学技術研究所)

14:45 ~ 15:00

[MIS05-05] Infrasound multi-site observation of thunders 3: preparation process for SATREPS

★Invited Papers

*山本 真行[1] (1.高知工科大学　システム工学群)

15:00 ~ 15:15

[MIS05-06] Data Acquisition System for an Infrasound Network for Thunderstorm Monitoring

*Doreena Karmina Abril Pulutan[1]、Yukihiro Takahashi[1]、Mitsuteru Sato[1]、Hisayuki Kubota[1]、Kozo Yamashita[2]、Masa-yuki Yamamoto[3] (1.Department of Cosmosciences, Hokkaido University、2.Department of Engineering, Ashikaga University、3.Department of Systems Engineering, Kochi University of Technology)

[E] 口頭発表 | セッション記号 M (領域外・複数領域)：M-IS ジョイント

15:30 ~ 17:00 | 101 1F

[M-IS05] New technologies to monitor thunderstorm and severe weather activities

コンビーナ:佐藤 光輝(北海道大学 大学院理学研究院)、高橋 幸弘(北海道大学・大学院理学院・宇宙理学専攻)、久保田 尚之(北海道大学)、山下 幸三(足利大学工学部)、座長:高橋 幸弘(北海道大学)、久保田 尚之(北海道大学 大学院理学研究院)

15:30 ~ 15:45

[MIS05-07] Estimation of Lightning Location Using V-POTEKA Lightning Observation Network

*Loren Joy De Vera Estrebillo[1]、Mitsuteru Sato[2]、Yukihiro Takahashi[2]、Hisayuki Kubota[2]、Kozo Yamashita[3]、Junichi Hamada[4]、Joel Marciano[5] (1.Department of Cosmosciences, Hokkaido University、2.Faculty of Science, Hokkaido University、3.Faculty of Engineering, Ashikaga University、4.Graduate School of Urban Environmental Sciences, Tokyo Metropolitan University、5.ASTI/DOST)

15:45 ~ 16:00

[MIS05-08] **Observation system for thunderstorm development using ground lightning detection network and thermal infrared camera onboard satellite LAPAN-A4 in Indonesia**

*Purwadi Purwadi[1,2]、Yukihiro Takahashi[1]、Mitsuteru Sato[1]、Kozo Yamashita[3]、M. Arif Saifudin[4] (1.Department of Cosmosciences, Hokkaido University, Sapporo 0600810, Japan、2.Agency for Assessment and Application of Technology (BPPT), Jakarta 10340, Indonesia、3.Department of Technology, Ashikaga Institute of Technology, Tochigi 3268558, Japan、4.Indonesian National Institute of Aeronautics and Space (LAPAN), Jawa Barat 16310, Indonesia)

16:00 ~ 16:15

[MIS05-09] Remote Sensing Water Quality Determination using Multi-spectral Analysis

*Ahmad Shaqeer Mohamed Thaheer[1]、Yukihiro Takahashi[1] (1.Hokkaido University)

16:15 ~ 16:30

[MIS05-10] Study of cloud effects on atmospheric electric field during lightning activities and snowfall using the 95-GHz cloud radar FALCON-I

★Invited Papers

*大矢 浩代[1]、中森 広太[1]、鴨川 仁[2]、鈴木 智幸[2]、鷹野 敏明[1]、諸富 和臣[3]、中田 裕之[1]、塩川 和夫[4] (1.千葉大学大学院工学研究院、2.東京学芸大学、3.日本無線株式会社、4.名古屋大学)

16:30 ~ 16:45

[MIS05-11] Preferred environmental conditions of precipitation systems in and around Bangladesh observed by ground-based radars

★Invited Papers

*村田 文絵[1]、東 修平[2]、寺尾 徹[3]、Hassan Quamrul[4] (1.高知大学理工学部、2.高知大学理学部、3.香川大学教育学部、4.バングラデシュ気象局)

16:45 ~ 17:00

[MIS05-12] 雷ガンマ線観測：2018年度における冬の柏崎でのコリメータ付きガンマ線検出器の観測結果と夏の東京スカイツリーでの観測の試み

★招待講演

*中澤 知洋[1]、松元 崇弘[2]、和田 有希[2]、Fabiani Alexia[1]、榎戸 輝揚[3]、奥田 和史[2]、古田 禄大[4]、會澤 優輝[2]、湯浅 孝行[5]、土屋 晴文[4]、佐藤 光輝[6]、牧島 一夫[7] (1.名古屋大学、2.東京大学、3.京都大学、4.日本原子力研究開発機構、5.理化学研究所、6.北海道大学、7.東京大学 Kalvi IPMU)

[E] 口頭発表 | セッション記号 M (領域外・複数領域)：M-GI 地球科学一般・情報地球科学

10:45 ~ 12:15 | 301B 3F

[M-GI29] Near Surface Investigation and Modeling for Groundwater Resources Assessment and Conservation

コンビーナ:Jui-Pin Tsai(National Cheng Kung University, Taiwan)、Hwa-Lung Yu(National Taiwan University)、Ching-Chung Cheng(National Chiao Tung University Taiwan)、Jing-Sen Cai(China University of Geosciences)、座長:Jui-Pin Tsai(National Cheng Kung University, Taiwan)、Hwa-Lung Yu(National Taiwan University, Taiwan)

10:45 ~ 11:00

[MGI29-01] Groundwater management for global sustainability

★招待講演

*谷口 真人[1] (1.総合地球環境学研究所)

11:00 ~ 11:15

[MGI29-02] **Building the large-scale specific yields over the Zhuoshui river alluvial fan and Minzhu basin with gravimetric technique**

*Ren-Jhih Yang[1]、Shen Yu Hsiao[1]、Yan-Jyun Lin[1]、Zhen-Yu Wu[1] (1.National Chung Hsing University)

11:15 ~ 11:30

[MGI29-03] **Poro-elastic Deformation of a Heterogenous Geologic Medium due to Groundwater Withdrawal**

*Ajit Joshi[1]、Masaatsu Aichi[1] (1.Department of Environment Systems, Graduate School of Frontier Sciences, The University of Tokyo)

11:30 ~ 11:45

[MGI29-04] **Analytical Solution of a Ditch Drainage System for the restoration of waterlogged site considering a Subsurface Source/Sink**

*SHUBHAM TIWARI[1]、BRIJESH KUMAR YADAV[1]、RATAN SARMAH[2] (1.Indian Institute of Technology Roorkee、2.Indian Institute of Technology Ropar)

11:45 ~ 12:00

[MGI29-05] **Variable-density flow and mass transport in unsaturated-saturated aquifers under horizontal groundwater flow conditions**

*Jiaqi Liu[1]、Tomochika Tokunaga[1] (1.The University of Tokyo)

12:00 ~ 12:15

[MGI29-06] A practical approach to evaluating water inflow for underground water-sealed storage cavern

*Jing-Sen Cai[1] (1.China University of Geosciences)

[E] 口頭発表 | セッション記号 M (領域外・複数領域)：M-ZZ その他

15:30 ~ 17:00 | 304 3F

[M-ZZ50] 越境火山災害をめぐるガバナンス

コンビーナ:阪本 真由美(兵庫県立大学大学院減災復興政策研究科)、中道 治久(京都大学防災研究所附属火山活動研究センター)、荒木田 勝(アジア防災センター)、座長:阪本 真由美(兵庫県立大学大学院減災復興政策研究科)、中道 治久(京都大学防災研究所)、荒木田 勝(アジア防災センター)

15:35 ~ 15:50

[MZZ50-01] The development of the European collaborative mechanism of volcanic monitoring systems after 2010 Eyjafjallajokull eruption - from the perspective of European Union law -

*荒島 千鶴[1] (1.神戸学院大学)

15:50 ~ 16:05

[MZZ50-02] Preparing for volcanic disasters: Risk communication issues when dealing with international tourists.

★Invited Papers

*Ana Maria Cruz Naranjo[1]、Giuseppe Aliperti[1] (1.Kyoto University Disaster Prevention Research Institute)

16:05 ~ 16:20

[MZZ50-03] Mitigation of volcanic hazard in Sakurajima, Japan, through the coordinating committee and through communication with the public

*中道 治久[1] (1.京都大学防災研究所附属火山活動研究センター)

16:20 ~ 16:35

[MZZ50-04] An experimental forecasting technique for the ash hazard from Sakurajima volcano, Japan

*Alexandros Panagiotis Poulidis[1]、Tetsuya Takemi[1]、Masato Iguchi[1] (1.Disaster Prevention Research Institute, Kyoto University)

16:35 ~ 16:50

[MZZ50-05] 宇宙技術の早期警報への応用と越境型災害への効果的な対応

★招待講演

*鈴木 弘二[1] (1.アジア防災センター、神戸大学都市安全研究センター)

16:50 ~ 17:00

[MZZ50-06] Discussion -Research Framework for Trans-boudary Disaster

*Mayumi Sakamoto[1] (1.Graduate School of Disaster Resilience and Governance, University of Hyogo)

[E] 口頭発表 | セッション記号 P (宇宙惑星科学)：P-PS 惑星科学

2019年5月28日(火) 9:00 ~ 10:30 | A03 東京ベイ幕張ホール

[P-PS01] Outer Solar System Exploration Today, and Tomorrow

コンビーナ:木村 淳(大阪大学)、笠羽 康正(東北大学 惑星プラズマ・大気研究センター)、Kunio M. Sayanagi(Hampton University)、座長:Kunio Sayanagi(Hampton University)、黒田 剛史

The giant planets provide many keys to understanding planetary processes. They play an important role in shaping our solar system, and the physical and chemical processes they harbor also provide a unique opportunity to study the phenomena relevant for studying Earth and other planets, including exoplanetary systems. In this session, we discuss a wide range of topics encompassing the giant planets and their moons, including their origins, interiors, atmospheres, compositions, surface features, and electromagnetic fields. To advocate for current and future outer planets exploration (Cassini, Juno, New Horizons, JUICE, and beyond), we also call for discussions on future missions to explore giant planet systems, including how to develop better international cooperation. Discussion in this latter category will include progress in developing a solar sail mission concept for observing the Jupiter system and its trojan asteroids.

9:00 ~ 9:15

[PPS01-06] Radiative transfer simulation including a non-LTE model for terahertz observations of Ganymede's atmosphere

*山田 崇貴[1]、Rezac Ladislav[2]、Larsson Richard[2]、Hartogh Paul[2]、吉田 尚弘[3]、笠井 康子[1,3] (1.情報通信研究機構、2.マックスプランク太陽系研究所、3.東京工業大学)

9:15 ~ 9:30

[PPS01-07] Vertical Mass Flux by the 2010-2011 Great Storm of Saturn

*Sayanagi Kunio M.[1]、Gunnarson Jacob L.[1]、Blalock John J.[1]、Achterberg Richard K.[2]、Flasar F. Michael[2]、Ingersoll Andrew P.[3]、Ewald Shawn P.[3]、Dyudina Ulyana A.[3] (1.Hampton University、2.NASA Goddard Space Flight Center、3.California Institute of Technology)

9:30 ~ 9:48

[PPS01-08] Microwave observations of the giant planets - Cassini/Radar and Juno/MWR

★Invited Papers

*Cheng Li[1]、Virgil Adumitroaie[2]、John Arballo[2]、Sushil K Atreya[3]、Scott J Bolton[4]、Andrew Ingersoll[1]、Michael Janssen[2]、Steven Levin[2]、Jonathan Lunine[5]、Glenn Orton[2]、Paul Steffes[6]、Hunter Waite[4] (1.California Institute of Technology、2.Jet Propulsion Laboratory、3.University of Michigan Ann Arbor、4.Southwest Research Institute、5.Cornell University、6.Georgia Institute of Technology)

9:48 ~ 10:06

[PPS01-09] **Tracing Formation and Evolution of Outer Solar System Bodies through Stable Isotopes and Noble Gas Abundances**

★Invited Papers

*Kathleen Mandt[1] (1.Johns Hopkins University Applied Physics Laboratory)

10:06 ~ 10:24

[PPS01-10] Icy Giant Planet Exploration

★Invited Papers

*Sushil K Atreya[1]、Mark D. Hofstadter[2]、Amy Simon[3]、Kim R. Reh[2]、Olivier Mousis[4]、Krista Soderlund[5] (1.University of Michigan Ann Arbor、2.Jet Propulsion Laboratory、3.Goddard Space Flight Center、4.Laboratoire d'Astrophysique de Marseille、5.University of Texas at Austin)

10:24 ~ 10:30

Discussion

Radiative transfer simulation including a non-LTE model for terahertz observations of Ganymede's atmosphere

*山田 崇貴[1]、Rezac Ladislav[2]、Larsson Richard[2]、Hartogh Paul[2]、吉田 尚弘[3]、笠井 康子[1,3]
*Takayoshi Yamada[1], Ladislav Rezac[2], Richard Larsson[2], Paul Hartogh[2], Naohiro Yoshida[3], Yasuko Kasai[1,3]

1. 情報通信研究機構、2. マックスプランク太陽系研究所、3. 東京工業大学
1. National Institute of Information and Communications Technology, 2. Max Planck Institute for Solar System Research, 3. Tokyo Institute of Technology

We are developing a teraherz radiative transfer code, named Atmospheric Teraherz Radiation Simulator (ATRASU), for simulations of sub-millimeter observations of planetary atmospheres.
Because of the tenuous Ganymede atmosphere we need to include non-local thermodynamic equilibrium (non-LTE) conditions of H_2O rotational levels to simulate observations by the Submillimeter Wave Instrument (SWI) on the JUpiter ICy moon Explorer (JUICE). The frequency windows of the JUICE/SWI are 530 to 625 GHz and 1080 to 1275 GHz with 100 kHz spectral resolution.
We developed a deterministic non-LTE solution based on the multilevel Gauss–Seidel method. The simulated energy level populations of H_2O for SWI observations start to deviate from LTE at 100 to 200 km altitude around sub-solar latitudes of 10 degrees. At sub-solar latitudes around 60 degrees the populations are in non-LTE over the entire range, starting from the surface. The difference of the simulated spectra between LTE and non-LTE conditions, and their sensitivity to various parameters, such as collisional rates for H_2O, will be presented.

キーワード：THz、放射伝達計算
Keywords: THz, Radiative trasfer

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Vertical Mass Flux by the 2010-2011 Great Storm of Saturn

*Sayanagi Kunio M.[1]、Gunnarson Jacob L.[1]、Blalock John J.[1]、Achterberg Richard K.[2]、Flasar F. Michael[2]、Ingersoll Andrew P.[3]、Ewald Shawn P.[3]、Dyudina Ulyana A.[3]
*Kunio M. Sayanagi[1], Jacob L. Gunnarson[1], John J. Blalock[1], Richard K. Achterberg[2], F. Michael Flasar[2], Andrew P. Ingersoll.[3], Shawn P. Ewald[3], Ulyana A. Dyudina[3]

1. Hampton University、2. NASA Goddard Space Flight Center、3. California Institute of Technology
1. Hampton University, 2. NASA Goddard Space Flight Center, 3. California Institute of Technology

We present a re-analysis of Cassini Composite Infrared Spectrometer (CIRS) data captured during the 2010-2011 Great Storm of Saturn to calculate the vertical mass flux caused by the storm. The intense cumulus outburst started on December 5, 2010 at 33ºN planetocentric latitude, and the clouds that emanated from the storm engulfed the entire latitude band over the subsequent months. The CIRS observation captured the storm's impact on the tropospheric thermal structure (Achterberg et al. 2014). The change in the thermal structure detected by Achterberg et al. (2014) is caused by the vertical uplifting of mass by the cumulus convection in the storm. We re-analyze the CIRS data processed by Achterberg et al. (2014) to determine the vertical mass flux. Images captured by the Imaging Science Subsystem (ISS) camera showed that active convective phase of the storm lasted until August 2011 (Sayanagi et al. 2013). Our preliminary analysis of CIRS data shows that, by August 2011, between 15ºN and 45ºN latitudes, the storm lifted about 1.65×10^{19} kg of mass to levels above the 700-mbar pressure altitude from levels below.

Analyzing images captured by ISS using the CB2 (750 nm) filter and Cassini Visible and Infrared Mapping Spectrometer (VIMS)'s 5-micron channel reveals that, after August 2011, cumulus activities ceased in the storm's latitudes, and a vast cloudless area grew until it encircled the entire band between 30ºN and 40ºN latitude by January 2012. The cloudless region further grew to the south and reached 20ºN by December 2012. Interestingly, analysis of the CIRS data indicates that the vertical mass flux continued as the clouds cleared after the storm. Our preliminary analysis shows that, between August 2011 and August 2012, 1.9×10^{18} kg more mass was lifted to altitudes above the ~700-mbar level. We hypothesize that the vertical mass flux during the cloud clearing was caused when the tropospheric air parcels became buoyant when they were relieved from the mass loading of the storm clouds.

We note that measuring vertical mass flux caused by a cumulus storm is extremely difficult for storms on Earth because the mass uplifted by the storms is rapidly dispersed and diluted by the storm's environment. In comparison, Saturn's Great Storm of 2010-2011 completely filled the latitude zone between 20°N and 40°N; thus, the storm was essentially contained in a closed box, and allowed us to measure the storm's vertical mass flux.

References:

Achterberg, R. K., Gierasch, P. J., Conrath, B. J., Fletcher, L. N., Hesman, B. E., Bjoraker, G. L., Flasar, F. M., 2014. Changes to Saturn's Zonal-mean Tropospheric Thermal Structure after the 2010-2011 Northern Hemisphere Storm. Astrophysical Journal 786, 92.

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Sayanagi, K. M., Dyudina, U. A., Ewald, S. P., Fischer, G., Ingersoll, A. P., Kurth, W. S., Muro, G. D., Porco, C. C., West, R. A., 2013. Dynamics of Saturn's great storm of 2010-2011 from Cassini ISS and RPWS. Icarus 223, 460-478.

キーワード：土星、惑星大気、カッシーニ・ミッション
Keywords: Saturn, Planetary Atmospheres, Cassini Mission

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Microwave observations of the giant planets - Cassini/Radar and Juno/MWR

*Cheng Li[1], Virgil Adumitroaie[2], John Arballo[2], Sushil K Atreya[3], Scott J Bolton[4], Andrew Ingersoll[1], Michael Janssen[2], Steven Levin[2], Jonathan Lunine[5], Glenn Orton[2], Paul Steffes[6], Hunter Waite[4]

1. California Institute of Technology, 2. Jet Propulsion Laboratory, 3. University of Michigan Ann Arbor, 4. Southwest Research Institute, 5. Cornell University, 6. Georgia Institute of Technology

The thermal emission of a giant planet's atmosphere in the microwave region reveals the thermal structure and composition of the atmosphere below the clouds. During the last decade, the Cassini/Radar instrument mapped Saturn's global thermal radiation at 2.2 cm wavelength. Particularly, in the year 2010, the planet-encircling giant storm on Saturn appeared 16 K brighter than average, revealing desiccation of ammonia gas due to convection and atmospheric dynamics. More recently at Jupiter, the Juno spacecraft has completed a dozen orbits around the planet, making detailed observations of Jupiter's troposphere from north to south and down to pressures of about 200 bars. The results are both astonishing and stimulating. Jupiter's equatorial zone appears cold in all six channels of Juno/MWR, which range from 1.2 –50 cm, whereas the other latitudes are significantly warmer than what was predicted by an adiabatic model. The internal structure of the GRS has also been mapped during orbit 7th close approach. Yet, the interpretation is partly confounded by the inhomogeneous distribution of ammonia gas. We will give an overview of the previous findings, current challenges, and future opportunities of microwave sounding of the giant planets.

Keywords: Jupiter, Saturn, Cassini, Juno, microwave, composition

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Tracing Formation and Evolution of Outer Solar System Bodies through Stable Isotopes and Noble Gas Abundances

*Kathleen Mandt[1]

1. Johns Hopkins University Applied Physics Laboratory

Comparative planetology using isotope geochemistry has played a critical role in understanding processes at work in and the history of outer Solar System bodies [see 1, and references therein]. The $^{12}C/^{13}C$ measured in methane on Titan has enabled us to determine the maximum length of time that methane has been present in the atmosphere [2,3], showing that methane has not been present in Titan's atmosphere throughout the history of the solar system and is limited to no more than 1 billion years (Gyr) [3]. We have also determined how much methane has been converted to organics over that were then deposited on the surface [3] and find agreement with estimates of surface inventories [4]. Observations of $^{14}N/^{15}N$ in HCN and N_2 in the atmosphere of Titan provides direct evidence of how photochemistry influences stable isotopes [5,6]. We have used these observations to determine that Titan's nitrogen originated as NH_3 in the protosolar nebula [7]. All of this work relies on spacecraft-based observations made at Titan. Ground-based observations combined with spacecraft observations are also of high value. The lower limit observed for $^{14}N/^{15}N$ in HCN in Pluto's atmosphere by ALMA [8] combined with New Horizons observations of the atmospheric composition [9] provides a valuable tool for determining the origin of nitrogen for Pluto if the influences of condensation and aerosol trapping on isotopes can be constrained [10] for which work is ongoing. All of this work is relevant to a future Ice Giants mission to Neptune, where the same methods could be applied to Triton and combined with ALMA observations. Furthermore, a mission to Io that makes in situ observations of the isotopic composition of the atmosphere could provide important information about volatile loss and interior processes at Io, assuming production and loss processes can be well constrained. Finally, noble gas abundances have been an important tool for understanding the origin and evolution of volatiles in the terrestrial planet atmospheres [see review in 1]. The recent measurement of cometary noble gas abundances [11] provides important information on the composition of the icy bodies that contributed to the formation of the gas giants, providing constraints for future in situ measurements that should be made with an atmospheric probe [12].

[1] Mandt K. E. et al. (2015a) *SSRv, 197,* 297–342. [2] Mandt K. E. et al., (2009) *PSS, 57,* 1917–1930. [3] Mandt K. E. et al., (2012) *ApJ, 749,* 160. [4] Lorenz, R. D. et al. (2008). *GRL*, *35*(2), L02206. [5] Liang et al. (2007) *ApJL, 664*, L115-L118. [6] Mandt et al. (2012b) *JGR, 117*, E10006. [7] Mandt K. E. et al., (2014) *ApJL, 788,* L24. [8] Lellouch et al. (2017) *Icarus, 286*, 289-307. [9] Young et al. (2017). [10] Mandt et al. (2017) *MNRAS*, *472*, 118-128. [11] Rubin et al. (2017) *Sci Adv*, *4*(7), eaar6297. [12] Mandt et al., in preparation.

Keywords: Titan, Pluto, Triton, Ice Giants, Stable Isotopes, Noble Gases

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Icy Giant Planet Exploration

*Sushil K Atreya[1], Mark D. Hofstadter[2], Amy Simon[3], Kim R. Reh[2], Olivier Mousis[4], Krista Soderlund[5]

1. University of Michigan Ann Arbor, 2. Jet Propulsion Laboratory, 3. Goddard Space Flight Center, 4. Laboratoire d'Astrophysique de Marseille, 5. University of Texas at Austin

Giant planets hold the secrets of solar system formation, and there is much interest in their exploration. They also serve as analogs for the giant planets in extrasolar systems. While Saturn-Jupiter sized exoplanets number about 500, mini-Neptune and Neptune sized objects (2-5 times Earth) comprise nearly half of approximately 4000 confirmed exoplanets to date. Since the early 1970’s, spacecraft have explored the gas giants, Jupiter and Saturn, extensively using flybys, orbiters and an entry probe (at Jupiter). Voyager 2 is the only spacecraft ever to visit the two icy giants, with a flyby of Uranus in 1986 and Neptune in 1989. Though the Voyager instruments were optimized for observations of Jupiter and Saturn, tantalizing data were collected at Uranus and Neptune as well. Those data have raised such fundamental questions as: did Uranus and Neptune form in the same manner as the gas giants, did they form at their present orbital locations or not, what role did migration play in their formation and evolution, why (and how) does Neptune generate internal heat, whereas Uranus does not, what is responsible for their intrinsic magnetic fields in the absence of a metallic hydrogen phase, why are the rings of Uranus different from Neptune’s rings and what’s maintaining them, why does Neptune’s moon Triton possess an atmosphere of nitrogen and methane, etc. To address these questions and others requires a comprehensive exploration of the icy giant planet systems by an orbiter-probe spacecraft at Uranus or Neptune or both [1], like the Galileo orbiter-probe mission at Jupiter. International partnership is most desirable for maximizing the science return of such a mission. [1] M. Hofstadter, A. Simon, K. Reh, J. Elliott, and the NASA Ice Giants Science Definition Team, Ice Giants Pre-Decadal Survey Report (2017) NASA-JPL-ID-100520, https://www.lpi.usra.edu/icegiants/mission_study/Full-Report.pdf

Keywords: Giant Planets, Origin and Evolution, Uranus and Neptune Missions, Extrasolar Planets, International Partnerships

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2019年5月28日(火) 10:45 ~ 12:15 | A03 東京ベイ幕張ホール

[P-PS01] Outer Solar System Exploration Today, and Tomorrow

コンビーナ:木村 淳(大阪大学)、笠羽 康正(東北大学 惑星プラズマ・大気研究センター)、Kunio M. Sayanagi(Hampton University)、座長:Jun Kimura(Osaka University)、鎌田 俊一(北海道大学創成研究機構)

The giant planets provide many keys to understanding planetary processes. They play an important role in shaping our solar system, and the physical and chemical processes they harbor also provide a unique opportunity to study the phenomena relevant for studying Earth and other planets, including exoplanetary systems. In this session, we discuss a wide range of topics encompassing the giant planets and their moons, including their origins, interiors, atmospheres, compositions, surface features, and electromagnetic fields. To advocate for current and future outer planets exploration (Cassini, Juno, New Horizons, JUICE, and beyond), we also call for discussions on future missions to explore giant planet systems, including how to develop better international cooperation. Discussion in this latter category will include progress in developing a solar sail mission concept for observing the Jupiter system and its trojan asteroids.

10:45 ~ 11:03

[PPS01-11] Saturn's ring rain and Enceladus' subsurface ocean as seen by the Cassini Cosmic Dust Analyser

★Invited Papers

*Sean Hsu[1]、Sascha Kempf[1]、Mihaly Horanyi[1]、Ralf Srama[2]、James O'Donoghue[3] (1.LASP, University of Colorado, Boulder, CO, USA、2.IRS, University of Stuttgart, Stuttgart, Germany、3.NASA Goddard Space Flight Center, Greenbelt, Maryland, USA)

11:03 ~ 11:18

[PPS01-12] Titan Trek: A New Online NASA Visualization and Analysis Portal for Saturn's Largest Moon

*Emily Law[1]、Brian Hamilton Day[2] (1.NASA Jet Propulsion Laboratory、2.NASA Ames Research Center)

11:18 ~ 11:36

[PPS01-13] Internal structure of icy moons: ice-ocean systems as commonly seen in the outer solar system

★Invited Papers

*Hauke Hussmann[1] (1.DLR Institute of Planetary Research)

11:36 ~ 11:51

[PPS01-14] Callisto as a keystone to reproduce the formation process of the Jovian system

*関根 康人[1]、鎌田 俊一[2]、青山 雄彦[3]、生駒 大洋[3]、谷川 享行[4] (1.東京工業大学地球生命研究所、2.北海道大学創成研究機構、3.東京大学大学院理学系研究科、4.一関高等工業専門学校)

11:51 ~ 12:09

[PPS01-15] Origin of Jupiter Trojan asteroids: To be explored by OKEANOS

★Invited Papers

*癸生川 陽子[1]、岡田 達明[2]、伊藤 元雄[3]、青木 順[4]、河井 洋輔[4]、松本 純[2]、Grand Noel[5]、Buch Arnaud [6]、豊田 岐聡[4]、Cottin Hervé[5]、坎本 尚義[7,2]、矢野 創[2]、岩田 隆浩[2]、森 治[2] (1.横浜国立大学、2.宇宙航空研究開発機構、3.海洋研究開発機構　高知コア研究所、4.大阪大学、5.LISA, Université Paris-Est Créteil、6.Ecole Centrale Paris、7.北海道大学)

12:09 ~ 12:15

Discussion

Saturn's ring rain and Enceladus' subsurface ocean as seen by the Cassini Cosmic Dust Analyser

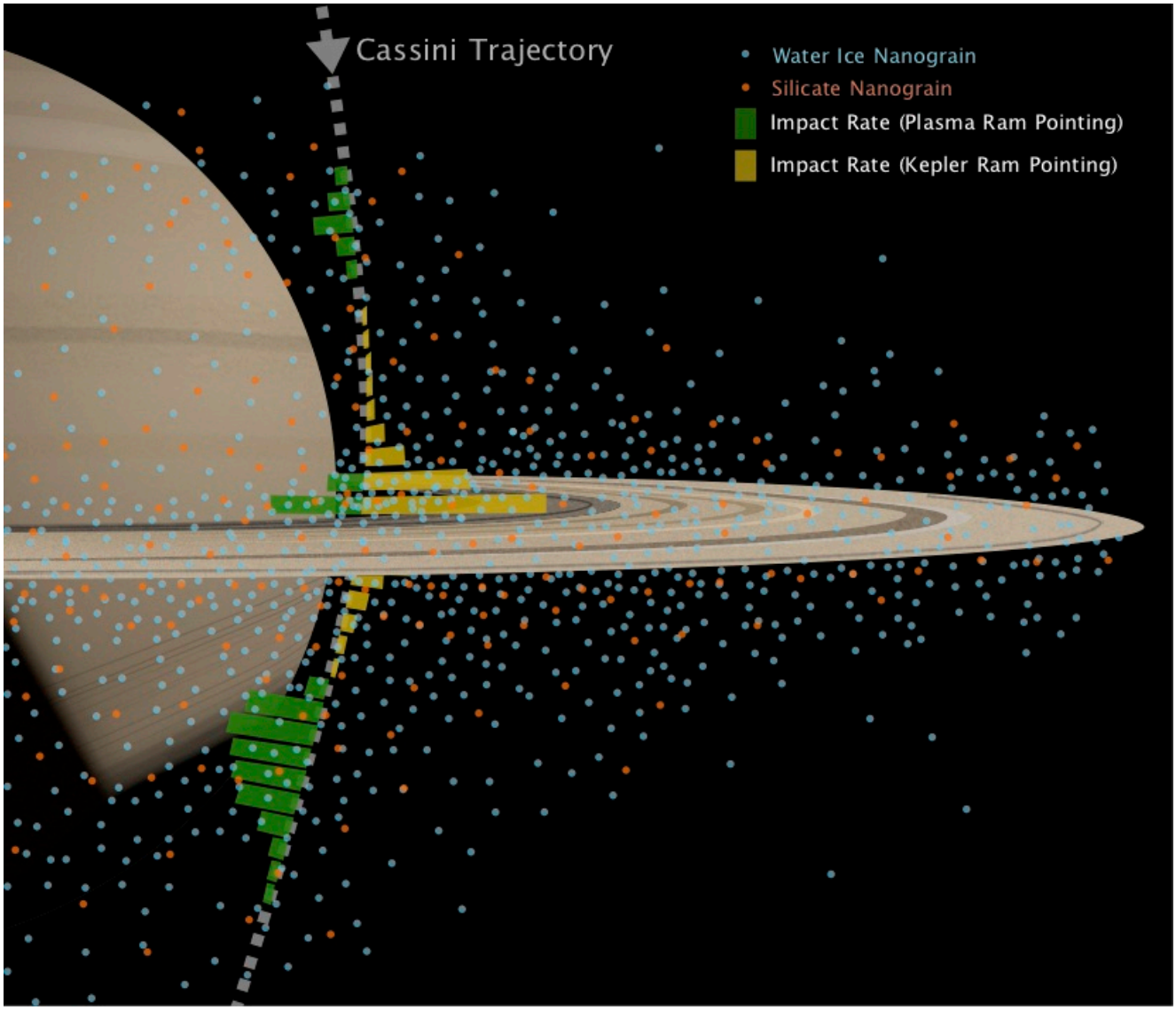
*Sean Hsu[1], Sascha Kempf[1], Mihaly Horanyi[1], Ralf Srama[2], James O'Donoghue[3]

1. LASP, University of Colorado, Boulder, CO, USA, 2. IRS, University of Stuttgart, Stuttgart, Germany, 3. NASA Goddard Space Flight Center, Greenbelt, Maryland, USA

Dust particles serve as microscopic messengers carrying information from sources inaccessible by space probes. The compositional and dynamical information of various dust populations provided by the Cosmic Dust Analyser offer a unique perspective to examine the rings, moons, and their interactions in the Saturnian system. In this talk I will focus on the latest results from the Cassini Grand Finale mission about Saturn's ring rain, i.e., the ring-planet interactions driven by the infall of ring material to Saturn's atmosphere, and its implications about Saturn and its magnificent ring system. I will also provide a brief summary of other major findings by the Cassini Cosmic Dust Analyser, including the discovery of the subsurface ocean and hydrothermal activities within the geologically active moon Enceladus, the composition of interstellar grains, Saturn's diffuse rings, and the electromagnetic interactions of charged nanodust particles with the magnetosphere and the solar wind.

Keywords: Saturn, Dust, Planetary Rings

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Titan Trek: A New Online NASA Visualization and Analysis Portal for Saturn’s Largest Moon

*Emily Law[1], Brian Hamilton Day[2]

1. NASA Jet Propulsion Laboratory, 2. NASA Ames Research Center

In its investigations of Saturn’s moons, NASA’s Cassini mission and ESA’s Huygens lander have returned an immense amount of data detailing the dynamic surface of Saturn’s largest moon, Titan. In order to greatly facilitate dissemination, visualization, and analysis of this data, the Cassini mission has partnered with NASA’s Solar System Treks Project (SSTP). SSTP has recently released a new online portal (https://trek.nasa.gov/titan/), Titan Trek, that enables mission planners, planetary scientists, engineers, students, and the general public to interactively access, visualize, and analyze Cassini’s mapped data products of Saturn’s largest moon.

The initial release of Titan Trek provides a suite of interactive tools and incorporates over 130,000 data products from the range of Cassini encounters with Titan, creating a comprehensive Titan research and educational web portal. Titan Trek data products include: Global Radar mosaic, Radar SAR BIDR BIFQI swaths, Global VIMS mosaics, Global ISS mosaic, Vector data (geological units of Afekan region, material flux based on dune orientation, fluvial networks), Nomenclature, ISS footprints, VIMS footprints, and Global radar topography.

We intend to continue to enhance the new Titan Trek portal with new data products as they are released by the Cassini mission including Huygens DISR, Global radiometry, scatterometry, VIMS, ISS, UVIS, CIRS, and other topography products.

Titan Trek is the latest addition to the NASA Solar System Treks Project (SSTP), available at https://trek.nasa.gov. NASA's Solar System Trek online portals provide web-based suites of interactive data visualization and analysis tools providing access to mapped data products from past and current missions for the Moon, Mars, Vesta, etc. As web-based toolsets, the portals do not require users to purchase or install any software beyond current web browsers. These portals are being used for site selection and analysis by NASA and a number of its international partners, supporting upcoming missions.

Keywords: Titan, Cassini, Visualization, Analysis

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Internal structure of icy moons: ice-ocean systems as commonly seen in the outer solar system

*Hauke Hussmann[1]

1. DLR Institute of Planetary Research

Among the icy satellites in the outer solar system, several objects have been identified that may contain substantial amounts of liquid water in their interiors. In particular the large satellites, e.g., Europa, Ganymede, Callisto, and Titan may contain subsurface oceans until the present day. However, the example of Enceladus shows that also smaller satellites can have sufficient internal heat sources to maintain liquid water layers. Also Pluto and Triton are potential ocean candidates. The available heat sources differ considerably among the icy moons depending on their initial composition, and thus the amount of radiogenic heating, the tidal interaction with the primary planet, their rheological states and -in some cases- their interaction with other satellites due to orbital resonances. In this talk the current knowledge on the ice-ocean systems in the outer solar system will be summarized. Prospects for their investigation with future planetary missions will be discussed.

Keywords: solar system, icy satellites, oceans

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Callisto as a keystone to reproduce the formation process of the Jovian system

*関根 康人[1]、鎌田 俊一[2]、青山 雄彦[3]、生駒 大洋[3]、谷川 享行[4]
*Yasuhito Sekine[1], Shunichi Kamata[2], Yuhiko Aoyama[3], Masahiro Ikoma[3], Takayuki Tanigawa[4]

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1. Earth-Life Science Insitute, Tokyo Institute of Technology, 2. Creative Res. Institution, Hokkaido Univerisity, 3. Dept of Earth and Planetary Sci., University of Tokyo, 4. Nat'l Inst. Tech., Ichinoseki Col.

Callisto is the outermost Galilean satellite, with 2410 km of radius and 1.83 g/cc of density. The size and mass are comparable to those of another Jovian moon, Ganymede and the largest moon of Saturn, Titan. Unlike Ganymede and Titan, however, heavily-cratered Callisto may have experienced only limited geological activities since its formation. Owing to the low geological activities, Callisto may serve as a “fossil” of the Jovian system formation in the early Solar System. Volatile and isotope compositions of ice materials on Callisto would reflect ice compositions of the building materials of the Jovian satellites, which is critical to constrain the disk temperature of the formation region of proto-Jupiter as well as both shock heating and size of infalling materials onto proto-Jupiter. The interior structure, namely degree of differentiation, of Callisto is essential to constrain the inflow rate of the building materials from the protoplanetary disk. In this talk, we discuss the key observations, e.g., surface materials and interior structure of Callisto, in future missions to constrain the formation process of the Jovian system.

キーワード：氷衛星、太陽探査、惑星形成
Keywords: icy satellite, Solar System exploration, planetary formation

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Origin of Jupiter Trojan asteroids: To be explored by OKEANOS

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*Yoko Kebukawa[1], Tatsuaki Okada[2], Motoo Ito[3], Jun Aoki[4], Yosuke Kawai[4], Jun Matsumoto[2], Noel Grand[5], Arnaud Buch[6], Michisato Toyoda[4], Hervé Cottin[5], Hisayoshi Yurimoto[7,2], Hajime Yano[2], Takahiro Iwata[2], Osamu Mori[2]

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The Jupiter Trojan asteroids are expected to be a key to understand planet formation and solar system evolution. The Jupiter Trojan asteroids are an asteroid group at the Lagrangian point (L4 and L5) on the Jupiter’s orbit, and their spectral types are mainly D and P type, also called “Red” and “Less red”, respectively [1,2]. The origin of these asteroids was considered to be trapped by Jupiter according to the classical planet formation theory [3,4]. On the other hand, according to a relatively new theoretical study such as Nice model, the small bodies formed at the Kuiper belt region are disturbed by giant planet migrations, and some of them trapped at the current Jupiter orbit [5]. Thus, constraining planetary formation theories can be possible by investigating whether the Jupiter Trojan asteroids originated from the outer region of the solar system such as the Kuiper belt area or originated from the current Jupiter orbit region (the extension of the main belt asteroids). The stable isotopic ratios of light elements are expected to be an indicator of the origin of the Jupiter Trojan asteroids. Because heavy isotopes such as ^{2}H (D) and ^{15}N tend to incorporate into water and organic matter in low temperatures (<10-100 K) such as in the outer region of the solar system [6,7]. In fact, heavy isotopes are concentrated in materials from the outer region of the solar system such as comets, and materials from main belt asteroids such as chondrites often show relatively light isotopic ratios [8].

The OKEANOS (Outsized Kite-craft for Exploration and AstroNautics in the Outer Solar system) is a candidate for the upcoming strategic middle-class space exploration to rendezvous with and land on a Jupiter Trojan asteroid using a Solar Power Sail (SPS). The mission concept includes sampling and in-situ analysis of the materials of a Jupiter Trojan asteroid [9]. We plan to analyze isotopic and molecular compositions of volatile materials from organic matter, hydrated minerals, and ice, in order to understand origin and evolution of the Jupiter Trojan asteroids, using a multi-turn time-of-flight type high-resolution mass spectrometry (HRMS) system. Our goal is to improve our understanding of (1) planet formation/migration theories, (2) distribution and evolution of volatile substances in protoplanetary disks, (3) origins and evolution of organic matter, and (4) origin and evolution of the Solar System small bodies beyond the snow line.

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[E] 口頭発表 | セッション記号 P (宇宙惑星科学)：P-PS 惑星科学

2019年5月28日(火) 10:45 ~ 12:15 | A01 東京ベイ幕張ホール

[P-PS03] Solar System Small Bodies: A New Frontier Arising Hayabusa 2, OSIRIS-REx and Other Projects

コンビーナ:石黒 正晃(ソウル大学物理天文学科)、中本 泰史(東京工業大学)、安部 正真(宇宙航空研究開発機構宇宙科学研究所)、Olivier S Barnouin(Johns Hopkins University Applied Physics Laboratory)、座長:Masateru Ishiguro(Seoul National University)

2018年6月、小惑星探査機「はやぶさ2」が約3年半の航海を経て、目的地リュウグウに到着した。また、別の小惑星探査機「OSIRIS-REx」も探査天体Bennuに間もなく到着しようとしている。これらの探査によって、太陽系小天体研究は、今まさに新しい局面を迎えようとしている。本セッションは、2012年から開催されてきたもので、これまでに実験、観測、探査、理論、さらにサンプル分析の観点から太陽系小天体の研究に関して議論を行ってきた。特に今回は、はやぶさ2とOSIRIS-RExの初期成果を中心に太陽系小天体に関する最新研究を持ち寄り、今後の展望を議論することを目的とする。はやぶさ2、OSIRIS-REx以外の研究成果発表も歓迎する。

10:45 ~ 11:00

[PPS03-01] ラブルパイル小惑星リュウグウの形状と起源

★招待講演

*渡邊 誠一郎[1,5]、平林 正俊[2]、平田 成[3]、平田 直之[4]、野口 里奈[5]、嶌生 有理[5]、池田 人[6]、巽 瑛理[7]、吉川 真[5]、菊地 翔太[5]、薮田 ひかる[8]、中村 智樹[9]、橘 省吾[7,5]、石原 吉明[10]、諸田 智克[1]、北里 宏平[3]、坂谷 尚哉[5]、松本 晃治[11,12]、和田 浩二[13]、千秋 博紀[13]、本田 親寿[3]、道上 達広[14]、竹内 央[5]、神山 徹[15]、本田 理恵[16]、Robert Gaskell[17]、Eric Palmer[17]、Olivier Barnouin[18]、Patrick Michel[19]、Paul Abell[20]、山本 幸生[5]、田中 智[5]、白井 慶[5]、松岡 萌[5]、杉田 精司[5,7]、岡田 達明[5]、並木 則行[11]、荒川 政彦[4]、石黒 正晃[21]、小川 和律[4]、照井 冬人[5]、佐伯 孝尚[5]、中澤 暁[5]、津田 雄一[5]、はやぶさ2 サイエンスチーム (1.名古屋大学大学院環境学研究科地球環境科学専攻、2.オーバン大学、3.会津大学、4.神戸大学、5.宇宙航空研究開発機構 宇宙科学研究所、6.宇宙航空研究開発機構 研究開発部門、7.東京大学、8.広島大学、9.東北大学、10.国立環境研究所、11.国立天文台、12.総合研究院大学、13.千葉工業大学、14.近畿大学、15.産業技術総合研究所、16.高知大学、17.惑星科学研究所、18.ジョンホプキンス大学、19.コート・ダジュール大学/観測所、20.NASA ジョンソンスペースセンター、21.ソウル大学)

11:00 ~ 11:15

[PPS03-02] Results of Hayabusa2 Near Infrared Spectroscopy at Asteroid Ryugu

*岩田 隆浩[1]、北里 宏平[2]、安部 正真[1]、大竹 真紀子[1]、仲内 悠祐[1]、松岡 萌[1]、津村 耕司[3]、松浦 周二[4]、Riu Lucie[1]、NIRS3 チーム (1.宇宙航空研究開発機構　宇宙科学研究所、2.会津大学、3.東北大学、4.関西学院大学)

11:15 ~ 11:30

[PPS03-03] はやぶさ２SCI/DCAM3による人工クレーターの形成と観測

★招待講演

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11:30 ~ 11:45

[PPS03-04] サイズ分布をもつガラスビーズ層へのクレーター形成実験：小惑星Ryuguのクレーター形成過程の解明

*保井 みなみ[1]、荒川 政彦[1]、長谷川 直[2]、山本 裕也[1]、杉村 瞭[1] (1.神戸大学大学院理学研究科、2.宇宙航空研究開発機構宇宙科学研究所)

11:45 ~ 12:00

[PPS03-05] Enhancement of impact heating in strength-supported media

*黒澤 耕介[1]、玄田 英典[2]、脇田 茂[2]、Thomas Davison[3]、兵頭 龍樹[2]、中村 智樹[4] (1.千葉工業大学　惑星探査研究センター、2.東京工業大学　地球生命研究所、3.Department of Earth Science & Engineering, Imperial College London、4.東北大学 地球惑星物質科学科・地学専攻)

12:00 ~ 12:15

[PPS03-06] Global Thermal Inertia and Surface Roughness of Asteroid 162173 Ryugu by TIR on Hayabusa2

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ラブルパイル小惑星リュウグウの形状と起源
The shape and origin of the rubble-pile asteroid Ryugu

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はやぶさ2は2018年6月に地球接近小惑星リュウグウに到着し，高度20 kmもしくはそれ以下の高度からのリモートセンシング観測を行ってきた[1, 2]．また，ローバーMINERVA-IIA，ランダーMASCOTの投下・観測に成功した．はやぶさ2搭載の可視カメラONC-Tの画像から，短期間で信頼できるものを作成するためにSPC[3]とSfM[4] という2つの手法で形状モデルを作成した．両者の比較から，高緯度地域や岩塊周辺を除いて2m以内の精度で形状復元ができていることを確認した[1]．

作成されたSPC形状モデルから得られたリュウグウの全体積は0.377±0.005 km^3であり，2018年8月の重力計測観測から求められた質量は(4.50±0.06) $\times 10^{11}$ kgであった．これより，バルク密度は 1.19±0.03 g cm^{-3} と求められた[1]．これは波長0.7 μmの吸収（水質変成）を持つCgh, Ch型の小惑星のうち質量測定されているもののバルク密度範囲（1.6ー2.4 g cm^{-3}）より有意に低いが，その吸収を持たず非加熱氷小惑星起源の可能性のあるBCG型小惑星（B, Cb, C, Cg型）のバルク密度の測定範囲（0.8ー1.5 g cm^{-3}）とは同程度である[5]．このことは，リュウグウはCb型のスペクトルを持ち，0.7 μmの吸収は見られないことと調和的である[2, 6]．リュウグウ表面には含水鉱物が存在することがNIRS3の分光観測から明らかになった[6]．リュウグウの放

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射平衡温度は250 K程度とリュウグウ中心圧力（~8 Pa）での氷の昇華温度（230 K）よりも高く，熱拡散時間も地球接近小惑星としての寿命よりずっと短いため，水氷が内部にあるとは考えにくい．ただし，リュウグウが小惑星帯にあった時期に水氷を保持していて，それが抜けたために高空隙率となった可能性はある．

リュウグウの空隙率は，CMコンドライトの粒子密度[7]を仮定すると57ー63%，CIコンドライトOrgueilのそれ[7]を仮定すると50ー52%となる．この空隙率は，ラブルパイル小惑星イトカワ（44±4%）[8, 9]よりも高く，クレーターからの放出では説明できない大きなボルダーが表面に散在することと合わせて，リュウグウがラブルパイル天体であり，より大きな小惑星の破片が再集積してできたことを強く支持する．

はやぶさ2の観測により，リュウグウはいわゆるtop shpaeをもち，顕著な赤道リッジを持つことが明らかになった．地球接近小惑星は地上レーダー観測からいくつもtop shpaeを持つものが見つかっているが，探査機が訪れたのはリュウグウが最初である．OSIRIS-RExが近傍探査しているBennuが2番目だが，リュウグウほど顕著な赤道リッジを持ってはいない．

リュウグウの現在の自転周期は約7.63時間で，中緯度帯が重力ポテンシャルの極小部分となっている．しかし，現在の形状のままリュウグウの自転周期を3.5時間にすると，赤道が重力ポテンシャルの極小となり，重力ポテンシャル面からの表面傾斜は広い範囲で31°程度となることが，明らかになった．これは，かつて高速回転していた時代に遠心力による変形でリュウグウが形成されたことを示唆する．変形は，形成期の再集積時[10]，もしくは後期になってYORP効果などによるスピンアップ時に生じたと考えられる[11]．後者の場合，変形モードは表面地滑りもしくは内部変形が考えられる．表面粒子に大きなサイズ分別が見られないこと，赤道帯が新鮮な物質でできている可能性があることなどは，内部変形モードと調和的である．

NIRS3が観測した近赤外吸収は熱変成/衝撃変性を受けたCI/CMコンドライトと相似性が高い[6]．地上落下隕石に占めるこれら相似な隕石の割合はかなり低い一方，BCG型小惑星は小惑星メインベルトに豊富に存在する．今回，BCG型小惑星リュウグウが，高空隙率で，強度が弱いことが示唆されたが，このような小惑星破片が地球大気圏に突入した場合，破壊され地上に到達しにくいことが予想される．これはBCG型小惑星を母天体とする隕石が少ないことを説明し，惑星間塵にその対応物を探す意義[5]を示していると考える．地球への水・有機物の供給源を考える上で，炭素質の小惑星の組成のみでなく，その強度や内部状態の理解も重要であり，はやぶさ2およびOSIRIS-RExの更なる観測および帰還試料分析が，その鍵を握るはずである．

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キーワード：惑星探査、C型小惑星、ラブルパイル天体、はやぶさ2
Keywords: Planetary exploration, C-type asteroids, Rubble-pile objects, Hayabusa2

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Results of Hayabusa2 Near Infrared Spectroscopy at Asteroid Ryugu

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The Near Infrared Spectrometer (NIRS3) is installed on the Hayabusa2 spacecraft to observe the target C-type asteroid 162173 Ryugu at near infrared wavelengths of 1.8 to 3.2 μm. It aims to obtain reflectance spectra in order to detect absorption bands of hydrated and hydroxide minerals in the 3 μm-band spectral region. Spectra obtained during the cruising and proximity-operation phases have revealed that the performance of NIRS3, using the newly developed linear-image sensor with indium arsenide (InAs) photodiodes, are good enough as expected from the ground performance tests.
Prior to the touch down of Hayabusa2 on the surface of Ryugu, NIRS3 has completed global observations from the Home Position, where the altitude is about 20 km above the surface. NIRS3 also performed low-altitude observations in several opportunities, such as the separation operation of the small rovers and lander, during which the lowest altitude was less than 30 m. Analyzing the spectra, NIRS3 contributed to estimate the temperature of the asteroid surface. After removing the thermal emission, we successfully detected a weak and narrow absorption feature centered at 2.72 μm, which suggests the existence of hydroxyl (OH)-bearing minerals formed by aqueous alteration. This feature is, however, almost uniform over the whole surface in terms of band depth and position. Additionally, it is remarkable that the albedo of Ryugu is extremely low. These results imply the following hypotheses; 1) dehydration caused by heating or space weathering, or 2) masking effects by dark materials on the surface. We will argue about the inspection of the evolution scenario of Ryugu inferred from the above results.

キーワード：はやぶさ２、リュウグウ、NIRS3、含水鉱物
Keywords: Hayabusa2, Ryugu, NIRS3, hydrated mineral

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はやぶさ２SCI/DCAM3による人工クレーターの形成と観測
Impact experiment on asteroid Ryugu by Small-Carry on impactor of Hayabusa-2 and observation of the impact ejecta by a Deployable CAMera-3

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A small carry-on impactor (SCI) equipped on Hayabusa2 is scheduled to be propelled toward to the surface of asteroid Ryugu this spring. Cratering process on Ryugu made by the impactor will simultaneously observed by a deployable camera 3 (DCAM3) detached from Hayabusa2. The mission objective of the impactor is to excavate the asteroid to expose a subsurface material as ejecta deposits around the crater. Thus, not only it enables us to give a good opportunity for obtaining a fresh or subsurface material by a sampler system, remote sensing instruments such as ONC, TIR, NIRS3 onboard Hayabusa2 will also have a good chance to observe the exposed subsurface material. Furthermore, this impact experiment on Ryugu is also a rare opportunity to verify the crater scaling law in the microgravity environment on the real asteroid materials, and is expected to enable us to improve the conventional scaling law, especially for the crater size and the ejecta velocity distribution.

After arrival at Ryugu, the surface morphology observation through remote sensing has turned out that a plenty of boulders cover throughout the surface, and many of the boulders are larger than 10 m. These boulders are distributed almost uniformly and the size frequency distribution of the boulders is a power law distribution with the power law index around -1, indicating relatively large boulders are dominant on

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the surface. Therefore, taking into account that the precision of an actual impact point toward an aiming point expands several 10 m, the impactor possibly collides with a large boulder, otherwise with small boulders having the power law size distribution, wherever the impactor would aim at on the surface of Ryugu. If the impactor collides with a large boulder, a crater should be formed in the strength regime, and if the impactor collides into a finer-boulder area, a crater will be formed in the gravity regime. The DCAM3 was designed for the observation of not only the impact cratering in the strength regime but also that in the gravity regime.

We believe that we will success to observe impact ejecta induced by the impactor when the SCI and DCAM3 operations are conducted as scheduled. We are planning to present a first report of the DCAM3 observation in this talk, and discuss how to search the impact point on the Ryugu surface using the DCAM3 images, beforehand the onboard imaging instruments. Moreover, the morphology of the ejecta curtain imaged by DCAM3 will bring us a lot of information about the crater formation process. We report the surface condition around the impact point, such as a large block or a small-boulders area, and an excavated area corresponding to the crater size. The DCAM3 will also observe individual dusts in the ejecta curtain to obtain information of the ejecta velocity distribution, so that we may have a chance to introduce these images. However, please note that this presentation strongly depends on the success of the SCI/DCAM3 operation.

キーワード：小惑星リュウグウ、衝突実験、小型衝突装置、分離カメラ、ラブルパイル天体
Keywords: Asteroid Ryugu, Impact Experiment, Small carry-on impactor, Deployable camera3, Rubble pile body

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サイズ分布をもつガラスビーズ層へのクレーター形成実験：小惑星Ryuguのクレーター形成過程の解明

Impact cratering experiments on glass beads with bead size frequency distribution: Implications for cratering process on asteroid Ryugu

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探査機はやぶさ２によって，小惑星Ryugu上には直径100mオーダーの巨大衝突クレーターは観察されているが，数m以下の衝突クレーターが非常に少ないことがわかっている．この原因の１つに，小さなクレーターが形成されない表面環境をRyuguが持っているということが挙げられる．Ryuguの表面は，ほぼ全ての領域において，岩石物質の衝突破壊実験で得られる衝突破片に似たベキ乗のサイズ頻度分布を持つ岩塊で覆われている[1] このような表層に衝突が起こった場合，衝突体である小天体がそれよりも大きなサイズの岩塊に衝突すると，その岩塊が破壊され，クレーターが形成されにくくなることが考えられる．弾丸より大きなサイズの標的粒子を用いた先行研究はいくつかあり，弾丸と標的粒子のサイズ比が大きくなるほど，クレーターサイズが小さくなることが報告されている[e.g., 2]．しかし，Ryuguを始めとした小惑星上の岩塊サイズ頻度分布を持つ標的を用いたクレーター実験の例はない．そこで本研究では，サイズ頻度分布をもつ粒子層に対するクレーター形成実験を行い，粒子層のサイズ頻度分布とクレーターサイズの関係を調べ，クレーター形成効率が低下する条件を明らかにした．

実験は，神戸大学に設置された縦型一段式軽ガス銃と，宇宙科学研究所に設置された縦型二段式軽ガス銃を用いた．標的には直径0.1, 1, 3, 10 mmのガラスビーズを用いて，2種類の単一ビーズ層（0.1 mmと3 mm）と2種類の混合ビーズ層（0.1-10 mmの4種混合と1-10 mmの3種混合）を用意した．宇宙科学研究所で行った実験は4種混合のみ用いた．混合ビーズ層の各ビーズの質量は等量である．神戸大学では直径2 mmまたは3 mmの鉄球を弾丸とし，衝突速度は53～181 m/sとした．宇宙科学研究所では直径1 mmのアルミ球を弾丸とし，衝突速度は1.2～4.4 km/sとした．衝突の様子は高速カメラで撮影し，弾丸の跳ね返りやビーズが飛散する様子を観察した．

衝突の様子を調べたところ，単一ビーズ層では弾丸が標的ビーズより大きい場合（0.1 mm）は，円錐形に放射状のエジェクタカーテンが確認された．弾丸が標的ビーズより小さい場合（3mm）は，無傷のビーズがより低速で噴出する様子が確認された．混合ビーズ層では，4種混合の場合は0.1 mmビーズが他のビーズの隙間を通って，靄状に噴出する様子が確認された．また，両混合層ともにほとんどの場合において，弾丸が跳ね返る様子が確認された．さらに，10 mmビーズに弾丸が衝突した場合，エジェクタの量が極端に少なくなることがわかった．形成されたクレーターを観察したところ，単一ビーズ層は逆円錐形のクレーターが形成され，非常に浅いことがわかった．一方，混合ビーズ層はリムがはっきりと確認できず，クレーター内部には10 mmビーズが多数埋もれているのが確認できた．

このクレーターサイズをノギスで計測し，クレータースケール則に適応した．クレータースケール則は規格化クレーター半径π_R（$=R(\rho/m)^{1/3}$でRはクレーター半径，ρは標的密度，mは弾丸質量）と規格化重力π_2（$=ga/U^2$でgは重力加速度，aは弾丸半径，Uは衝突速度）を用いて，$\pi_R=a\cdot\pi_2^{-b}$と表される．実験の結果，単一0.1 mmビーズ層が最も規格化半径が大きくなり，単一3 mmビーズ層と混合ビーズ層（10 mmビーズに衝突しない場合）が0.1 mmビーズ層に比べて約0.9倍になることがわかった．さらに，混合ビーズ層で弾丸が10 mmビーズに衝突した場合は，約0.7倍になることがわかった．

今回の実験では，単一0.1 mmビーズ層のスケール則（a=0.58, b=0.21）を用いて，他の標的のスケール則を説明する改良型スケール則を構築することができた．今回，弾丸が跳ね返る様子が確認されたことから，弾丸が3 mmビーズまたは10 mmビーズに衝突して運動量が輸送され，3 mmビーズまたは10 mmビーズがより

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低速で標的に潜り込み，クレーター孔を形成するという仮定を用いて，弾丸の反発係数と運動量保存則を用いたクレーター則を構築した．その結果，3 mmビーズ，10 mmビーズのどちらのビーズに衝突したと仮定した場合でも，反発係数が0.5-1の範囲に本研究の結果が分布することがわかった．

[1] 坂谷他，第２回水惑星学全体会議，神戸大学，2018年12月．[2] Tatsumi & Sugita，Icarus 300, 227-248, 2018.

キーワード：クレーター形成過程、小惑星、岩塊、サイズ頻度分布、クレータースケール則
Keywords: cratering mechanism, asteroids, boulders, size frequency distribution, crater scaling law

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Enhancement of impact heating in strength-supported media

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Hypervelocity mutual collisions between small bodies, which include the asteroid Ryugu,occur throughout the history of the solar system. A strong compression and thermal pulse caused by an impact can produce various unique features, such as a change in spectral properties, mosaicism, planer deformation features, high-pressure minerals, atomic diffusion, volatile loss, shock veins, impact melt, and so on. We can obtain these features in samples returned from Ryugu, collected by the Hayabusa2 spacecraft. When we have a reliable model connecting the degree of shock metamorphism with the impactor/target conditions, we can reveal the impact history of Ryugu more correctly.

Frequently, the table from Stöffler et al. (1991, 2018) is used to deduce the shock stage of meteorites using observed shock features, which are subsequently used to infer impact velocities on target bodies. Recently, Kurosawa and Genda (2018) reported that the degree of heating in low-velocity impacts (<10 km/s) is expected to be much higher than previously expected. This is caused by the irreversible heating during plastic deformation against material strength. Low-velocity impacts do not produce large-scale impact melting, but trigger a comminution of both impactor and target materials. Although the materials experiencing compression do not have a tensile strength, they still have a compressive one. Thus, the required impact velocities for producing the unique features produced mainly by the rise in temperature is greatly lowered as shown by Kurosawa and Genda (2018). Another work also confirmed the importance of plastic deformation during impacts to a target embedding hydrous minerals (Wakita and Genda 2019). The experienced temperature at a given shock stage defined by Stöffler’s table would be revised to somewhat higher temperatures, which would mean that impact histories derived from shock features using the previous table would need to be revised. For example, the target bodies are likely to experience many fewer high-speed energetic impacts than previously expected.

We are planning to revise the Stöffler’s table by using the state-of-the-art numerical shock physics code, iSALE, which includes both recent equation-of-state (EOS) models and various constitutive models. The Hayabusa2 spacecraft is planning to return to Earth with Ryugu samples in 2020. The revised table would largely help to reproduce the impact history of Ryugu.

In the presentation, we will introduce the work done by Kurosawa and Genda (2018) using the iSALE-2D model and will present some preliminary results from the three-dimensional (3D) model. We newly investigated the effects of impact obliquity using iSALE-3D. As a preliminary result, the enhancement of the impact heating in strength-supported media at oblique impacts becomes larger than the case at vertical impacts to the tangent plane. Although it is widely accepted that the degree of heating correlates well with the vertical component of the impact velocity, our preliminary results show that oblique impacts (45-degrees) produce nearly the same amount of heated volume as vertical impacts do. We are also going to discuss the strategy for reproducting Ryugu’s impact history.

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キーワード：衝突、衝突加熱、数値衝突計算、リュウグウの衝突史
Keywords: Hypervelocity impacts, Impact heating, Shock physics code, Ryugu’s impact history

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Global Thermal Inertia and Surface Roughness of Asteroid 162173 Ryugu by TIR on Hayabusa2

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Thermal infrared imager TIR onboard the Hayabusa2 spacecraft acquired thermal images of the asteroid 162173 Ryugu for one asteroid rotation during Mid-altitude operation on August 1, 2018, with around 5 m/pixel resolution. The thermal images were converted to brightness temperature maps on a shape model based on the ground tests, then temperature profiles of the surface of Ryugu were obtained. For comparison, thermal calculations by a thermophysical model without roughness using the shape model (TPM1) and by one with roughness using fractal rough surfaces (TPM2) were carried out.

Thermal images by TIR reveled that the surface of Ryugu showed ubiquitously high temperature above 300 K, and its temperature profile showed flat pattern at noon. Thermal calculations by TPM1 did not reproduce observed temperature profiles. By comparing maximum temperatures by TIR with those by TPM1, thermal inertia of Ryugu was estimated to be around 160 in MKS unit and reached maximum at the equatorial ridge. By contrast, thermal calculations by TPM2 successfully created flat temperature profile at noon for various thermal inertia and surface roughness. The temperature profiles were fitted by 4-order function to characterize its pattern. A multi linear regression analysis was carried out to estimate thermal inertia and surface roughness from the fitting coefficients. From the regression equations and fitting coefficients by observed temperature profiles, thermal inertia and surface roughness of Ryugu were estimated. Since the estimation is strongly affected by surface tilt angle of a polygon on a shape model, we carried out tilt angle corrections. Finally, thermal inertia of Ryugu by TPM2 was estimated to be around 330 in MKS unit and showed little variation in latitude, and with moderate homogeneous surface roughness. Thermal inertia of Ryugu determined in this study by two TPMs are consistent with that determined by ground observations. Our results suggest that thermal inertia of Ryugu is consistent with that of boulders, indicating porous nature of the boulders widely distributed on Ryugu.

キーワード：Hayabusa2、Thermal Infrared Imager、Asteroid Ryugu
Keywords: Hayabusa2, Thermal Infrared Imager, Asteroid Ryugu

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[E] 口頭発表 | セッション記号 P (宇宙惑星科学)：P-PS 惑星科学

2019年5月28日(火) 13:45 ~ 15:15 | A01 東京ベイ幕張ホール

[P-PS03] Solar System Small Bodies: A New Frontier Arising Hayabusa 2, OSIRIS-REx and Other Projects

コンビーナ:石黒 正晃(ソウル大学物理天文学科)、中本 泰史(東京工業大学)、安部 正真(宇宙航空研究開発機構宇宙科学研究所)、Olivier S Barnouin(Johns Hopkins University Applied Physics Laboratory)、座長:Olivier Barnouin(Johns Hopkins University Applied Physics Laboratory)

2018年6月、小惑星探査機「はやぶさ2」が約3年半の航海を経て、目的地リュウグウに到着した。また、別の小惑星探査機「OSIRIS-REx」も探査天体Bennuに間もなく到着しようとしている。これらの探査によって、太陽系小天体研究は、今まさに新しい局面を迎えようとしている。本セッションは、2012年から開催されてきたもので、これまでに実験、観測、探査、理論、さらにサンプル分析の観点から太陽系小天体の研究に関して議論を行ってきた。特に今回は、はやぶさ2とOSIRIS-RExの初期成果を中心に太陽系小天体に関する最新研究を持ち寄り、今後の展望を議論することを目的とする。はやぶさ2、OSIRIS-REx以外の研究成果発表も歓迎する。

13:45 ~ 14:00

[PPS03-07] Asteroid Ryugu's parent body and its properties inferred from Haybusa2 multi-band imaging observations

★Invited Papers

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14:00 ~ 14:15

[PPS03-08] 小惑星リュウグウにおける表面赤化と層序

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14:15 ~ 14:30

[PPS03-09] Preliminary report on global distribution visible spectra of asteroid Ryugu based on clustering

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14:30 ~ 14:45

[PPS03-10] Visible spectra of small bright spots on asteroid 162173 Ryugu

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14:45 ~ 15:00

[PPS03-11] Geomorphological characteristics of asteroid Ryugu: implications to its evolutional history

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15:00 ~ 15:15

[PPS03-12] リュウグウ画像テクスチャー解析によるサブメートルスケールのボルダー全球分布解析

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Asteroid Ryugu's parent body and its properties inferred from Haybusa2 multi-band imaging observations

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JAXA’s Hayabusa2 has conducted global observations of Ryugu and revealed many important properties of Ryugu, such as Cb-type average spectrum, the lack of a strong 0.7-um absorption, very low 0.55-um geometric albedo (4.5+/-0.2) %, and very young (< a few Myr) crater retention age for small craters (>10m).

The Cb-type spectrum of Ryugu is consistent with Eulalia and Polana families in the inner main belt, which are dynamically most probable source families. This agreement between the prediction from dynamic calculations and spectral observations suggests that one of the two asteroids is likely Ryugu’s parent body. These families are among the most widely dispersed C-complex families in the inner main belt, allowing to deliver family members at very high flux rate to the resonance zones (nue6 and 3:1) at both inner and outer boundaries of the inner main belt, which are the dominant source of near-Earth objects (NEOs).

Furthermore, high abundance of boulders are found on Ryugu. Evidence for mass wasting indicates mechanically unconsolidated surfaces, allowing surface boulders to move easily. The morphologies of impact craters on Ryugu are consistent with gravity-regime formation, in which impact events produce large ejecta masses. These suggest that large mass of boulders and pebbles can be ejected from Ryugu to space over time.

Consequently, a large mass of Ryugu-like macroscopic objects would enter Earth’s atmosphere, suggesting the presence of counterparts in our meteorite collection. Among such candidates is moderately dehydrated carbonaceous chondrites, which have both very low albedo and flat spectra. They are also found with high abundance in Antarctica, which may represent the long-term average flux of infalling meteorites on Earth. Another is interplanetary dust particles (IDPs), which also have low albedos and account for large influx of extraterrestrial materials to Earth. Although a decisive conclusion may not be obtained before the analysis of Ryugu samples returned to Earth, currently available observational

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evidence, such as high boulder abundance on Ryugu, favors that its composition may be similar to moderately dehydrated carbonaceous chondrites. This would further suggest that Ryugu’s relatively low abundance of hydrated minerals may be due to partial dehydration on Ryugu’s parent body.

キーワード：はやぶさ２、リュウグウ、太陽系進化
Keywords: Hayabusa2, Ryugu, The evolution of the solar system

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小惑星リュウグウにおける表面赤化と層序
REDDENING PROCESS OF THE RYUGU SURFACE BASED ON THE CRATER SIZE-FREQUENCY DISTRIBUTION

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The Hayabusa2 has acquired the high-resolution images and spectra of the Ryugu surface. Although the Ryugu surface has almost homogeneous reflectance and color at the macro scale, the regional variation in the spectral slope is observed by the telescopic optical navigation camera (ONC-T). The redder materials of the Ryugu surface seem to cover bluer materials. Some small craters excavate the red materials on the surface and penetrate the underlying blue materials, suggesting that the craters are younger than the reddening of the surface (space weathering or deposition of red materials). In this study, we performed the crater size-frequency measurements on the Ryugu surface using the ONC image data to constrain the surface age of the Ryugu and the age of reddening event or the timescale of reddening process of the Ryugu surface.
To identify the craters excavating the red materials we used the b-x slope images calculated from multi-band images obtained in the Mid-altitude operation. We identified 15 craters excavating the red materials. These craters have diameters from 10 to 50 m, suggesting that the thickness of the red material layer is less than 1 m.
The cratering chronology models of asteroids have been numerically calculated from the collision rate with other asteroids and scaling laws for crater formation. In this study, we used the intrinsic collision probabilities Pi for the main belt and the NEAs, the population models of the main belt asteroids and NEAs, the mean impact velocities for the main belt (5.3 km/s) and the NEAs (18 km/s), and the new Pi–scaling law developed by Tatsumi and Sugita to develop the cratering chronology model of Ryugu. Because little is known about the bulk strength of materials on Ryugu, we examined two cases (i) the strengthless target (Y = 0 MPa) and (ii) the strength for dry soil (Y = 0.18 MPa).
The density of large craters (D>100 m) on Ryugu is lower than the empirical saturation level and its slope is steeper than that of the saturated distribution, suggesting that craters larger than 100 m are not saturated and the size distribution reflects the crater production function. However, craters smaller than 100 m are significantly under-saturated, suggesting that some crater erasure processes such as seismic

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shaking and armoring effect are active on the Ryugu surface. Based on cratering chronology model for the main belt, the surface age of Ryugu is estimated to be 5–200 Ma from the size–frequency distribution of craters larger than 100 m.
The observed frequency of craters penetrating the underlying blue materials is ~1/50 of that of craters found on the whole Ryugu. The model age of the reddening is estimated to be 0.1–4 Ma based on the main-belt chronology model and 4–160 Ma based on the NEA chronology model. The NEA model age is roughly close to the median dynamical lifetime of NEAs (~10 Ma), suggesting that the reddening of the Ryugu surface may have some connect with the orbital transition from the main belt to near Earth orbit.

キーワード：はやぶさ２、小惑星リュウグウ、クレータ
Keywords: Hayabusa2, Ryugu, crater

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Preliminary report on global distribution visible spectra of asteroid Ryugu based on clustering

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Preliminary result of global distribution of visible spectra of asteroid Ryugu derived from multi-band images obtained by ONC-T onboard Hayabuasa 2 is presented.
The ONC-T is a telescopic charge-coupled-device (CCD) camera with a 6.27˚ ×6.27˚ field of view (FOV) , having a 1024 pixels x 1024 pixels sensor and seven narrow band filters ranging from 395nm and 950nm and one wide-band filter. Images obtained by ONC-T are spatially aligned and converted into seven-band visible spectra (reflectance factor).

The spectra are clustered, and the obtained cluster id are shown on the global map. As the method of clustering, k-means++, x-means, gaussian mixture model via EM are tested for synthetized data and x-means is selected since this method is stable to obtain a suitable number of components.

The obtained spectra are divided into seven to nine groups depending the slope of the spectra. Flat spectrum group is distributed around the equatorial ridge, the redder and darker groups are in the southern hemisphere and the relatively bright and bluer spectra are observed at the polar region, in particular at Otohime Saxum. The distribution of these spectra groups appears to indicate the surface history such as space weathering and erosion and the supply from different sources.

キーワード：小惑星、リュウグウ、可視、はやぶさ２、スペクトル、クラスタリング
Keywords: asteroid, Ryugu, visible, Hayabusa2, spectra, clustering

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Visible spectra of small bright spots on asteroid 162173 Ryugu

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The Optical Navigation Camera (ONC) onboard the Hayabusa2 spacecraft has obversed asteroid 162173 Ryugu at various scales and found that Ryugu has a uniform spectrum in km-scale and that boulders exhibit a range of albedo (0.89 –1.3 times of the surface average) and spectra [1]. Higher resolution images taken during descent operations revealed the presence of bright spots, which are typically much brighter than the brightest large boulders. Brightness variation may reflect differences in composition, thermal alteration, or space weathering maturity. Such materials would follow spectral trends seen on other materials on Ryugu. In fact, brightest boulders are the end-members in reflectance/slope statistics and Principal Component Analysis (PCA) of boulders on Ryugu. If bright spots are fragments of the parent body at the origin of Ryugu, they may correspond to the fresher components of the boulder population constituting Ryugu, contributing to the spectral variety observed on the asteroid. In contrast, it is also possible that Ryugu contains materials of exogenous origin. In that case, the spectra of bright spots should not follow the spectral trends observed for other materials on Ryugu and should rather be consistent with the spectra of asteroids found in the inner main belt. In either case, bright spots will help us place important constraints on to the formation and evolution of Ryugu.

In this study, we analyzed the brightest spots whose reflectance is ≧ 1.7 times the reflectance global average. The dimensions of these sports are very small: ≦ 3 m. The spectra of these brightest spots were extracted from I/F images taken at altitudes of Hayabusa2 between 100 and 500 m (i.e., low-altitude descent observations) and 3 –4 km (hovering operation after MASCOT deployment) and were compared with meteorite spectra. As for low altitude images, we conducted a photometric correction because the rotation of Ryugu results in a several degrees phase angle gap between different filters. The spectra of meteorites include 250 carbonaceous chondrite spectra and 106 ordinary chondrite spectra from RELAB of Brown University and they are linearly interpolated to match the bands of ONC-T [2]. We searched for meteorite spectrum that gives minimum residual sum of squares (RSS) of spectra among the 356 samples.

Analysis results indicate that 5 out of 10 bright spots have spectra consistent with carbonaceous chondrites (CC), such as CM2 and CV3, and that the other half are consistent with ordinary chondrite (OC) such as LL6. Some of CC-like bright spot spectra are very similar to that of type3 (bright and molted) boulders found in [1], which was one of the end-members in reflectance/slope statistics and PCA of boulders. This suggests that these bright spots can be new members of this boulder group.

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Because Ryugu most likely comes from the inner main bet, OC-like bright spots are consistent with exogenous origin. Preliminary results indicate that two types of spectra are present. One has a spectral peak at v-band (centered at 0.55 micron) and the other has a peak at w-band (0.86 micron). If this spectral variation is large enough to require the delivery of meteoritic materials from asteroids, it would reflect the variety in composition among many projectiles that collided with Ryugu after its formation. In contrast, if the shift in spectral peak is consistent with spectral modification mechanisms within a large OC-like projectile, such as thermal metamorphism, these bright spots could be remnants of one projectile only. In either case, however, because the average impact velocity in the main belt is very high ~5km/s [3], the fact that we may observe remnants of projectiles impacting at such speeds on the surface of Ryugu has strong implications in our understanding of the impact process and in our interpretation of the compositional heterogeneity of small bodies and meteorites.

[1] Sugita, S. et al., (2019) submitted to *Science*
[2] Tatsumi et al., (2019) *Icarus*
[3] Bottke et al., (1994) *Icarus*

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Geomorphological characteristics of asteroid Ryugu: implications to its evolutional history

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Observations by Hayabusa 2 spacecraft indicate that Ryugu is a highly porous C-type asteroid. Ryugu’s surface is covered by numerous boulders. These are consistent with the idea that Ryugu is a rubble-pile asteroid. Interestingly, Itokawa, the only other similarly-sized rubble-pile asteroid closely observed by spacecraft, is different from Ryugu in many aspects. For example, while the shape of Ryugu is a top-shape, that of Itokawa is somehow elongated cigar-like. Though Ryugu is generally homogeneous in terms of roughness, Itokawa has two distinctive areas such as smooth and rough terrains. Ryugu has an almost continuous equatorial ridge, though Itokawa does not have such a large-scale topographic feature.

These differences may come from the difference in evolutional processes; a top-shape of rubble pile asteroid is believed to result of rotationally induced deformation or from re-accumulation. Another possibility is that the differences may come from variations in mechanical properties of asteroid forming materials. We are investigating geological characteristics of Ryugu, which may hold clues for these aspects. In this talk, we report initial results of geological investigations mostly using visible images obtained by the Optical Navigation Camera (ONC) onboard the Hayabusa2 spacecraft, and discuss about their implications to evolutional history of Ryugu..

キーワード：小惑星、はやぶさ２、リュウグウ
Keywords: asteroid, Hayabusa 2, Ryugu

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リュウグウ画像テクスチャー解析によるサブメートルスケールのボルダー全球分布解析
Global distribution of sub-meter boulders measured with texture analysis of Ryugu images

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探査機はやぶさ2は、2018年6月27日にC型小惑星リュウグウに到着し、現在リュウグウの全球観測や高解像度の局所観測を行っている。これらの観測から、リュウグウ表面には、20m以上のボルダー数密度がイトカワの約2倍と、非常に多くのボルダーが存在していることが明らかとなってきている。しかし、これらの観測で得られた画像の解像度は05.-2m程度であるため、数-10m程度のボルダーまでしか検出できていない。

そこで本研究では、目視では判別できないsub-pixelから数pixel程度の小ボルダーの存在度を、画像から機械的に評価する手法を開発し、これをリュウグウに適用した。まず、はやぶさ2の着陸地点決定時の安全性評価に用いた。さらに、本手法を用いてリュウグウ上のボルダーの全球的な空間分布・サイズ分布を解析することにより、リュウグウの形成過程に関する情報を調査した。

これらの解析から、リュウグウ表面のボルダーが全球的に比較的一様な分布を取っていることが分かった。特に、ボルダーのサイズ頻度分布のべき数が、75cm以上のボルダーについて、全球平均-2.53、標準偏差0.03と非常に一様な値を持つことが分かった。このべき数は、5m以上のボルダーカウンティングで得られた結果(-2.65 ±0.05)と整合的である。また、同様の手法を、同じく微小重力天体であるイトカワに適用したところ、べき数の全球平均-3.6、標準偏差0.83と、リュウグウと比べ非常に非一様な分布をもっていることが分かった。このことから、イトカワはGranular convectionによるものと見られる分級作用が顕著である[Miyamoto et al. 2007]が、リュウグウでは、このような分級作用が弱いということが分かった。

一方、より詳細に見ると、経度方向・緯度方向にボルダー数密度の偏りが存在することも分かった。経度方向については、東側領域は西側領域~1.4倍のボルダー数密度をもち、東西でボルダー数密度に二分性が存在することが分かった。クレーター分布[Cho et al. 2019 LPSC]や表面アルベド[Sugita et al. 2019]にも同様の傾向が見られているまた、西半球を囲んでいるトラフにおいて、ボルダー数密度が最も小さかった。このトラフは、重力ポテンシャルが高いためにより新しい表面が露出していると考えられる赤道リッジや極域と同様に、可視領域において青化の傾向が見られる。これらのことから、西半球は東半球と比べて表面物質の可動性が高い領域となっている可能性が示唆される。

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また、全球観測からリュウグウには、高緯度ほどボルダー数密度が高いという、程度は小さいが有意な、緯度方向の分級作用が見られることが分かっている[Sugita et al. 2019]。我々の解析からは、特に赤道域について、緯度方向のさらに特異な傾向も見られている。赤道リッジの頂上ではボルダー数密度が比較的多く、赤道リッジの南北斜面においてボルダー数密度が小さくなっている。これは全球的な傾向とは逆の傾向を示している。特にこの傾向は東半球の赤道リッジで強く、地形傾斜角との相関(R ~ -0.73)が存在することが分かった。この結果は、観測されているボルダー分布が、過去の自転速度の早かったと言われている時代ではなく、現在の重力ポテンシャルを反映したものであることを示唆している。さらにこのことは、自転速度低下後において、表面物質の移動が起きていたことを意味する。

キーワード：リュウグウ、はやぶさ２、ボルダー
Keywords: Ryugu, Hayabusa2, boulder

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[E] 口頭発表 | セッション記号 P (宇宙惑星科学)：P-PS 惑星科学

2019年5月28日(火) 15:30 ~ 17:00 | A01 東京ベイ幕張ホール

[P-PS03] Solar System Small Bodies: A New Frontier Arising Hayabusa 2, OSIRIS-REx and Other Projects

コンビーナ:石黒 正晃(ソウル大学物理天文学科)、中本 泰史(東京工業大学)、安部 正真(宇宙航空研究開発機構宇宙科学研究所)、Olivier S Barnouin(Johns Hopkins University Applied Physics Laboratory)、座長:Masanao Abe(Institute of Space and Astronautical Science, JAXA)

2018年6月、小惑星探査機「はやぶさ2」が約3年半の航海を経て、目的地リュウグウに到着した。また、別の小惑星探査機「OSIRIS-REx」も探査天体Bennuに間もなく到着しようとしている。これらの探査によって、太陽系小天体研究は、今まさに新しい局面を迎えようとしている。本セッションは、2012年から開催されてきたもので、これまでに実験、観測、探査、理論、さらにサンプル分析の観点から太陽系小天体の研究に関して議論を行ってきた。特に今回は、はやぶさ2とOSIRIS-RExの初期成果を中心に太陽系小天体に関する最新研究を持ち寄り、今後の展望を議論することを目的とする。はやぶさ2、OSIRIS-REx以外の研究成果発表も歓迎する。

15:30 ~ 15:45

[PPS03-13] 162173 リュウグウ表面の岩石の明るさと形状の変化

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15:45 ~ 16:00

[PPS03-14] 小惑星162173リュウグウのクレーターと赤道バルジの地形

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16:00 ~ 16:15

[PPS03-15] Observation of 1064 nm normal albedo around equator of the Ryugu using the Hayabusa2 LIDAR

*山田 竜平[1]、山本 圭香[2]、荒木 博志[2]、野田 寛大[2]、千秋 博紀[3]、並木 則行[2]、松本 晃治[2]、吉田 二美[3]、阿部 新助[4]、平田 成[1] (1.会津大学　コンピュータ理工学部、2.国立天文台、3.千葉工業大学、4.日本大学)

16:15 ~ 16:30

[PPS03-16] LIDARデータおよび形状モデルを組み合わせた「はやぶさ2」探査機軌道改良

*松本 晃治[1]、野田 寛大[1]、石原 吉明[2]、千秋 博紀[3]、山本 圭香[1]、平田 成[4]、平田 直之[5]、並木 則行[1]、大坪 俊通[6]、渡邊 誠一郎[7]、水野 貴秀[8]、山本 幸生[8]、池田 人[8]、尾川 順子[8]、菊地 翔太[8]、佐伯 孝尚[8]、津田 雄一[8] (1.国立天文台RISE月惑星探査検討室、2.国立環境研究所、3.千葉工業大学、4.会津大学、5.神戸大学、6.一橋大学、7.名古屋大学、8.宇宙航空研究開発機構)

16:30 ~ 16:45

[PPS03-17] はやぶさ2帰還リュウグウ試料のキュレーションに関する準備状況

*矢田 達[1]、安部 正真[1]、中藤 亜衣子[1]、与賀田 佳澄[1]、坂本 佳奈子[1]、西村 征洋[1]、岡田 達明[1]、中埜 夕希[2]、吉武 美和[1]、熊谷 和也[3]、岩前 絢子[3]、古屋 静萌[1]、橘 省吾[4,1]、圦本 尚義[1,2] (1.宇宙航空研究開発機構、2.北海道大学、3.マリン・ワーク・ジャパン、4.東京大学)

16:45 ~ 17:00

[PPS03-18] Analysis of the grain from the asteroid Ryugu proposed by the Phase 2 curation “Team KOCHI”

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162173 リュウグウ表面の岩石の明るさと形状の変化
Brightness and morphology variations on surface boulders of 162173 Ryugu: Space Weathering, Breccia, and Thermal Cracks

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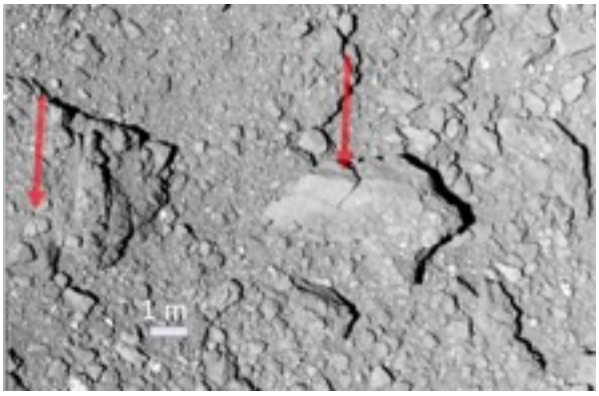
2014年12月に打ち上げられた「はやぶさ２」は、予定通り2018年6月にターゲット天体リュウグウに到着した。離れた距離からの全球マッピングのほか、何回かの近接オペレーションを行い、着地探査機MINERVA-IIA,BおよびMASCOTを成功させている。

リュウグウは二方向反射率が２％以下の、太陽系でも最も暗い天体である。表面はさまざまなサイズの岩石で覆われていて（存在度はイトカワの約2倍）ラブルパイル天体である。密度から求められる空隙率は50%を越える。表面の岩石には数十%の明るさの違いがある。一般的には、明るい岩石は表面が滑らかで層構造を有する。暗い岩石の表面は凹凸が多い。これは、数10メートルスケールの大きなボルダーから数10cmの岩石まで共通するスケールによらない特徴である。岩石の中で、割れている断面が3-4倍明るいものがある。これは、表面の暗さが宇宙風化によることを強く示唆している。岩石の中には、南北方向に割れているものがあり、熱ストレスによるものかもしれない。

「はやぶさ２」は、2019年2月末にリュウグウに着陸して表面のサンプルを採取する。また、衝突体を高速で方面に衝突させ、人工的なクレーターを形成させる予定である。明るい物質が現れることが期待される。

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キーワード：地球近傍小惑星、はやぶさ２、宇宙風化作用、熱疲労、炭素質隕石
Keywords: Near Earth asteroids, Hayabusa 2, Space weathering, Thermal fatigue, Carbonaceous meteorites



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小惑星162173リュウグウのクレーターと赤道バルジの地形
Topography of large craters and equatorial bulge of 162173 Ryugu

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2018年10月30日に行われた高度6 kmでのスキャン観測により，小惑星リュウグウの赤道帯(北緯20度から南緯40度，東経170度から東経120度まで)の詳細な地形データが得られた．この詳細地形データにはウラシマ，コロボック，ブラボーの3つの大クレーターが含まれている．また赤道リッジの大部分をカバーしている．ウラシマ，コロボック，ブラボークレーターについては，7-9月に取得された高度20 kmからの高空間分解能の地形データもあるが，測線が東西方向のみであり，緯度範囲も限定的であったため，10月30日スキャン観測によって，はじめて2次元的な地形データを取得する事ができた．

ウラシマクレーターの中心を横切る測線は合計4回取得されており，いずれも東西断面の地形は非常に良く一致している．コロボック，ブラボークレーターについても同様に再現性が高く，レーザー高度計の測定精度の実力値は2〜3 mと評価される．クレーターの深さと直径の比率はウラシマが0.2，コロボックが0.14，ブラボーが0.155であり，様々なサイズの小惑星と同程度の比率を示す．一方で，同じラブルパイル天体でありサイズも似かよっている小惑星イトカワ，ベンヌの浅いクレーターとは明らかな違いがある．

クレーターの形状はボウル型というよりは円錐型に近い．ウラシマクレーターには中央に小さい窪みがあり，2段の凹地になっている．コロボックとブラボークレーターは中心部が平らになっている．また，クレーター斜面の傾度は岩塊を除けば一定で，ウラシマが16-20度，コロボックが7-15度，ブラボーが16-18度である．この傾斜は30-35度という一般的な安息角に比べて小さい．コロボックとブラボークレーターの平らな中央部と，緩やかな傾斜は一見，クレーターに地形緩和が進んでいる事を示唆しているように思われる．実際に，光学カメラ画像にはウラシマクレーター内部の斜面で地すべりが起きている事が認められる．しかしながら，他の小惑星クレーターと同程度の深さ/直径比率と，ウラシマクレーターの2重凹みは，クレーター形成当時の地形が保存されている事を強く示唆する．従って，リュウグウ上のクレーター地形は20度以下の緩斜面の円錐形として形成され，安息角よりも緩やかだったために地形緩和による大きな変形が起きなかったと考えられる．

クレーターの東西断面は東側斜面と西側斜面に顕著な違いを示している．いずれのクレーターも西側斜面が粗く，東側斜面が滑らかである．東西の相違はクレーターリムの形状に最も顕著に認められる．西側のリムは細く急であるが，東側のリムは幅が広く緩やかである．東西の形状の非対称は，クレーターからの低速度放出

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物がリュウグウに再集積する際に，西側の斜面に選択的に降り積持ったためと考えられる．低速度放出物は大きな破片が卓越するため，西側斜面が東側斜面よりも粗くなっていると推定される．同じ原因で東側リムが幅広になったと解釈する事が可能であるが，リムの東西非対称については放出物にはたらくコリオリ力の影響も考えられる．東向きに飛び出した放出物は，北半球では南向きに，南半球では北向きに進路を変えて，赤道付近に集まった可能性もある．

赤道バルジの南北地形断面形状はほぼ対照的である．しかし，クレーターと同じように，斜面の粗さ，滑らかさには南北非対称がある．かつ，非対称の表れ方は経度によって異り，北側が滑らかで，南側が粗い地域もあれば，逆に北側が粗く南側が滑らかな地域もある．中間熱赤外カメラからは赤道バルジの熱的特性に関して顕著な地域差は確認できておらず，南北非対称の原因が粒度や空隙率の地域差によるとは想定し難い．この南北非対称についてはさらに考察を要する．

キーワード：はやぶさ2、クレーター、赤道バルジ、地形、リュウグウ
Keywords: Hayabusa2, Crater, Ea\quatorial bulge, topography, Ryugu

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Observation of 1064 nm normal albedo around equator of the Ryugu using the Hayabusa2 LIDAR

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In June 2018, the Japanese asteroid explore Hayabusa2 has arrived to C-type asteroid 162173 Ryugu after three and half years journey. The Hayabusa2 has the laser altimeter (light detection and ranging: LIDAR) for navigation of the spacecraft and scientific uses. The main purpose of the LIDAR is to measure the distance between the spacecraft and the asteroid using time delay between the transmission and reception of the laser. In addition, the Hayabusa2 LIDAR has the function of measuring the intensities of a transmitted laser pulse and received laser pulse reflected from the asteroid surface. In this study, we have derived the normal albedo of the Ryugu at the laser wavelength of 1064 nm using the intensity data. The observation of normal albedo using the LIDAR has never been performed on C-type asteroid. Our observation will provide first knowledge of normal albedo variation at 1064 nm on C-type asteroid.

Usually, the Hayabusa2 spacecraft stands at home position (altitude of 20 km) and the intensity and ranging data are obtained with 1/32 Hz. As special operation, the spacecraft moves to latitudinal and longitudinal direction or descend to low altitude. Then, the LIDAR data are sampled at 1Hz. For analysis of normal albedo, we have selected the data obtained in altitude lower than 7 km. The size of the footprint become smaller with descent of the spacecraft, and mapping resolution is higher. Then, less size of footprint is effective to reduce effect of the surface terrain on the LIDAR return pulse. We have applied the data obtained at July 20, August 1, 6, 7, September 11, 20, 21, October 2, 3, 4, 15, 24, 31 and November 1, 2018 for normal albedo analysis. In these days, the spacecraft has been operated at low altitude, for example, rehearsal of touchdown for sample sampling has been performed in October 15 and 24. From the selected data, we have derived the normal albedo around equator of the Ryugu in range of about 10 degrees in latitude. The total data number is 37,5151.

For calculation of normal albedo, we applied some reflectance models; they are the Lambert, the Lommel-Seeliger and the Oren-Nayar models. The intensity of the reflected pulse calculated by the Oren-Nayar model depends on the applied value of roughness () in degree. We have applied 9 Oren-Nayar model changing the roughness from 10 to 90 degrees with interval of 10 degrees. On a footprint, 11 types of normal albedo have calculated for 11 reflectance models, respectively.

Firstly, we have found that the derived values of the 1064 nm normal albedo are different for each model. The lowest albedo is derived for the Lommel-Seeliger model, and the highest albedo is derived for the

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Oren-Nayar model with roughness of 90 degrees. Secondary, it has been found that values of normal albedo depend on the incident angle of the laser pulse for some reflectance models. Especially, the normal albedo using the Lambert model are evidently higher with increase in incident angle at many areas around the equator. This is impossible phenomena for real material as rocks, and this means the Lambert model is inappropriate to represent reflectance of a lot of areas on the Ryugu. Therefore, we have investigated relation between the normal albedo and incident angle in each grid with resolution of 5 5 degrees. In the investigation, slope of normal albedo for incident angle were derived for 11 reflectance models in each grid, and the model which have the smallest slope would be appropriate in the area. From the results, we found that the Lommel-Seeliger model is dominant around equator of the Ryugu. When we apply the Lommel-Seeliger model, the average of normal albedo in the equator area is 0.042, and the deviation is 9.0 %. It corresponds to typical albedo of C-type asteroid (0.03-0.06) observed by ground telescope. In this presentation, we will also discuss regionality of the normal albedo on Ryugu and relation with surface terrain.

キーワード：C型小惑星、リュウグウ、はやぶさ2、レーザ高度計、ノーマルアルベド
Keywords: C-type asteroid , Ryugu, Hayabusa2, LIDAR, Normal albedo

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LIDARデータおよび形状モデルを組み合わせた「はやぶさ2」探査機軌道改良

Improved Trajectory of Hayabusa2 by Combining LIDAR Data and a Shape Model

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Hayabusa2 spacecraft successfully arrived at the target C-type asteroid 162173 Ryugu on 27 June, 2018, with its “home position” being about 20 km above the sub-Earth point. Soon after arrival, Hayabusa2’s remote sensing instruments started near-global observations. Because map products from these instruments depend on the spacecraft position with respect to the asteroid, it is necessary to provide precise spacecraft trajectory in a timely manner. The basic idea is to find a trajectory correction which makes “LIDAR-derived topography” fit to the reference shape model. The LIDAR-derived topography is, in other words, a sequence of LIDAR footprint positions expressed in asteroid-centered body-fixed rotating frame. The footprints can be computed by using the following information; spacecraft position with respect to the asteroid, spacecraft attitude, LIDAR range, rotational information of the asteroid (orientation and spin period). If all the information above was perfect, the collective footprints would delineate the shape of the asteroid. In reality, however, there are various errors affecting the footprint positions, among which the largest is generally the trajectory error, making the resultant LIDAR footprints deviate from the shape model. We call the deviation as residual. A shape model constructed by stereo photoclinometry (SPC) method is used as reference. We obtain trajectory correction by minimizing the residuals with polynomial functions. We made use of Markov chain Monte Carlo (MCMC) algorithm to explore better parameters. We compared the LIDAR-corrected trajectory with camera positions that are determined through SPC shape modeling. The two estimates agree with each other within about 40 m on 10 July 2018, and 20 m on 20 July 2018. LIDAR-derived topography with such an improved trajectory can be used for analysis of boulder height, crater shape, surface roughness, etc.

キーワード：はやぶさ2、探査機軌道、レーザ高度計
Keywords: Hayabusa2, spacecraft trajectory, LIDAR

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はやぶさ2帰還リュウグウ試料のキュレーションに関する準備状況
Present status of preparation for the Ryugu sample curation returned by the Hayabusa2

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小惑星探査機はやぶさ2は2014年12月に打ち上げられ、2018年6月にC型小惑星リュウグウに到着した[1]。現在、一連のリモートセンシング機器による観測を行っており、今年の初めには小惑星上へタッチダウンによる試料採集を実施する予定である[1, 2]。探査機は2019年の終りには小惑星を出発し、2020年終わりに地球にリュウグウ表層試料を収めた再突入カプセルを帰還させる予定である[1, 2]。

これらの探査機運用と並行して、JAXAでは小惑星から帰還する試料のキュレーションの準備を進めている。2017年9月にはやぶさ2帰還試料を取り扱う為のクラス1000のクリーンルームが完成し、試料を扱う為のクリーンチェンバー(CC)が昨年10月に整備された。このクリーンチェンバーは5室(CC3-1, CC3-2, CC3-3, CC4-1, CC4-2)から構成されている。

小惑星リュウグウは水質変成を受けた炭素質コンドライトの母天体と思われる為[3]、水・有機物などの揮発性物質分析が帰還試料にとって非常の重要な科学目標である[4]。揮発性物質を含む小惑星試料を地球の揮発性物質で汚染させない為に、はやぶさ2の試料コンテナには新たに開発した金属シール機構が備えられている[5, 6]。はやぶさ初号機ではバイトン2重Oリングによるシールであった為、地球大気の汚染を防ぐことが出来なかったが[7]、はやぶさ2の金属シール機構は1Pa以下の真空を100時間に渡って保持することが可能である[5, 6]。

探査機が帰還した再突入カプセルを回収した後、再突入カプセルは近くのクイックルック施設(QLF)に搬送される。カプセルの安全化処理の後、試料コンテナが取り出され、クリーニングを行い、コンテナ内部のガス状揮発性物質を回収する為のガス採集ラインに接続される。ガス状物質の回収の後、コンテナは窒素雰囲気で密封された状態でQLFからJAXAキュレーション施設へ運ばれる。コンテナのうち、CCへ搬入できない部品をクリーンルームで取り除く。最後にコンテナはコンテナ開封機構に設置され、CC3-1に導入される。

コンテナはCC3-1内の真空環境で開封され、リュウグウ試料を収めた試料キャッチャーが取り出される。取り出された試料キャッチャーはCC3-2に搬送される。試料キャッチャーは3室に分かれており、3ヵ所の異なる地点からの採集試料が各々納められており[5, 6]、その内最初のタッチダウン地点の試料が納められた室の蓋を開けて、少量の試料を取り出す。この採集された少量試料は将来の分析の為にCC3-2内で真空にて保管される。キャッチャーは真空環境にてCC3-2からCC3-3に搬送され、CC3-3を窒素環境に置き換える。そしてキャッチャーはCC4-1、CC4-2に搬送され、キャッチャーの3室からそれぞれ試料の取り出しが行われる。Phase-1と呼ばれる初期記載作業に於いて、取り出された試料の秤量、顕微鏡観察、CC3-3とCC4-2に設置された赤外分光装置による分析が行われる。

上記システムにおける試料ハンドリングの機能試験、試料受け入れ・ハンドリングのリハーサルは2019年

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4月から開始する予定である。2020年初頭にはそれらの機能試験・リハーサルを反映した調整・整備を行い、2020年終わりの試料帰還に備える予定である。

参考文献: [1] Watanabe S. et al. (2018). AGU 2018 fall meet., present. #P21A-02. [2] Watanabe S. et al. (2017) Space Sci. Rev. 208, 3–16. [3] Vilas et al. (2008) Astron. J. 135, 1101–1105. [4] Tachibana S. et al. (2014) Geochem. J., 48, 571-587. [5] Sawada T. et al. (2017) Space Sci. Rev. 208, 81-106. [6] Okazaki R. et al. (2017) Space Sci. Rev. 208, 107-124. [7] Okazaki R. et al. (2011) LPS XLII, abstract #1653.

キーワード：はやぶさ2、C型小惑星、リュウグウ、試料キュレーション、炭素質コンドライト、地球近傍小惑星
Keywords: Hayabusa2, C-type asteroid, Ryugu, sample curation, carbonaceous chondrite, Near Earth asteroid

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Analysis of the grain from the asteroid Ryugu proposed by the Phase 2 curation “Team KOCHI”

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Returned samples from asteroids and comets have provided unique characteristics to investigate their origin and nature of the Solar System [1-3]. For example, analytical studies of the S-type asteroid Itokawa by the Hayabusa mission provided new insights for the asteroid-meteorite connections, space weathering processes, small asteroidal body formation in the Solar System [e.g., 1, 3, 4]. JAXA Hayabusa2 and NASA Osiris-REx are both on-going sample return missions from the primitive asteroids, Ryugu (C-type) and Bennu (B-type), respectively [5, 6]. Both missions have complementary scientific goals that are to understand the Solar System evolution in the point of view of organics, water, and associated minerals (i.e., hydrous minerals).

Phase 2 curation teams will be acting under the scientific direction and strong ethic of the Astromaterial Science Research Group (ASRG) of JAXA and was authorized 2 institutes by the steering committee of the ASRG in 2017: (1) Kochi Institute for Core Sample Research (KOCHI), JAMSTEC in collaboration with JASRI/SPring-8, UVSOR Synchrotron Facility/National Institutes of Natural Sciences, Institute for Molecular Science, National Institute of Polar Research (NIPR) and Tokyo Metropolitan University, and (2) the Institute for Planetary Materials, Okayama University at Misasa. The JAXA Curation requested us to make an in-depth analysis of a few grains by the state-of-the-art instruments/techniques and nationwide collaborative research activities. We will conduct on analyses in parallel with the initial analysis team led by the Hayabusa2 project.

Recent reports by the Near-IR Spectrometer (NIRS3) on Hayabusa2 spacecraft presented that the asteroid Ryugu may consist of either CM chondritic materials [8] or shocked/heated carbonaceous chondrites [9]. Matsuoka et al. [9] pointed out that the low albedo of the asteroid Ryugu could be explained by a combination of C-rich material, grains size, porosity and space weathering effects on the asteroid surface materials. This implies that the avoiding terrestrial contaminations (i.e., atmospheric water/air, organics) during sample curation, transportation and analysis are important to obtain original chemical characteristics of Hayabusa2 returned samples.

We have developed novel and universal sample holders (KOCHI grid and KOCHI clamp) for a linkage analysis utilizing micro-analytical instruments of FIB, TEM, STXM and NanoSIMS minimizing terrestrial contaminations and sample lost or broken. We also made an additional sample holder (Okazaki cell) for STXM analysis (Ohigashi T. et al. in preparation), and a sample transport vessel (FFTC: facility to facility transfer container; Uesugi K. et al. in preparation) under vacuum or inert gas in parallel.

We have carried out the development of coordinated synchrotron based-CT (SPring-8) –XRD (SPring-8)

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–FIB (JAMSTEC KOCHI) –STXM (UVSOR Synchrotron Facility) –NanoSIMS (JAMSTEC KOCHI) –TEM (JAMSTEC KOCHI) analysis to obtain complex structure inside of the sample, light element/isotope images to obtain their spatial distributions, speciation of elements: type of bonding, chemical species, redox state and ultra-fine textural observation: mineralogy and crystallography in fine-grained mineral and organic assemblages in few tens to hundreds of micrometer-scale Hayabusa2 samples. We, therefore, have chosen Antarctic micrometeorites provided by NIPR as analogues of Hayabusa2 sample because of their size (50 to 800 μm, as an example of small particle) and chemical characteristics.

We will report the current status, ethic and motivation of “Team KOCHI” of Phase2 Curation. In addition, we will present newly developed universal sample holders for FIB, TEM, NanoSIMS, STXM, and a sample transport vessel under vacuum or inert gas among nationwide/international universities and institutes.

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キーワード：はやぶさ２試料、微小領域分析機器を組み合わせたリンケージ分析
Keywords: Hayabusa2 returned sample, Linkage analysis utilizing micro-analytical instruments

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[E] 口頭発表 | セッション記号 P (宇宙惑星科学)：P-EM 太陽地球系科学・宇宙電磁気学・宇宙環境

2019年5月28日(火) 9:00 ~ 10:30 | A04 東京ベイ幕張ホール

[P-EM12] Space Weather and Space Climate

コンビーナ:片岡 龍峰(国立極地研究所)、Antti A Pulkkinen(NASA Goddard Space Flight Center)、草野 完也(名古屋大学宇宙地球環境研究所)、坂口 歌織(情報通信研究機構)、座長:片岡 龍峰(国立極地研究所)

We share the latest scientific papers to understand how the solar-terrestrial environment changes in various time scales, and to discuss how we will react via international and interdisciplinary collaborations. More specifically, welcomed papers include space climate studies to reconstruct long-term variations from radio isotopes; cutting-edge observational and modeling studies of the ionosphere, geospace, heliosphere and the sun; simulation and statistical studies to predict the future space weather and space climate; applied science such as operational space weather forecast and mitigation of the social impact due to extreme space hazards.

9:00 ~ 9:15

[PEM12-25] Variation of carbon-14 in tree rings around the onset of the Spoerer Minimum

★Invited Papers

*宮原 ひろ子[1]、門叶 冬樹[2]、森谷 透[2]、大山 幹成[3]、箱崎 真隆[4]、武山 美麗[2]、櫻井 敬久[2] (1.武蔵野美術大学、2.山形大学、3.東北大学、4.名古屋大学)

9:15 ~ 9:30

[PEM12-26] Current Status of WASAVIES: Warning System for Aviation Exposure to Solar Energetic Particles

★Invited Papers

*佐藤 達彦[1]、片岡 龍峰[2,3]、塩田 大幸[4,5]、久保 勇樹[4]、石井 守[4]、保田 浩志[6]、三宅 晶子[7]、Park InChun[5]、三好 由純[5] (1.原子力機構、2.極地研、3.総研大、4.情報通信研究機構、5.名古屋大学、6.広島大学、7.茨城高専)

9:30 ~ 9:45

[PEM12-27] 太陽高エネルギー粒子(SEP)の発生に関する統計的研究

*木原 孝輔[1]、黄 于蔚[2]、西村 信彦[3]、八代 誠司[4]、新田 就亮[5]、一本 潔[2]、浅井 歩[2] (1.京都大学理学研究科宇宙物理学教室、2.京都大学大学院理学研究科附属天文台、3.名古屋大学宇宙地球環境研究所 、4.米国カトリック大学物理学科、5.ロッキード・マーティン太陽天体物理学研究所)

9:45 ~ 10:00

[PEM12-28] 名古屋多方向ミューオン計で観測された宇宙線強度の長周期変動

*宗像 一起[1]、Rafael Mendonca[2]、加藤 千尋[1]、徳丸 宗利[3] (1.信州大学理学部物理科学科、2.ブラジル宇宙科学研究所、3.名古屋大学ISEE研究所)

10:00 ~ 10:15

[PEM12-29] Solar modulation of galactic cosmic rays during grand minima: A hybrid simulation

*三宅 晶子[1]、松本 倫明[2,3]、片岡 龍峰[4,5]、佐藤 達彦[6]、塩田 大幸[7]、宮原 ひろ子[8]、今田 晋亮[9]、上野 遥[10] (1.茨城工業高等専門学校、2.法政大学、3.プリンストン大学、4.国立極地研究所、5.総合研究大学院大学、6.日本原子力研究開発機構、7.情報通信研究機構、8.武蔵野美術大学、9.名古屋大学、10.宇宙航空研究開発機構)

10:15 ~ 10:30

[PEM12-30] Overview of radio propagation project

*Kornyanat Hozumi[1]、Hiroyuki Nakata[2]、Susumu Saito[3]、Takumi Kondo[1]、Ryo Nakao[2]、Takashi Maruyama[1]、Takuya Tsugawa[1]、Mamoru Ishii[1] (1.National Institute of Information and Communications Technology、2.Graduate School of Engineering, Chiba University, Chiba, Japan、3.National Institute of Maritime, Port and Aviation Technology, Electronic Navigation Research Institute (ENRI), Tokyo, Japan)

Variation of carbon-14 in tree rings around the onset of the Spoerer Minimum

*宮原 ひろ子[1]、門叶 冬樹[2]、森谷 透[2]、大山 幹成[3]、箱崎 真隆[4]、武山 美麗[2]、櫻井 敬久[2]
*Hiroko Miyahara[1], Fuyuki Tokanai[2], Toru Moriya[2], Motonari Ohyama[3], Masataka Hakozaki[4], Mirei Takeyama[2], Hirohisa Sakurai[2]

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1. Musashino Art University, 2. Yamagata University, 3. Tohoku University, 4. Nagoya University

Solar activity in the past has been reconstructed using carbon-14 in tree rings and beryllium-10 in ice cores, and it has been indicated that the Sun has long-term activity cycles such as Gleissberg cycle (~88 yrs) and the de Vries cycle (~200 yrs). Long-term variations of solar activity sometimes bring the grand minima such as the Dalton Minimum (1800-1820 CE) and the Maunder Minimum (1645-1715 CE). The detailed mechanism of such grand minima, however, remain unsolved. Reconstruction of solar cycles around the onset of the grand minima may shed light on the process of the occurrence of grand minima. We therefore have been conducting high-precision measurement of carbon-14 in tree rings with annual resolution using the Accelerator Mass Spectrometer at the Yamagata University. In this paper, we present our recent results on the measurement of carbon-14 around the onset of the Spoerer Minimum.

キーワード：太陽活動周期、太陽活動極小期、宇宙線生成核種
Keywords: solar cycle , grand solar minima, cosmogenic nuclide

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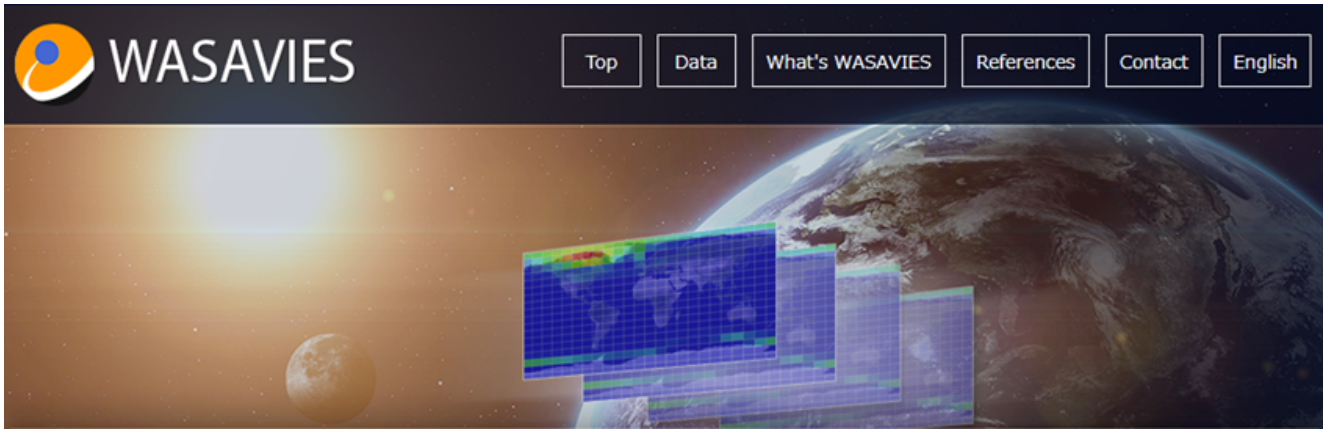
Current Status of WASAVIES: Warning System for Aviation Exposure to Solar Energetic Particles

*佐藤 達彦[1]、片岡 龍峰[2,3]、塩田 大幸[4,5]、久保 勇樹[4]、石井 守[4]、保田 浩志[6]、三宅 晶子[7]、Park InChun[5]、三好 由純[5]
*Tatsuhiko Sato[1], Ryuho Kataoka[2,3], Daikou Shiota[4,5], Yuki Kubo[4], Mamoru Ishii[4], Hiroshi Yasuda[6], Shoko Miyake[7], InChun Park[5], Yoshizumi Miyoshi[5]

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A physics-based warning system of aviation exposure to solar energetic particles, WASAVIES, is improved to be capable of real-time and automatic analysis. In the improved system, the count rates of several neutron monitors (NM) at the ground level, as well as the proton fluxes measured by the GOES satellite are continuously downloaded at intervals of 5 min and used for checking the occurrence of ground level enhancement (GLE). When a GLE event is detected, the system automatically determines the model parameters for characterizing the profiles of each GLE event, and nowcasts and forecasts the radiation dose rates all over the world up to 24 h after the flare onset. A web-interface of WASAVIES (see picture below) was also developed, which broadcasts radiation dose rates due to cosmic-ray exposure for all over the world as well as on 9 selected flight routes at intervals of 5 min and 1 day during GLE and the other periods, respectively. It is planned to be in operation from March 2019 through the public server of NICT.

キーワード：太陽高エネルギー粒子、放射線被ばく、宇宙天気
Keywords: solar energetic particle, radiation exposure, space weather



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太陽高エネルギー粒子(SEP)の発生に関する統計的研究
Statistical analysis of solar energetic particle events

*木原 孝輔[1]、黄 于蔚[2]、西村 信彦[3]、八代 誠司[4]、新田 就亮[5]、一本 潔[2]、浅井 歩[2]
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Solar energetic particles (SEPs), which originate in powerful eruptions in the solar corona, give rise to critical radiation hazards for astronauts and airline passengers, causing damages to satellites, which result in serious societal impacts. The SEP phenomenon encompasses many cross-disciplinary fields, so collaborative research is indispensable. As a part of the Japanese space weather project PSTEP (Project for Solar-Terrestrial Environment Prediction), a Coordinated Data Analysis Workshop (CDAW) was held at Kyoto University in August 2018. As a first step toward building the capabilities to predict SEP events, we need to better understand what solar eruptions lead to SEP events of varying magnitudes. One approach, as adopted by this CDAW, is to start from energetic coronal mass ejections (CMEs) regardless of SEP occurrences, rather than from the actual SEP events. We first identified 197 CMEs between 2006 and 2017 that were faster than 900 km/s and wider than 60 degrees, as determined using data from SOHO/LASCO.

Our first objective is to characterize the basic properties of SEP events, such as the occurrence, proton flux intensity, and their time variations. We examined proton peak intensity, duration, and onset time with respect to the extrapolated CME onset time, using GOES >10-MeV proton data. STEREO LET and HET data were also analyzed to study the longitudinal distribution of the SEPs. We investigated the correlations of these SEP properties with the source longitude and speed of the CMEs, and soft X-ray intensity of the associated solar flares. We found that the SEP onset time is correlated with the source longitude of the CMEs. There were correlations between other parameters that we found in our statistical analysis, which will also be discussed. Finally, we will present examples of peculiar SEP events that were found as outliers in some scatter plots.

キーワード：太陽高エネルギー粒子、コロナ質量放出、宇宙天気
Keywords: Solar Energetic Particles, Coronal Mass Ejections, Space Weather

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名古屋多方向ミューオン計で観測された宇宙線強度の長周期変動
Long-term variation of galactic cosmic ray intensity observed with the Nagoya multidirectional muon detector

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我々は、GMDN（Global Muon Detector Network）による観測データにもとづき、地表ミューオン強度に対する気温効果の補正法を開発した（R. R. S. Mendonca et al., Astrophys. J., 830:88, 2016）。本講演では、名古屋多方向ミューオン計による観測データ（1次宇宙線の平均リジディティー～50GV）を補正し、1970－2016に観測された宇宙線強度を中性子計による観測（～10GV）と比較することにより、11年周期及び22年周期変動のエネルギー依存性について報告する。

キーワード：銀河宇宙線強度の長周期変動、銀河宇宙線のエネルギー・スペクトル、太陽変調
Keywords: long-term variation of galactic cosmic ray intensity, energy spectrum of galactic cosmic rays, solar modulation

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Solar modulation of galactic cosmic rays during grand minima: A hybrid simulation

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1. NIT, Ibaraki College, 2. Hosei Univ., 3. Princeton Univ., 4. NIPR, 5. SOKENDAI, 6. JAEA, 7. NICT, 8. Musashino Art Univ., 9. Nagoya Univ., 10. JAXA

In the current and next weak solar cycles, we expect higher flux of galactic cosmic rays than that in the previous solar cycles because of the decreasing trend of the solar activity. It is important to quantitatively evaluate the high flux of galactic cosmic rays because it leads to the increase in the radiation exposure of aircrews and the increasing rates of single event upset events at spacecraft. However, reliable prediction of the increasing galactic cosmic rays in upcoming weak solar cycles is a challenges topic in the field of space weather forecast. We introduce a new project called Grand Minimum 7 (Gm7) for developing a hybrid simulation of galactic cosmic rays in such a weak solar condition, solving the stochastic differential equations of energetic particles in the MHD solar wind resolved by adaptive mesh refinement technique. We also discuss the possible situation of galactic cosmic rays and the radiation dose during the grand minima such as Maunder Minimum.

キーワード：銀河宇宙線、太陽風
Keywords: galactic cosmic ray, solar wind

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Overview of radio propagation project

*Kornyanat Hozumi[1], Hiroyuki Nakata[2], Susumu Saito[3], Takumi Kondo[1], Ryo Nakao[2], Takashi Maruyama[1], Takuya Tsugawa[1], Mamoru Ishii[1]

1. National Institute of Information and Communications Technology, 2. Graduate School of Engineering, Chiba University, Chiba, Japan, 3. National Institute of Maritime, Port and Aviation Technology, Electronic Navigation Research Institute (ENRI), Tokyo, Japan

Dated back to early 2016, the radio propagation subgroup was started in the A01 group (Space Weather Forecast System) of the PSTEP (Project for Solar-Terrestrial Environment Prediction). This subgroup has been working on clarifying of space weather (ionosphere is particular) effect on the radio propagation. Day-to-day variation of the bottom side of ionosphere has great influence on availability and integrity of radio waves in high frequency (HF, 3-30 MHz) band. HF is used as a backbone of communication systems for aviation during en-route phase and for amateur radio during disaster relief operation. We, therefore, focused on the HF band. The radio propagation simulator named HF-START (HF Simulator Targeting for All-users' Regional Telecommunications) has been developed. Availability and integrity of HF band are expected to be provided through HF-START interface after receiving users’ input/ request. The HF-START project activity and its future operation plan will be overviewed in this talk.

Keywords: HF-START, Radio Propagation Simulator, Space Weather, Ionosphere

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[E] 口頭発表 | セッション記号 P (宇宙惑星科学)：P-EM 太陽地球系科学・宇宙電磁気学・宇宙環境

2019年5月28日(火) 10:45 ~ 12:15 | A04 東京ベイ幕張ホール

[P-EM12] Space Weather and Space Climate

コンビーナ:片岡 龍峰(国立極地研究所)、Antti A Pulkkinen(NASA Goddard Space Flight Center)、草野 完也(名古屋大学宇宙地球環境研究所)、坂口 歌織(情報通信研究機構)、座長:坂口 歌織

We share the latest scientific papers to understand how the solar-terrestrial environment changes in various time scales, and to discuss how we will react via international and interdisciplinary collaborations. More specifically, welcomed papers include space climate studies to reconstruct long-term variations from radio isotopes; cutting-edge observational and modeling studies of the ionosphere, geospace, heliosphere and the sun; simulation and statistical studies to predict the future space weather and space climate; applied science such as operational space weather forecast and mitigation of the social impact due to extreme space hazards.

10:45 ~ 11:00

[PEM12-31] Dynamic Spectral Characteristics of Equatorial Plasma Bubbles

★Invited Papers

*横山 竜宏[1]、Charles Rino[2]、Charles Carrano[2] (1.京都大学、2.Boston College)

11:00 ~ 11:15

[PEM12-32] Recent advances in space weather monitoring using the Super Dual Auroral Radar Network

★Invited Papers

*Evan G Thomas[1]、Simon G Shepherd[1] (1.Dartmouth College)

11:15 ~ 11:30

[PEM12-33] **A Study of Solar Flare Effects on Radio Wave Propagation using SuperDARN & riometer**

*Shibaji Chakraborty[1]、Joseph Baker[1]、John Michael Ruohoniemi[1]、Nozomu Nishitani[2] (1.Virginia Tech、2.Institute for Space-Earth Environmental Research, Nagoya University)

11:30 ~ 11:45

[PEM12-34] Exploring the use of cell phone GNSS receivers for global monitoring of the ionosphere

*Dawn Kellogg Merriman[1]、Omar A Nava[1]、Jennifer L Meehan[2]、Hsien-Liang R Tseng[1] (1.AFIT、2.NOAA)

11:45 ~ 12:00

[PEM12-35] 2004年11月7-8日に発生した磁気嵐に伴う午後側から夕方側における全球全電子数の極端な増加について

*惣宇利 卓弥[1]、大塚 雄一[1]、新堀 淳樹[1]、津川 卓也[2]、西岡 未知[2] (1.名古屋大学　宇宙地球環境研究所、2.情報通信研究機構)

12:00 ~ 12:15

[PEM12-36] Large scale traveling ionospheric disturbances origin and propagation

*Iurii Cherniak[1,2]、Irina Zakharenkova[2,5]、Paul Prikryl[3,4]、William Schreiner[1] (1.COSMIC Program Office, University Corporation for Atmospheric Research、2.University of Warmia and Mazury in Olsztyn、3.Physics Department, University of New Brunswick、4.Geomagnetic Laboratory, Natural Resources Canada、5.West Department of IZMIRAN)

Dynamic Spectral Characteristics of Equatorial Plasma Bubbles

*横山 竜宏[1]、Charles Rino[2]、Charles Carrano[2]
*Tatsuhiro Yokoyama[1], Charles L Rino[2], Charles S Carrano[2]

1. 京都大学、2. Boston College
1. Kyoto University, 2. Boston College

Equatorial plasma bubble (EPB) is a well-known phenomenon in the equatorial ionospheric F region. As it causes severe scintillation in the amplitude and phase of radio signals, it is important to understand and forecast the occurrence of EPB from a space weather point of view. In order to simulate the instability in the equatorial ionosphere, a 3D high-resolution bubble (HIRB) model with a grid spacing of as small as 200 m has been developed. It provides a unique opportunity to characterize intermediate-scale EPB structure, which was not well resolved until very recently. Estimation of altitude-dependent power law spectral density function parameters provides an altitude versus time history of the intermediate-scale structure development. Local structure onset is associated with successive bifurcation of rising EPBs. Developed structure characterized by a two-component power law spectral density function ultimately subtends several hundred kilometers in altitude. The EPB simulation data fully support the reported EPB diagnostics from previous in situ measurements. In the near future, HIRB model may be able to directly resolve Fresnel scale of GPS frequency band (300-400m), so that the effects of EPBs on radio wave propagation could be evaluated without any assumption.

キーワード：プラズマバブル、シンチレーション、電離圏
Keywords: plasma bubble, scintillation, ionosphere

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Recent advances in space weather monitoring using the Super Dual Auroral Radar Network

*Evan G Thomas[1], Simon G Shepherd[1]

1. Dartmouth College

Over the last decade, the Super Dual Auroral Radar Network (SuperDARN) has undergone a dramatic expansion in the Northern Hemisphere with the addition of more than a dozen radars offering improved coverage at midlatitudes (50º–60º magnetic latitude) and in the polar cap (80º–90º magnetic latitude). This has led to the development of new empirical models which better describe both the regional and global morphology of ionospheric convection under a range of solar wind and geomagnetic activity conditions. In addition, real-time measurements of ionospheric plasma motion are once again being collected from more than 15 SuperDARN radar sites to produce nowcasts of the global convection pattern. In this presentation we discuss the operational challenges and space weather applications of these real-time SuperDARN products.

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A Study of Solar Flare Effects on Radio Wave Propagation using SuperDARN & riometer

*Shibaji Chakraborty[1], Joseph Baker[1], John Michael Ruohoniemi[1], Nozomu Nishitani[2]

1. Virginia Tech, 2. Institute for Space-Earth Environmental Research, Nagoya University

A prolonged study is underway to improve the understanding of the lower ionospheric (D & lower E layer) response to solar flare and its effects on HF propagation. Over-the-Horizon communication is strongly dependent on the state of the ionosphere, which is fragile to solar X-ray flares. The Super Dual Auroral Radar Network (SuperDARN) is an active HF radio receiver, primarily used to probe ionosphere and upper atmosphere. SuperDARN has one common mode of operation which simulates a ground-to-ground communications link, commonly known as ground scatter. Riometers on the other side are passive HF radio receiver, provides information about HF absorption in the ionosphere by measuring variations in cosmic radio noise. Both instruments' observations get altered due to the well-known effects of Short-Wave Fadeout or SWF. During an SWF the number of SuperDARN ground-scatter echoes drops suddenly (≈1 min) and sharply followed by an apparent increase in Doppler velocity (also known as "Doppler Flash"), often to near zero, reflecting disruption. In addition to that, riometer observe an enhancement in cosmic noise absorption. Since decades, enhanced D and E region electron density are known to be the significant driver of HF radio wave absorption, and we have steadily developed a better understanding of the sources and driving processes of HF absorption. However, the picture is less clear when we talk about the influence of collision frequency in radio wave absorption and Doppler frequency anomaly during SWF. This study aims to propose a relatively newer semi-empirical model to provide insights into the physical significance of collision frequency in HF absorption effect which can be seen in the riometer data. In addition to that, the study also aims to provide physical insights to Doppler frequency anomaly seen in SuperDARN data. Furthermore, this study will help us to advance our understanding of the role of collision frequency in HF absorption and Doppler frequency anomaly, their sources and driving parameters.

Keywords: Solar Flare, Shortwave-Fadeout, HF Absorption

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Exploring the use of cell phone GNSS receivers for global monitoring of the ionosphere

*Dawn Kellogg Merriman[1], Omar A Nava[1], Jennifer L Meehan[2], Hsien-Liang R Tseng[1]

1. AFIT, 2. NOAA

Accurate characterization of the ionosphere in response to space weather events has important implications for the effective use of high-frequency (HF) communications in civilian and military operations, including, but not limited to, emergency services, amateur radio, aviation, and over-the-horizon radar. This study investigates the use of cell phone Global Navigation Satellite System (GNSS) technology to monitor and study highly variable phenomena in the ionosphere, such as the aurora at high-latitudes or scintillation at the equator. Field campaigns to high and mid-latitudes will be summarized here, emphasizing the sensitivity of cell phone GNSS receivers to pick up on space weather events such as traveling ionospheric disturbances. Preliminary analysis on the potential to combine data from various cell phone manufacturers (e.g. Hauwei, Samsung, Google, LG and Moto) to enhance data quality will also be presented. Based on this research the potential to collect data from millions of cell phones GNSS technology may allow for real-time monitoring and measuring of the ionosphere to occur on an unprecedented global scale.

Keywords: GNSS, cell phone, space weather

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2004年11月7-8日に発生した磁気嵐に伴う午後側から夕方側における全球全電子数の極端な増加について
Large enhancements of global GPS total electron content during a magnetic storm on 7-8 November 2004

*惣宇利 卓弥[1]、大塚 雄一[1]、新堀 淳樹[1]、津川 卓也[2]、西岡 未知[2]
*Sori Takuya[1], Yuichi Otsuka[1], Atsuki Shinbori[1], Takuya Tsugawa[2], Michi Nishioka[2]

1. 名古屋大学　宇宙地球環境研究所、2. 情報通信研究機構
1. Institute for Space-Earth Environmental Research, Nagoya University, 2. National Institute of Information and Communications Technology

磁気嵐時に中緯度電離圏で発生するstorm enhanced density (SED) は、午後側において局所的に増加した電子密度の領域が低緯度から高緯度に伸びる現象である。Foster and Rideout [2007]は、SED現象が両半球において磁気共役性を持つことを報告した。今回、2000~ 2012年の磁気嵐イベントの中で日本において最大のTEC増加を示した2004年11月8日に発生した磁気嵐中のSEDの解析結果について報告する。Maruyama [2006]は日本の稠密GPS観測網のデータを用いて2004年11月8日に発生した磁気嵐においてTotal Electron Content (TEC)が増大することを示し、夕方過ぎに高緯度で観測されたTEC増加はSED現象に関連していると指摘した。しかし、これまでの研究の多くは、領域ごとのTECの時間・空間変動に着目し、また、TECの時間・空間分解能が低かったことから磁気嵐の発達・衰退過程におけるTECの全球的でかつ詳細な時間・空間変動特性が未解明のままである。そこで本研究では、情報通信研究機構から提供されている高時間・空間分解能を持つ全球GPS-TECデータを用いて、2004年11月8日に発生した磁気嵐に伴う全球的な電離圏の変動特徴を調べ、そのメカニズムを解明することを目的とする。本研究で用いるGPS-TECデータの空間分解能は、緯度0.5度×経度0.5度であり、時間分解能は5分である。ここでは10日静穏時の平均TECに対する擾乱時と静穏時の差分TECの比 (rTEC) を求め、その水平二次元分布の時間・空間変動を解析した。2004年11月8日に発生した磁気嵐は、SYM-H指数において最小値-400 nTを6:00 UTでとり、その後1日程度かけて回復している。その結果、回復相の11:00 UT において日本にのみrTECの特に大きな増加が見られ、その値はおよそ17 (~90 TECU) であった。この高rTEC構造は西向きに317 m/sの速度で伝播していた。また、東経142度 (稚内) でのTECの地理緯度-時間変動を調べたところ、地理緯度40~50度において特に高いTECが5:00 UTと11:00 UT付近に二度出現しており、これらは時間とともに高緯度側から低緯度側に伝播していたことが明らかになった。さらに、高rTEC領域の西向き伝播速度を求めるため、NOAAで公開されているDMSP衛星イオン・ドリフト・メーターのデータとGPS-TECデータとの比較を行った。日本上空で高rTEC領域が観測された11:00 UT付近に日本上空を通過したDMSP-F15衛星によると、磁気緯度40度において高rTEC構造の伝播速度に近い約250 m/sの西向きイオンドリフト速度が存在した。一方、rTECの全球水平二次元マップから、日本上空で高TEC値が観測された時間にオーストラリアでも同様にrTEC増加領域が観測された。そこで、IGRFモデルを用いてこのrTEC増加領域の南北共役性を調べた結果、日本上空で観測された二つのTECピークは南半球側のrTEC増加領域に対応していた。また、rTEC増加量は南半球よりも北半球において2倍以上大きく、増加領域の緯度幅も広く、空間構造も異なっていた。さらに、rTEC増加は両半球ともに5:00 UT付近において磁気緯度50度から開始し、時間とともに低緯度側に伝播していた。次に、rTECの全球的変動を調べるためにヨーロッパ、日本、アメリカにおけるrTECの磁気緯度-時間プロットを用いて比較を行った。その結果、日本の経度で一つ目のTECピークが観測された5:00 UTに日本の高緯度とアメリカの低緯度において同時に大きなrTEC増加が観測され、それらの値は6を超えていた。また、5:00 UTでのrTECマップから、高rTEC領域がアメリカから日本まで北西方向に広がっていたことが分かった。このrTEC増加の原因の一つにSEDが考えられる。従来、SEDは低緯度におけるTEC増加領域が高緯度側へ拡大し、その後西向きに運ばれることで生成されると考えられている [Tsurutani et al., 2004]。そこで、日本上空で高rTEC領域が317 m/sで西向きに伝播していた結果に基づき、rTEC増加領域がアメリカから日本までこの速度で伝播したと仮定すると、rTEC増加領域がアメリカから

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日本まで伝播するには9.5時間必要である。しかし、日本とアメリカのrTEC増加開始時間の差は6時間程度であり、日本でのrTEC増加は、アメリカから伝播してきたものではなく、日本周辺で発生したものと考えられる。二つ目のTECピークについても同様の解析を行い、11:35 UTにrTEC増加領域が日本からヨーロッパまで同時に存在していたことが観測された。以上の事実から、日本の高緯度で観測された一つ目のTECピークに関してTEC増加領域がアメリカと日本の間に存在し、二つ目のTECピークに関してTEC増加領域が日本とヨーロッパの間に存在していたと考えられる。したがって、従来のSED生成メカニズムとは異なるTEC増加メカニズムが存在する可能性があり、それは夜間のTEC増加を引き起こし、100度を超える経度方向の広がりを持つ可能性があると言える。

キーワード：電離圏、磁気嵐、全電子数、磁気共役
Keywords: Ionosphere, Geomagnetic storm, Total electron content, Magnetic conjugacy

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Large scale traveling ionospheric disturbances origin and propagation

*Iurii Cherniak[1,2], Irina Zakharenkova[2,5], Paul Prikryl[3,4], William Schreiner[1]

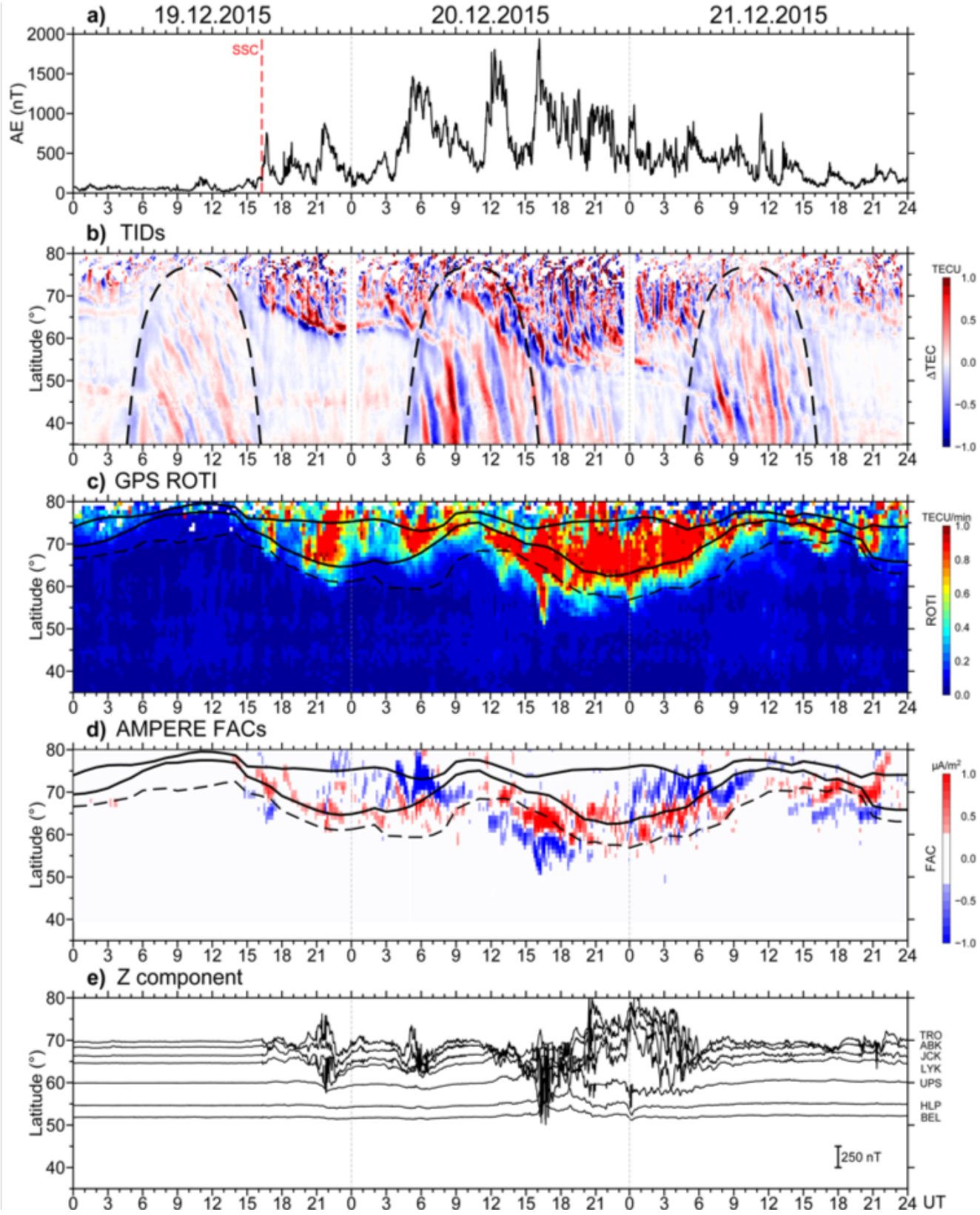
1. COSMIC Program Office, University Corporation for Atmospheric Research, 2. University of Warmia and Mazury in Olsztyn, 3. Physics Department, University of New Brunswick, 4. Geomagnetic Laboratory, Natural Resources Canada, 5. West Department of IZMIRAN

We investigate an origin, occurrence, and propagation of large-scale traveling ionospheric disturbances (LSTIDs) with an analysis of the total electron content (TEC) perturbation component deduced from the ground-based GPS and GLONASS observations. The high spatio-temporal resolution mapping approach provides a very detailed specification of the ionospheric small- to large-scale disturbances associated with two major sources of the LSTIDs generation: the solar terminator passage during the quiet time and auroral activity caused by auroral particle precipitation and field-aligned currents (FACs) intensification during geomagnetic disturbances. For the first time, the joint analysis of the ionospheric plasma irregularities, FACs, and LSTIDs reveals that a zone with the intense FACs and ionospheric irregularities occurred at the same region that represent the most probable source of LSTIDs excitation. The COSMIC RO electron density profiles confirm the E layer plasma density enhancement within LSTIDs excitation area. Such density enhancement leads to an increase of ionospheric conductivity, intensification of currents in the ionosphere, and release of energy by Joule heating into the lower thermosphere.
This approach was demonstrated for the case of the 19-21 December 2015 geomagnetic storm, when LSTIDs propagated over the European region were detected. During the main phase of the storm, the LSTIDs propagated equatorward from European high latitudes to middle latitudes (35-40N) with the horizontal velocities of ~700-800 m/s. The LSTIDs as deduced from the TEC-disturbed component had a much larger magnitude and propagate much longer distances during the daytime (sunlit part) than in the night. We found that an equatorward expansion of the strong ionospheric irregularities zone and an increase of the FACs magnitude led to a simultaneous intensification of the LSTIDs occurrence at high latitudes. The GPS ROTI (rate of TEC index) technique, a sensitive one for detection of the rapid ionospheric gradients and irregularities, could not recognize any signatures of the TIDs structures.

The research is supported by the NSF CAS AGS-1033112, the NASA LWS grant NNX15AB83G, by the National Science Centre, Poland, through grants 2017/25/B/ST10/00479 and 2017/27/B/ST10/02190, and by RFBR Grant 19-05-00570A.

Keywords: LSTIDs, GNSS, ionosphere, geomagnetic storm, FACs, plasma irregularities

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2019年5月28日(火) 13:45 ~ 15:15 | A04 東京ベイ幕張ホール

[P-EM13] 内部磁気圏

コンビーナ:海老原 祐輔(京都大学生存圏研究所)、Danny Summers(Memorial University of Newfoundland)、三好 由純(名古屋大学宇宙地球環境研究所)、齊藤 慎司(名古屋大学　大学院理学研究科)、座長:Danny Summers、三好 由純(名古屋大学宇宙地球環境研究所)

The inner magnetosphere is characterized by the dominance of intrinsic dipolar Earth's magnetic field. The dipolar magnetic field traps charged particles, resulting in the formation of unique particle environment known as the plasmasphere, the ring current, and the radiation belt. The inner magnetosphere is always changing because of incoming energy from the outer magnetosphere and the ionosphere in the forms of particles and electromagnetic fields. In the inner magnetosphere, the particle energy is transferred to the field energy, and vice versa. The mutual coupling between particles and fields also makes the inner magnetosphere unique. The outgoing energy to these regions is also known to be significant, such as precipitation into the upper atmosphere and sub-auroral disturbances. A number of satellites (e.g., DMSP, NOAA, Geotail, Cluster, THEMIS, Van Allen Probes, MMS, and Arase), ground-based instruments (e.g., SuperDARN and EISCAT radars, magnetometers, and cameras), and numerical simulations (e.g., global particle simulation, PIC simulation, and hybrid simulation) have successfully surveyed the inner magnetosphere, which deepen our knowledge significantly. USAF DSX, UCLA Elfin and NASA CeRES will be launched soon, being expected to provide important information. We solicit papers describing recent results on the inner magnetosphere and/or its coupling with the other regions, including the ionosphere and the outer magnetosphere.

13:45 ~ 14:05

[PEM13-01] Developing an improved understanding of Earth’s outer radiation belt electrons with combined observations from Van Allen Probes, MMS, and Arase

★Invited Papers

*Drew L Turner[1]、Ian Cohen[2]、Alexander Boyd[1,3]、Joseph Fennell[1]、Geoff Reeves[3]、Yoshizumi Miyoshi[4] (1.Aerospace Corporation El Segundo、2.Johns Hopkins University Applied Physics Lab、3.Los Alamos National Laboratory、4.Nagoya University)

14:05 ~ 14:25

[PEM13-02] Recent results from Van Allen Probes and future prospects from the CeREs Cubesat

★Invited Papers

*Shrikanth G Kanekal[1]、Daniel N Baker[2]、Ashley Greeley[1]、Lauren Blum[1]、Quintin Schiller[1]、David G Sibeck[1]、Hong Zhao[2]、Xinlin Li[2]、Allison Jaynes[3] (1.NASA Goddard Space Flight Center、2.LASP, University of Colorado, Boulder、3.Univeristy of Iowa)

14:25 ~ 14:40

[PEM13-03] Optimal Use of Time Lags Between MMS Spacecraft : Application to the Estimation of Wave-Vectors

*Gerard Marcel CHANTEUR[1,2,3]、Drew L. Turner、Olivier Le Contel[1,2,3]、Alessandro Retino[1,2,3]、Laurent Mirioni[1,2,3] (1.CNRS、2.SORBONNE UNIVERSITE、3.ECOLE POLYTECHNIQUE)

14:40 ~ 14:55

[PEM13-04] Conjugate observation of EMIC waves by Arase and RBSP with associated POES and AARDDVARK detected electron precipitation

*Aaron T. Hendry[1]、Ondrej Santolik[1,2]、Yoshizumi Miyoshi[3]、Yoshiya Kasahara[4]、Yasumasa Kasaba[5]、Ayako Matsuoka[6]、Craig J Rodger[7]、Mark Clilverd[8]、Masafumi Shoji[3]、Shoya Matsuda[6]、Craig Kletzing[9]、Iku Shinohara[6] (1.Dept. of Space Physics, Inst. of Atmospheric Physics, Czech Acad. of Science、2.Fac. of Mathematics and Physics, Charles Univ.、3.Inst. for Space Earth Environmental Research, Nagoya Univ.、4.Graduate School of Natural Science and Technology, Kanazawa Univ.、5.Planetary Plasma and Atmospheric Research Center, Tohoku Univ.、6.Inst. of Space and Astronautical

Science, Japan Aerospace Exploration Agency、7.Dept. of Physics, Univ. of Otago、8.British Antarctic Survey (NERC)、9.Dept. of Physics and Astronomy, Univ. of Iowa)

14:55 ~ 15:10

[PEM13-05] Over-darkening pulsating aurora: simultaneous observations with Arase and an all-sky camera in Scandinavia

*細川 敬祐[1]、三好 由純[2]、大山 伸一郎[2]、小川 泰信[3]、栗田 怜[2]、笠原 禎也[4]、尾崎 光紀[4]、笠羽 康正[5]、八木谷 聡[4]、松田 昇也[6]、土屋 史紀[5]、熊本 篤志[5]、篠原 育[6]、藤井 良一[7] (1.電気通信大学大学院情報理工学研究科、2.名古屋大学宇宙地球環境研究所、3.国立極地研究所、4.金沢大学、5.東北大学、6.宇宙航空研究開発機構宇宙科学研究所、7.情報・システム研究機構)

15:10 ~ 15:15

Discussion

Developing an improved understanding of Earth’s outer radiation belt electrons with combined observations from Van Allen Probes, MMS, and Arase

*Drew L Turner[1], Ian Cohen[2], Alexander Boyd[1,3], Joseph Fennell[1], Geoff Reeves[3], Yoshizumi Miyoshi[4]

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In this presentation, we focus on two aspects of Earth’s outer radiation belt electrons: acceleration due to interactions with whistler-mode chorus waves and losses due to magnetopause incursions and outward radial transport. Using a combination of energetic electron intensities and wave data from NASA’s Van Allen Probes and MMS missions plus JAXA’s Arase (ERG) mission, we evaluate evidence of local acceleration and losses to outward radial transport based on phase space density and multipoint wave analysis. A telltale sign of local acceleration due to interactions between 100s of keV electrons and chorus waves within the heart of the outer radiation belt is a growing peak in electron phase space density for those energies and pitch angles affected by the acceleration. Sometimes that peak in phase space density might occur beyond the apogee of the Van Allen Probes orbit, but MMS and Arase data can be used to disambiguate dominant acceleration processes for such cases. Losses to the magnetopause and from outward radial transport also result in distinct features in the time history of radial distributions of electron phase space density. Again, with their apogees extending to higher L-shells (including into the magnetosheath for MMS), MMS and Arase can supplement the Van Allen Probes dataset by directly observing evidence of these processes beyond Van Allen Probes apogee. In this presentation, we showcase several examples of these processes using multipoint data from these missions.

Keywords: Radiation belts, Relativistic electrons, Wave-particle interactions

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Recent results from Van Allen Probes and future prospects from the CeREs Cubesat

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The Van Allen Probes mission, since its launch in August 2012 has advanced our understanding of fundamental questions regarding the acceleration and loss of outer Van Allen belt electron populations. Electron dynamics in the outer radiation belt are driven by a number of physical processes, which affect low energy cold plasma to relativistic and ultra-relativistic particle populations. I will present recent results from Van Allen Probes mission focusing on the energetic electron dynamics. I will also discuss the significant role of CubeSats that may lead to a paradigm shift in the way space-based observations are carried out, e.g., by enabling multipoint observations. I am currently leading a CubeSat mission, CeREs, the Compact Radiation belt Explorer, CeREs that was launched December 2018 and is currently in the commissioning phase. CeREs will provide high quality measurements of radiation belt electrons, especially microbursts.

Keywords: Radiation belts, CubeSat, energetic electrons

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Optimal Use of Time Lags Between MMS Spacecraft : Application to the Estimation of Wave-Vectors

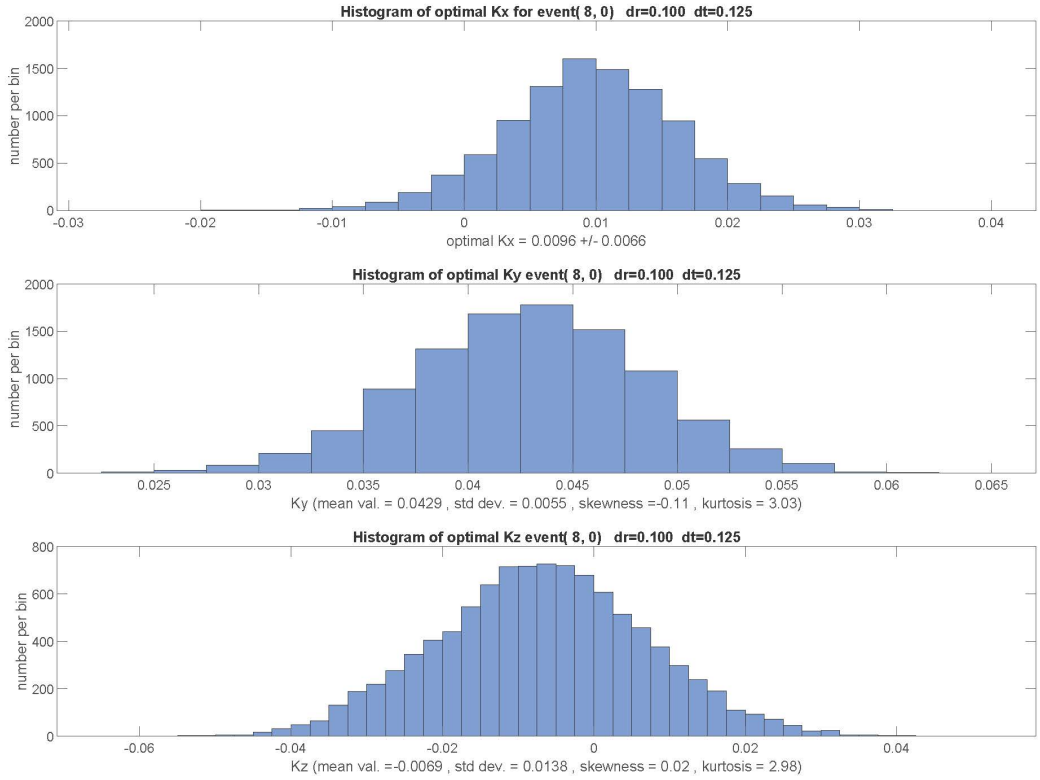
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Turner et al. (2017) made use of cross-correlations of SCM quasi monochromatic data between pairs of MMS spacecraft to estimate phase lags and to derive wave vectors of whistler mode chorus elements in the inner magnetosphere. A new approach has been developped to revisite this study. For a cluster of four spacecraft there are six pairs of spacecraft, each one giving raise to a scalar equation relating the vector position **R** from the first to the second spacecraft, the wave vector **K** and the phase lag $\Delta\phi$: **R.K**=$\Delta\phi$. A positive weight is attributed to each equation (w_j, j=1 to 6). A statistical ensemble of 6-uplets is built and we look for the 6-uplet giving the lowest condition number of matrix **M**. This procedure warrants the best accuracy of the pseudo-inverse of **M** and hence the best estimate of the wave vector **K**. Adding random perturbations to M and $\Delta\phi$ the procedure allows to estimate the uncertainties on **K.**

Turner, D. L. et al. JGR Space Physics, https://doi.org/10.1002/2017JA024474

Keywords: multi-spacecraft missions, MMS, field analysis, wave vectors, phase shifts



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Conjugate observation of EMIC waves by Arase and RBSP with associated POES and AARDDVARK detected electron precipitation

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We present a remarkable case study of strong EMIC wave emissions observed simultaneously by instruments on board the ARASE and RBSP-B satellites, as well as by ground-based observatories, during a period of significant geomagnetic activity. These waves coincided with strong substorm activity (AE>1000 nT) during a southward IMF Bz shift, corresponding to the initial phase of an intense geomagnetic storm (peak Dst < -170 nT). At the time of this observation, the ARASE and RBSP-B satellites were co-located in L and MLT, showing simultaneous observation of the same wave emission, but were significantly separated in magnetic latitude. This separation allows us to examine the evolution of the wave parameters as the wave propagates down the field-line to the Earth.

During this period of wave activity, we also see evidence of energetic electron precipitation into the ionosphere. At the time of the RBSP and ARASE observations, the POES METOP-02 satellite passed through the footprint of the source region and observed bursts of energetic ion and electron precipitation into the ionosphere, matching known signatures of EMIC-driven particle precipitation. This precipitation was then in turn observed from the ground as AARDDVARK-detected sub-ionospheric VLF perturbations. Through analysis of these ground-based observations, we are able to estimate the extent of the EMIC source region.

Keywords: Arase, Van Allen Probes, EMIC, Wave-particle interactions, AARDDVARK

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Over-darkening pulsating aurora: simultaneous observations with Arase and an all-sky camera in Scandinavia

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Pulsating aurora (PsA) is one of the major classes of aurora often seen in the lower latitude part of the auroral region in the morning side. PsAs are characterized by quasi-periodic variations in the optical intensity whose period typically ranges from a few to a few tens of second. Coordinated ground/satellite observations in the last decade demonstrated that the main optical pulsation well correlates with the intensity modulation of whistler mode chorus waves in the magnetosphere. Recent analyses of high time resolution ground-based optical observations have reported that the brightness of PsA decreases below the diffuse background immediately after the ON phase of the main pulsation. To date, however, the generation mechanism of such “over-darkening PsA” is still unclarified. In this paper, we investigate the characteristics of the over-darkening PsA by using simultaneous observations of PsA with an EMCCD all-sky camera in Sodankylä, Finland (67°N, 26°E, 64°MLAT) and the Arase satellite. The EMCCD all-sky camera captures auroral emission with a temporal resolution of 100 Hz. We make use of data from the PWE/OFA instrument to analyse the temporal variation of chorus wave as a source of PsA. During one of the conjunction events in Scandinavia on March 29, 2017, almost all the PsA pulses showed clear over-darkening characteristics. By analysing the 2D all-sky images at the times of over-darkening we identified that over-darkening areas appeared in the trailing edge of PsA patches and moved in tandem with the poleward propagating patches. It was also found that similar over-darkening characteristics were not seen in the chorus data from PWE/OFA onboard Arase located at the magnetospheric counterpart of PsA. These results indicate that the over-darkening PsA is not caused by a temporal variation of chorus at a fixed point, but is produced by a propagation of over-darkening area with PsA patches. That is, the over-darkening PsA is a spatial structure rather than a temporal variation. In the presentation, we discuss several possible scenarios that can explain the over-darkening along the edge of PsA patches.

Acknowledgement: The operation of the EMCCD camera at Sodankyläh as been supported by Sodankylä Geophysical Observatory (SGO).

キーワード：脈動オーロラ、コーラス波動
Keywords: Pulsating Aurora, Chorus Waves

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[E] 口頭発表 | セッション記号 P (宇宙惑星科学)：P-EM 太陽地球系科学・宇宙電磁気学・宇宙環境

2019年5月28日(火) 15:30 ~ 17:00 | A04 東京ベイ幕張ホール

[P-EM13] 内部磁気圏

コンビーナ:海老原 祐輔(京都大学生存圏研究所)、Danny Summers(Memorial University of Newfoundland)、三好 由純(名古屋大学宇宙地球環境研究所)、齊藤 慎司(名古屋大学　大学院理学研究科)、座長:三好 由純(名古屋大学宇宙地球環境研究所)、Danny Summers

The inner magnetosphere is characterized by the dominance of intrinsic dipolar Earth's magnetic field. The dipolar magnetic field traps charged particles, resulting in the formation of unique particle environment known as the plasmasphere, the ring current, and the radiation belt. The inner magnetosphere is always changing because of incoming energy from the outer magnetosphere and the ionosphere in the forms of particles and electromagnetic fields. In the inner magnetosphere, the particle energy is transferred to the field energy, and vice versa. The mutual coupling between particles and fields also makes the inner magnetosphere unique. The outgoing energy to these regions is also known to be significant, such as precipitation into the upper atmosphere and sub-auroral disturbances. A number of satellites (e.g., DMSP, NOAA, Geotail, Cluster, THEMIS, Van Allen Probes, MMS, and Arase), ground-based instruments (e.g., SuperDARN and EISCAT radars, magnetometers, and cameras), and numerical simulations (e.g., global particle simulation, PIC simulation, and hybrid simulation) have successfully surveyed the inner magnetosphere, which deepen our knowledge significantly. USAF DSX, UCLA Elfin and NASA CeRES will be launched soon, being expected to provide important information. We solicit papers describing recent results on the inner magnetosphere and/or its coupling with the other regions, including the ionosphere and the outer magnetosphere.

15:30 ~ 15:50

[PEM13-06] Deformation of electron pitch angle distributions caused by chorus waves observed by the Arase satellite

★Invited Papers

*栗田 怜[1]、三好 由純[1]、笠原 慧[2]、横田 勝一郎[3]、笠原 禎也[4]、松田 昇也[5]、松岡 彩子[5]、篠原 育[5] (1.名古屋大学宇宙地球環境研究所、2.東京大学、3.大阪大学理学研究科、4.金沢大学総合メディア基盤センター、5.宇宙科学研究所)

15:50 ~ 16:10

[PEM13-07] Electron scattering by isolated chorus elements observed near the magnetospheric equator

★Invited Papers

*笠原 慧[1]、三好 由純[2]、横田 勝一郎[3]、笠原 禎也[4]、松田 昇也[5]、松岡 彩子[5]、桂華 邦裕[1]、堀 智昭[2]、篠原 育[5] (1.東京大学、2.名古屋大学、3.大阪大学、4.金沢大学、5.宇宙科学研究所)

16:10 ~ 16:25

[PEM13-08] れいめい衛星データによる脈動オーロラに関連した低エネルギー電子バンド状降下現象

*坂野井 健[1]、吹澤 瑞貴[1]、三好 由純[2]、海老原 祐輔[3]、浅村 和史[4]、平原 聖文[2] (1.東北大学大学院理学研究科惑星プラズマ・大気研究センター、2.名古屋大学太陽地球環境研究所、3.京都大学生存圏研究所、4.宇宙航空研究開発機構宇宙科学研究所)

16:25 ~ 16:40

[PEM13-09] Origin of energetic electron precipitation with fast fluctuation: Data-driven simulations using the ERG plasma wave observations

*齊藤 慎司[1]、三好 由純[2]、松田 昇也[3]、栗田 怜[2]、笠原 禎也[4]、熊本 篤志[5]、土屋 史紀[5]、松岡 彩子[3] (1.名古屋大学　大学院理学研究科、2.名古屋大学　宇宙地球環境研究所、3.宇宙科学研究所、4.金沢大学、5.東北大学)

16:40 ~ 16:55

[PEM13-10] Conjugated quasi-periodic ELF/VLF emissions between the Arase satellite and both Van Allen Probes

*Claudia Martinez Calderon[1,2]、Frantisek Nemec[3]、Kazuo Shiokawa[2]、Yuto Katoh[1]、Yoshiya Kasahara[4]、Shoya Matsuda[2]、Fuminori Tsuchiya[1]、Atsushi Kumamoto[1]、Mariko Teramoto[2]、Ayako Matsuoka[5]、Yoshizumi Miyoshi[2]、Ondrej Santolik[6,3]、George Hospodarksy[7] (1.Dept. Geophys., Grad. Sch. Sci., Tohoku University、2.Instute for Space-Earth Environmental Research, Nagoya University、3.Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic、4.Kanazawa University、5.Japan Aerospace Exploration Agency、6.Institute of Atmospheric Physics, Prague, Czech Republic、7.Department of Physics and Astronomy, University of Iowa, USA)

16:55 ~ 17:00

Discussion

Deformation of electron pitch angle distributions caused by chorus waves observed by the Arase satellite

*栗田 怜[1]、三好 由純[1]、笠原 慧[2]、横田 勝一郎[3]、笠原 禎也[4]、松田 昇也[5]、松岡 彩子[5]、篠原 育[5]
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1. Institute for Space-Earth Environmental Research, Nagoya University, 2. The University of Tokyo, 3. Graduate School of Science, Osaka University, 4. Information Media Center, Kanazawa University, 5. ISAS/JAXA

We report on deformation of electron pitch angle distributions associated with chorus waves observed by the Arase satellite. The deformation is characterized by flux increase of 17-30 keV electrons in a narrow and oblique pitch angle range and by flux decrease in 7-17 keV electron flux in the smaller pitch angle range than the flux increase. Comparison of change in electron pitch angle distributions with resonant ellipses of the upper band chorus shows that the deformation appears where effective wave-particle interaction is expected in the velocity space, and the flux increase takes place along the resonant ellipse of the upper frequency of the wave. This strongly suggests that the deformation is a consequence of wave-particle interactions between electrons and upper band chorus. The Arase observation demonstrates that the deformation occurs within 30 s, which is faster than expected from the quasi-linear diffusion theory.

キーワード：あらせ衛星、コーラス、電子加速
Keywords: ERG/Arase satellite, Chorus waves, Acceleration

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Electron scattering by isolated chorus elements observed near the magnetospheric equator

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*Satoshi Kasahara[1], Yoshizumi Miyoshi[2], Shoichiro Yokota[3], Yoshiya Kasahara[4], Shoya Matsuda[5], Ayako Matsuoka[5], Kunihiro Keika[1], Tomoaki Hori[2], Iku Shinohara[5]

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Theories have predicted significant pitch angle scattering of electron by chorus waves via cyclotron resonance, resulting in electron precipitation into the atmosphere and consequent auroral illumination. Recent observations of chorus waves at the equator, in conjunction with ground observations, have indicated that even a single chorus element can cause sufficient electron scattering causing auroral flashing. Here we report more direct, in-situ evidence that electrons are indeed scattered into the loss cone up to strong diffusion, by an isolated chorus element. We discuss the scattering rate based on the observed parameters.

キーワード：ピッチ角散乱、コーラス波動
Keywords: electron scattering, chorus waves

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れいめい衛星データによる脈動オーロラに関連した低エネルギー電子バンド状降下現象

Continuous precipitation of low-energy electrons associated with pulsating aurora obtained by the Reimei satellite

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We report the results of event and statistical analyses on continuous precipitation of low-energy electrons associated with pulsating aurora using the data taken by the Reimei satellite. From recent data obtained with a magnetospheric satellite like Arase, it is widely supported that chorus waves interact with plasma sheet electrons that produce diffuse aurora mainly in the post-midnight to morning sectors. In addition, temporal (a few Hz) variation of lower band chorus waves cause modulation of pitch-angle scattering of keV-range electrons that generate pulsating aurora in the ionosphere. On the other hand, such temporal variation is not commonly seen in upper band chorus and electrostatic electron cyclotron harmonic (ECH) waves that expected to interact with lower-energy electrons. However, the characteristics of such low-energy electrons and their relationship to pulsating aurora are not understood.
Reimei is a polar-orbiting sun-synchronous satellite at an altitude of 650 km and obtained simultaneous image and particle data with high-time and spatial resolutions. Thanks to its orbit, Reimei covers wide L-value ranges and measures velocity-dispersed electrons travelling from magnetospheric source region to ionosphere. Miyoshi et al. [2015] showed an event that Reimei observed continuous precipitation of low-energy electrons (mainly in the energy range of hundreds eV) in addition to high energy (more than a few keV) temporal electrons that caused pulsating auroral emission. Here, we investigated the characteristics and generation mechanism of continuous low-energy electron precipitation using all of the electron data (5150 paths) taken by Reimei/ESA from November 2005 to August 2008, and compared the data with simulation results. Event selection criteria are 1) existence of continuous precipitation of low-energy electrons below a few keV range, and 2) high-energy (more than a few keV) electrons that distinguished from the continuous low-energy electrons. We also examined simultaneous auroral image data obtained with Reimei/MAC. Using the criteria, we found 155 events of continuous low-energy electron band. From statistical analysis, the continuous low-energy electron evens occurred in 11 % of total observation paths in the nightside sector, while temporal precipitation of high-energy electrons that produced pulsating aurora appeared in 36 % of total observation paths in the nightside sector. From event analysis for several cases, we found in most cases that energy of continuous low-energy electrons increased from ~200 eV to a few keV as the latitude decreased. However, the electron energy decreased near the lower boundary of plasma sheet. In some cases, multiple electron band structures were seen in the low-latitude region. To understand the characteristics and mechanisms of continuous precipitation of low-energy electrons, we carried out simulations of electron pitch angle scattering with chorus waves and ECH waves, respectively. For the simulation of ECH wave resonance, we calculated wavenumber at ECH wave frequency (e.g., 1.6 fce(cyclotron frequency)) based on the Bernstein mode dispersion relation, and estimated electron energy by the cyclotron resonance equation assuming the electron density with GCPM

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model and magnetic field with IGRF model. From the comparison between the Reimei data with simulation results, we suggest that latitudinal dependence of low-energy electrons can probably be explained with the chorus wave resonance. The decrease of electron energy near the low-latitude boundary is likely to be caused with decrease of plasma density outside of the plamsapause. On the other hand, we showed the possibility for some cases that low-energy electron precipitations were generated by ECH waves.

キーワード：脈動オーロラ、内部磁気圏、れいめい
Keywords: pulsating aurora, inner magnetosphere, Reimei

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Origin of energetic electron precipitation with fast fluctuation: Data-driven simulations using the ERG plasma wave observations

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Bursty precipitation of keV electrons can be a source of pulsating aurora which has quasi-periodic on-off switching of luminosity. On the other hand, relativistic electrons also precipitate into the atmosphere with intermittent and bursty nature, which are observed as relativistic electron microbursts. A common cause of the electron bursty precipitation for the pulsating aurora and for the microbursts is expected to be whistler chorus waves propagating along a field line.
In this study, we demonstrate electron precipitation caused by realistic whistler chorus waves using our newly developed test-particle model, GEMSIS-RBW-II simulation code. Wave form data obtained from ERG satellite are applied to the simulation model as a boundary condition at the magnetic equator. The simulation shows that the whistler chorus waves propagating to high magnetic latitudes along the field line can precipitate electrons with energy from keV to MeV. We found that amplitude modulation of a whistler chorus burst observed by ERG causes over ten Hz modulation of keV electron precipitation. At relativistic energies fluctuation with higher frequencies and bursty/intermittent nature appear in time history of precipitation flux. It suggests that whistler chorus bursts can cause electron precipitation associated with pulsating aurora and relativistic electron microbursts.

キーワード：脈動オーロラ、相対論的電子マイクロバースト、ホイッスラー・コーラス・バースト、データ駆動型テスト粒子シミュレーション、あらせ衛星
Keywords: Pulsating Aurora, Relativistic electron microbursts, Whistler chorus bursts, Data-driven test-particle simulation, ERG

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Conjugated quasi-periodic ELF/VLF emissions between the Arase satellite and both Van Allen Probes

*Claudia Martinez Calderon[1,2], Frantisek Nemec[3], Kazuo Shiokawa[2], Yuto Katoh[1], Yoshiya Kasahara[4], Shoya Matsuda[2], Fuminori Tsuchiya[1], Atsushi Kumamoto[1], Mariko Teramoto[2], Ayako Matsuoka[5], Yoshizumi Miyoshi[2], Ondrej Santolik[6,3], George Hospodarksy[7]

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Extremely Low (ELF) and Very Low Frequency (VLF) emissions are naturally occurring magnetospheric plasma waves in the frequencies of 3 Hz to 30 kHz. They play a fundamental role in radiation belt dynamics, accelerating or scattering electrons through wave-particle interactions. We report the first quasi-periodic (QP) emission simultaneously observed by the Arase (ERG) satellite and both Van Allen Probes (RBSP). This is one of few known conjugated satellite events where the waves show very similar spectral and temporal features. The event was observed on November 29, 2018 from approximately 11 to 13:30 UT by both RBSP, while ERG observed it from 12 to 14 UT. Using wave analysis, propagation parameters, and intensities simultaneously measured at several locations we will discuss the approximate location of the source region. We will also discuss the eventual timing differences between QP periodicity at different locations. Some slight variation in the spectral shapes is observed. We will discuss possible relationships with the variations of plasma number density, magnetic field, and energetic electron distribution.

Keywords: conjugated event, VLF, QP, Arase, RBSP, plasma waves

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[E] 口頭発表 | セッション記号 P (宇宙惑星科学)：P-CG 宇宙惑星科学複合領域・一般

2019年5月28日(火) 13:45 ~ 15:15 | A03 東京ベイ幕張ホール

[P-CG22] Shock responses of planetary materials elucidated from meteorites and dynamic compression experiments

コンビーナ:関根 利守(Center for High Pressure Science and Technology Advanced Research)、奥地 拓生(岡山大学惑星物質研究所)、座長:関根 利守(HPSTAR & Osaa University)、Ai-Cheng Zhang(Nanjing University)

Impact phenomena had played essential roles in the process of planetary evolution. Recent analytical and experimental developments reveal a new prospective on the effects of shock-compression process for planetary materials. For deeper understanding of such shock effects, it is necessary to evaluate the detailed shock conditions from the observations of naturally-shocked planetary materials, and to compare them with the results on the planetary materials experienced a wide range of known shock conditions. Several metastable phases, that have not been known before, have recently been identified in shocked meteorites. They suggest that the shock state is often not in equilibrium and that it is more complicated process than ever thought. Experimental techniques including laser-driven shock compression and x-ray free electron laser diagnostics have been progressed to successfully simulate a wide range of shock conditions. The recent results indicate that shocked grains are fractured and rotated at relatively low pressures, and that they are subsequently transformed into denser phases or melts, or their mixtures at pressures of a few 100s GPa. Understanding of such shock dynamics requires another prospect, which is qualitatively different from the static high pressure and high temperature consensus. Therefore, it is timely to have an international symposium on dynamics of planetary materials.

13:45 ~ 14:00

[PCG22-01] Shock-induced phase transformation in howardite-eucrite-diogenite meteorites

★Invited Papers

*Ai-Cheng Zhang[1,2]、De-Liang Chen[1]、Run-Lian Pang[1] (1.School of Earth Sciences and Engineering, Nanjing University, China、2.CAS Center for Excellence in Comparative Planetary, China)

14:00 ~ 14:15

[PCG22-02] 隕石における結晶格子剪断誘起のケイ酸塩高圧相の準安定的形成

★招待講演

*富岡 尚敬[1]、奥地 拓生[2]、宮原 正明[3] (1.海洋研究開発機構高知コア研究所、2.岡山大学惑星物質研究所、3.広島大学理学部地球惑星システム学科)

14:15 ~ 14:30

[PCG22-03] Can high-pressure polymorphs clarify an ordinary chondrite parent-body breakup?

*宮原 正明[1]、山口 亮[2]、齋藤 優人[1]、吹本 幹太[1]、境 毅[3]、大藤 弘明[3]、富岡 尚敬[4]、兒玉 優[5]、大谷 栄治[6] (1.広島大学大学院理学研究科地球惑星システム学専攻、2.国立極地研究所、3.愛媛大学地球ダイナミクス研究センター、4.JAMSTEC・高知コア研究所、5.マリン・ワーク・ジャパン、6.東北大学大学院理学研究科地学専攻)

14:30 ~ 14:45

[PCG22-04] Linking occurrence and texture of dense silicate minerals in shocked meteorites with laser-shock experimental results of Mg_2SiO_4 analyzed by XFEL probe

*奥地 拓生[1]、Narangoo Purevjav[1]、尾崎 典雅[2]、松岡 健之[2]、瀬戸 雄介[3]、丹下 慶範[4]、薮内 俊毅[5]、富岡 尚敬[6]、関根 利守[7]、兒玉 了祐[2] (1.岡山大学惑星物質研究所、2.大阪大学工学研究科、3.神戸大学理学研究科、4.高輝度光科学研究センター、5.理化学研究所放射光科学研究センター、6.海洋研究開発機構高知コア研究所、7.Center for High Pressure Science and Technology Advanced Research)

14:45 ~ 15:00

[PCG22-05] Laser-shock evolution of organic molecules in carbonaceous meteorite

*薮田 ひかる[1]、藤岡 光[2]、境家 達弘[2]、近藤 忠[2]、大野 宗祐[3]、黒澤 耕介[3]、門野 敏彦[4]、重森 啓介[5]、弘中 陽一郎[5]、山中 高光[6] (1.広島大学大学院理学研究科 地球惑星システム学専攻、2.大阪大学大学院理学研究科 宇宙地

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15:00 ~ 15:15

[PCG22-06] Shock barometer using cathodoluminescence and synchrotron angle-dispersive x-ray diffraction analyses of minerals

★Invited Papers

*鹿山 雅裕[1] (1.東北大学)

Shock-induced phase transformation in howardite-eucrite-diogenite meteorites

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Phase transformation is an important type of mineralogical respects to shock metamorphism in planets and asteroids. It has been widely used to constrain the dynamic conditions (pressure-temperature-time, P-T-*t*) of shock events and the mineral constituents in deep planets. In the past decades, shock-induced phase transformation has been extensively studied in shocked ordinary chondrites, martian and lunar meteorites. However, shock-induced phase transformation in howardite-eucrite-diogenite (HED) meteorites was less studied. In the past five years, a few high-pressure minerals (coesite, stishovite, tissintite, vacancy-rich clinopyroxene, super-silicic garnet, grossular, and a new mineral vestaite (TiFe)Ti_3O_9) have been reported in shocked eucrites (Miyahara et al., 2014; Pang et al., 2016, 2018; Fudge et al., 2017). In this study, we report a few new observations about shock-induced phase transformation in HED meteorites and discuss their potential implications for constraining the shock metamorphism of Vesta.

Four eucrite meteorites NWA 8003 (unbrecciated), NWA 2650 (brecciated), NWA 10245 (unbrecciated), and Dhofar 007 (brecciated) and two unbrecciated diogenite meteorites NWA 8321 and NWA 8326 were studied with scanning electron microscopy, Raman spectroscopy, Electron backscatter diffraction, and transmission electron microscopy.

The four eucrite meteorites NWA 8003, NWA 2650, NWA 10245, and Dhofar 007 have a few similar shock-induced features. All of them contain coesite, stishovite, vacancy-rich clinopyroxene, and tissintite. NWA 8003, NWA 2650, and Dhofar 007 also contain super-silicic garnet in shock-induced melt veins; however, no super-silicic garnet was observed in NWA 10245. In NWA 8003, unique Ti-rich melt pockets have been observed and contain ilmenite, vacancy-rich clinopyroxene, vestaite, corundum, and kyanite. In NWA 2650, an oval-shaped region in a super-silicic garnet-dominant shock-induced melt vein contains grossular, kyanite, and silica glass. Some kyanite crystals are present in the interstitial glass between surrounding super-silicic garnet grains. Some of the grossular grains occur as overgrowth on super-silicic garnet. These textures indicate that the grossular + kyanite + silica assemblage has formed through shock-induced melting of anorthite and recrystallization. Reidite was observed as irregular region and lamellae in zircon from NWA 2650. It might have formed through solid-state phase transformation at a pressure >20 GPa.

The two unbrecciated diogenite meteorites have different shock-induced features. NWA 8321 contains shock-induced melt veins which contain some mineral fragments of olivine, and pyroxene. No high-pressure minerals were detected within and adjacent to shock-induced melt veins. However, in NWA 8326, a few high-pressure minerals have been observed. They include stishovite, xieite, reidite, tuite, and tissintite. Stishovite was observed with two different textures. Xieite was observed as brighter lamellae in chromite adjacent to a thin shock-induced melt veins. Reidite mainly occurs as lamellar phase in zircon. The textures indicate that stishovite, xieite, and reidite have formed through solid-state phase transformation. Tissintite was also observed, closely adjacent to a shock-induced melt vein. It has probably formed through crystallization from high-pressure and high-temperature melt.

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Our new observations reveal that shock-induced phase transformation in HED meteorites are more common than previous thought. Most of these HED meteorites have experienced a low to moderate degree of shock metamorphism. However, the presence of reidite and xieite indicates that some of the HED meteorites (NWA 2650 and NWA 8326 have experienced severe shock metamorphism. Generally, the diversity of high-pressure minerals in HED meteorites is consistent with the relatively low impact velocities in the main asteroid belt. In addition, compared to severe shock metamorphism in ordinary chondrites, martian and lunar meteorites, the high-pressure minerals in HED meteorites open a new window to study low to moderate shock metamorphism.

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Keywords: High-pressure minerals, Shock metamorphism, HED meteorites, Vesta

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隕石における結晶格子剪断誘起のケイ酸塩高圧相の準安定的形成
Lattice-shear-induced metastable formation of high-pressure silicates in shocked meteorites

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Heavily shocked meteorites contain various types of high-pressure polymorphs of silicate minerals. These high-pressure minerals are micron to submicron sized and occurred within and in the vicinity of shock-induced melt in stony meteorites. Their occurrence suggests two types of formation mechanisms: (1) solid-state high-pressure transformation of the host-rock minerals into monomineralic polycrystalline aggregates, and (2) crystallization of chondritic or monomineralic melts under high pressure [1]. In some cases of the former process, high-pressure minerals occur as coherent lamellae within grains of the host low-pressure minerals. A typical example is the (Mg,Fe)SiO_3pyroxene-akimotoite intergrowth in the Tenham meteorite [2]. The akimotoite has relatively high Fe content [Fe/(Mg+Fe)=0.21] but does not have its stability field at any P-T conditions [3]. Therefore, the akimotoite would have been formed metastably due to a rapidly-changing P-T history in the shock event. As another example, a new high-pressure polymorph of olivine, which has been defined as “ε-phase” with a spinelloid structure, was recently discovered as nano-scale lamellae in ringwoodite [$(Mg,Fe)_2SiO_4$-spinel] and wadsleyite [$(Mg,Fe)_2SiO_4$ -spinelloid] grains in Tenham and Miami meteorites, respectively [4]. The phase has never been observed in previous phase equilibrium studies. Both pyroxene-akimotoite and ringwoodite/wadsleyite-ε-phase intergrowths have topotaxy with preserving close-packed oxygen layers for their respective structures. The crystallographic relationships between these host and the product phases suggest that these polymorphic phase transformations are promoted by shear mechanism [5]. This process is achieved by shear deformation of oxygen sublattice associating movements of interstitial cations within single unit-cell dimension. Therefore, shear mechanism is considered to be a favorable mechanism under high differential stress, or under relatively low-temperatures, where atomic diffusion is kinetically hindered. Future experimental studies, which include ultrafast in-situ X-ray diffraction under laser shock compression, and high-resolution electron microscopy on recovered specimens of static high-pressure experiments, would contribute to better understanding of detailed structural changes in naturally shocked samples.

References: [1] Tomioka & Miyahara (2017) *Meteorit. Planet. Sci.*,52, 2017–2039. [2]Tomioka & Fujino (1999) *Amer. Mineral.*, 84, 267–271. [3] e.g. Ito & Yamada (1982) in*High-Pres. Res. Geophys.*, 405–419.[4] e.g. Tomioka & Okuchi (2017) *Sci. Rep.*, 7, 17351. [5] Tomioka (2007) *J. Mineral. Petrol. Sci.* ,102, 226–232.

キーワード：衝撃変成、隕石、相転移メカニズム、高圧鉱物
Keywords: shock metamorphism, meteorites, transformation mechanisms, high-pressure minerals

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Can high-pressure polymorphs clarify an ordinary chondrite parent-body breakup?

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An ordinary chondrite is the biggest clan in the meteorites. The ordinary chondrites are the building blocks of an ordinary chondrite parent-body that broke up by an impact in the solar nebula. The breakup process of the ordinary chondrite parent-body is one of the intriguing conundrums. Most ordinary chondrites have evidence for the impact event. Shock-induced melting textures and high-pressure polymorphs are the most distinct clues for the impact event. Chen et al. (1996) suggested that the high-pressure polymorphs occurring in the shock-induced melt can be a clue for clarifying the impact event occurred on the parent-body because we can constrain several parameters for the impact such as shock pressure and impact velocity based on the formation conditions of the high-pressure polymorph assemblage. Accordingly, many previous studies have worked on the high-pressure polymorphs in the ordinary chondrites for several decades. Most previous investigations have focused on the L6 chondrite because the meteorite type is abundantly recovered on the Earth. On the other hand, few previous studies have worked on other petrologic types such as L5 and L4. The inventories of the high-pressure polymorphs in shocked H- and LL-group ordinary chondrites have been barely described. The ordinary chondrite parent-body is expected to have an onion shell-like structure. H-, L-, and LL-group ordinary chondrites originate from their individual parent-bodies. We have to clarify the inventories of the high-pressure polymorphs included in all petrologic types and groups to elucidate the breakup processes of the ordinary chondrite parent-bodies. Accordingly, we initiated the systematic investigations of the high-pressure polymorphs included in the shocked ordinary chondrites. About sixty H-group, eighty L-group, and fifty LL-group ordinary chondrites with the shock-induced melting textures were systematically investigated by SEM and Raman spectrometer. There was the distinct difference in the modes of shock-induced melting between petrologic type 3–4 and type 5–6 in all groups. In the petrologic type 3–4, the melting occurred at the boundaries between the chondrules and surrounding matrices as a melt-pocket. In the petrologic type 5–6, melting occurred as isolated veins or networks. There was also a clear difference in abundance of the high-pressure polymorphs among H-, L-, and LL-groups: the high-pressure polymorphs are abundant in L- and LL-groups, whereas rare in H-group. The species and assemblages of the high-pressure polymorphs depended on the petrologic types. The abundance and assemblages of the high-pressure polymorphs in L- and LL-group were similar to each other, suggesting that both parent-bodies have similar impact histories. The shock-pressure conditions were estimated based on the identified high-pressure polymorph assemblages: from ~13 to ~24 GPa for L/LL6, from ~3 to ~12 GPa for L/LL4 and L/LL5, and less than ~3 GPa for L/LL3. When we adopted the estimations into the onion-shell-structured parent-body, the shock pressure condition on the parent-body surface is much lower than its interior, which is unlikely for a head-on impact. We cannot explain the

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parent-body breakup phenomenon based only on the estimation using the high-pressure polymorphs. There are clear differences on their petrographic structures between type 3–4 and type 5–6: the former consists of accumulated chondrules and the latter has equilibrated texture. It is also expected that type 3–4 and type 5–6 chondrites have different initial density and porosity. These differences will affect the response to the shock metamorphism. Unless we take these factors into the estimation, we cannot clarify the parent-body breakup phenomenon by using the high-pressure polymorphs.

Reference: Chen et al. Science 271: 1570–1573 (1996)

キーワード：衝撃、普通コンドライト、高圧相
Keywords: Shock, Ordinary chondrite, High-pressure polymorph

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Linking occurrence and texture of dense silicate minerals in shocked meteorites with laser-shock experimental results of Mg_2SiO_4 analyzed by XFEL probe

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Primitive meteorites often show features of shock metamorphism, including occurrences of dense polymorphs of major mineral phases. By previous transmission electron microscopy studies it was demonstrated that olivine (alpha-Mg_2SiO_4) often had transformed into its denser polymorphs such as ringwoodite (gamma-Mg_2SiO_4), and as a recently-discovered new structure (epsilon-Mg_2SiO_4: Tomioka and Okuchi, Sci. Rep. 2017). The impact events that produced these polymorphs played essential roles in the history of early solar system evolution. Here we tried to reproduce such a dynamic transformation process starting from forsterite olivine single crystals by using very strong laser beam and x-ray free electron laser (XFEL) beam in combination at SACLA, SPring-8, Japan. A transformation process has been successfully observed with sub-nanosecond resolution by x-ray diffraction using femtosecond XFEL pulses. We discovered an ultrafast transformation process completing only within few nanoseconds, which was not expected to occur during shock metamorphism of meteorites. It can be a shear-induced fast lattice slipping proceeding without any atomic diffusion process. We conclude that formation processes and environments of some of dense Mg_2SiO_4 polymorphs in heavily shocked meteorites are needed to be reconsidered to involve this fast process.

キーワード：高密度鉱物、レーザー衝撃圧縮実験、衝撃変成、Mg2SiO4
Keywords: dense silicate minerals, laser shock experiments, shock metamorphism, Mg2SiO4

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Laser-shock evolution of organic molecules in carbonaceous meteorite

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It has been hypothesized that extraterrestrial organic compounds were delivered to the early Earth by meteorites and comets during the Late Heavy Bombardment (LHB). There have been several experiments that simulated the shock synthesis of organic compounds during the LHB. However, in the past studies using gas guns, it is difficult to perform an open system experiment at higher impact velocities than Earth’ s escape velocity (> 17 km/s). In order to understand what compositions of meteoritic organic molecules were produced by the shock energy of LHB and delivered to the Earth, we carried out a high power laser compression experiment (up to 400 GPa) of carbonaceous chondritic meteorite, which contains 2wt% of organic carbon.

Pellets of Murchison carbonaceous meteorite was prepared by diamond anvil cell, respectively. Pellets of the meteorites in 3mm diameter and 1mm thickness were prepared. The titanium foil was located in front of the sample as the ablator for the laser and for preventing the sample from blowing out. The laser-shock experiment was carried using GEKKO XII/HIPER laser system, Institute of Laser Engineering, Osaka University. The laser wavelength, pulse width, and spot diameter were 1053 nm, ~20 ns, and ~0.4 mm, respectively. The shock pressures were 20, 50, and 400 GPa. The collected meteorite samples were extracted with dichloromethane and methanol. The extracts were concentrated and analyzed by a gas chromatography coupled with mass spectrometry (GCMS).

Molecular compositions of polycyclic aromatic hydrocarbons (PAHs) in Murchison meteorite are not changed before and after the shock experiment at 20 GPa, except that the concentration of naphthalene was depleted. At 50 and 400 GPa, the concentrations of pyrene and fluoranthene increased, while those of biphenyl, fluorenone, and anthracene decreased. Molecular compositions of *n*-alkanes (C_{14} –C_{24}) are not largely changed before and after the shock experiment at 20 GPa. However, at 50 GPa, the concentrations of short chain *n*-alkanes (C_{14} - C_{17}) decreased and those of long chain *n*-alkanes (C_{18} - C_{24}) relatively increased. These results indicate that impact processes promote aromatic ring condensation and elongation of carbon chains of *n*-alkanes.

キーワード：高強度レーザー、隕石有機物、アストロバイオロジー
Keywords: High-power laser, Organic compounds in meteorites, Astrobiology

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Shock barometer using cathodoluminescence and synchrotron angle-dispersive x-ray diffraction analyses of minerals

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A part of meteorites record collisional history of asteroidal and cometary impacts. Impactites were created in impact craters by the shock event on the Earth. These materials provide vital information on collision and accumulation processes of asteroid and planet and ejection process from the parent body. The shock pressure is one of the most important parameters to interpret these impact history. Various techniques such as optical and electron microscopy and infrared adsorption and Raman spectrometry have been applied for minerals (e.g., feldspar and silica minerals) in meteorites and impactites to estimate the shock pressure that occurs on the Earth, Moon, and Mars. Although there are many works to evaluate the shock pressure using these techniques, quantitative estimation of a wider dynamic range of shock pressure has not been possible for a micrometer-sized grain to date. Here, cathodoluminescence (CL) and synchrotron angle-dispersive x-ray diffraction (SR-XRD) of experimentally shocked feldspars and quartz and these minerals in meteorite and impactite have been investigated to establish a new shock barometer.

Shock experiments were performed for single crystals of synthetic and terrestrial quartz and terrestrial feldspars at the National Institute for Material Science using a one stage propellant gun. Quartz in an impactite from the Chicxulub crater and alkali feldspar and plagioclase in martian meteorites (NWA 2975, Shergotty, Dhofar 019, and Zagami) were selected here. CL spectroscopy of these samples was conducted at Okayama University of Science. SR-XRD was measured for the powder samples at KEK Photon Factory (PF; beam line: PF BL-4B2).

CL spectra of unshocked feldspars (starting material for the shock recovery experiments) consist of blue, yellow, and/or red emission bands in the wavelength range from 300 to 800 nm. The ultraviolet (UV) to blue emission bands at 330 and 380 nm were obtained from CL spectra of only experimentally shocked feldspars at 20 to 40 GPa. The intensities of all UV-blue emissions correlate positively with the shock pressure. Similar UV-blue emission bands were recognized in CL spectra of the shock-induced feldspar glasses in the martian meteorites and impactites.

CL spectra of unshocked synthetic and terrestrial quartz show an extremely weak blue emission band at 400 nm. The blue emission band was also detected in CL spectra of the experimentally shock recovered samples at 5 to 40 GPa and quartz in the impactite, whereas their blue emission intensities are obviously higher than those of the unshocked quartz. The blue emission intensities increase with the pressure due to shock experiments gradually from 5 to 15 GPa and drastically from 20 to 40 GPa. These correlations obtained from CL spectra of experimentally shocked feldspar and quartz would give quantitative values of the shock pressures that the minerals in martian meteorites and impactite have experienced. Therefore, the CL intensity of feldspar has a potential for a shock barometer with high spatial resolution.

SR-XRD analyses of experimentally shocked quartz demonstrated that the diffraction peaks increase in the intensity and become broader with increasing the shock pressure in the range from 5 to 30 GPa. At the shock pressure above 35 GPa, diffraction peak of quartz was no longer undetectable from the pattern,

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implying its complete amorphization. Moreover, several crystal planes exhibit peak shifts with the pressure in the pressure range from 15 to 30 GPa. Furthermore, the shock experiments enhance micro strain and reduce crystallite size. This fact indicates that the shock-induced amorphization was initiated by lattice distortion and structural defects induced by shock compression. The SR-XRD response to the shock pressure suggests the possibility of shock barometer using SR-XRD method, at least in the range from 15 to 30 GPa.

キーワード：天体衝突、長石、石英、カソードルミネッセンス、放射光X線回折
Keywords: Shock impact, Feldspar, Quartz, Cathodoluminescence, Synchrotron angle-dispersive x-ray diffraction

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2019年5月28日(火) 15:30 ~ 17:00 | A03 東京ベイ幕張ホール

[P-CG22] Shock responses of planetary materials elucidated from meteorites and dynamic compression experiments

コンビーナ:関根 利守(Center for High Pressure Science and Technology Advanced Research)、奥地 拓生(岡山大学惑星物質研究所)、座長:奥地 拓生(岡山大学)、Yongjae Lee(Yonsei University)

Impact phenomena had played essential roles in the process of planetary evolution. Recent analytical and experimental developments reveal a new prospective on the effects of shock-compression process for planetary materials. For deeper understanding of such shock effects, it is necessary to evaluate the detailed shock conditions from the observations of naturally-shocked planetary materials, and to compare them with the results on the planetary materials experienced a wide range of known shock conditions. Several metastable phases, that have not been known before, have recently been identified in shocked meteorites. They suggest that the shock state is often not in equilibrium and that it is more complicated process than ever thought. Experimental techniques including laser-driven shock compression and x-ray free electron laser diagnostics have been progressed to successfully simulate a wide range of shock conditions. The recent results indicate that shocked grains are fractured and rotated at relatively low pressures, and that they are subsequently transformed into denser phases or melts, or their mixtures at pressures of a few 100s GPa. Understanding of such shock dynamics requires another prospect, which is qualitatively different from the static high pressure and high temperature consensus. Therefore, it is timely to have an international symposium on dynamics of planetary materials.

15:30 ~ 15:45

[PCG22-07] Dynamic Compression at Pohang X-ray Free Electron Laser Facility (PAL-XFEL)

★Invited Papers

*Yongjae Lee[1] (1.Yonsei University, Seoul, Korea)

15:45 ~ 16:00

[PCG22-08] Exploration of extreme melt states of silicate usign high-power laser and XFEL

★Invited Papers

*尾崎 典雅[1] (1.大阪大学)

16:00 ~ 16:15

[PCG22-09] Hugoniot measurements for silicate: Understanding silicate magma under the planetary impacts

*梅田 悠平[1]、尾崎 典雅[1]、関根 利守[2]、Bruno Albertazzi[3]、Alessandra Benuzzi-Mounaix[3]、Riccardo Bolis[3]、Marco Guaruaglini[3]、片桐 健登[1]、兒玉 了祐[1]、Michel Koeing[3]、宮西 宏併[4]、森岡 信太郎[1]、西川 豊人[1]、大井 修吾[5]、Alessandra Ravasio[3]、坂和 洋一[4]、佐野 孝好[4]、佐藤 友子[6] (1.大阪大学大学院工学研究科、2.HPSTAR、3.エコールポリテクニーク、4.大阪大学レーザー科学研究所、5.滋賀大学、6.広島大学大学院理学研究科)

16:15 ~ 16:30

[PCG22-10] **An experimental design to determine iron melting at the Earth's core conditions via in-situ X-ray diffraction technique at high power laser facility**

★Invited Papers

*Hao Liu[1] (1.Laser fusion research center)

16:30 ~ 16:45

[PCG22-11] **Study on transport properties of liquid iron and iron alloy under high temperature and high pressure using the laser shock technique**

*宮西 宏併[1]、尾崎 典雅[2]、大村 訓史[3]、Marion Harmand[4]、Andy Krygier[5]、西川 豊人[2]、梅田 悠平[2]、重森 啓介[1]、坂和 陽一[1]、佐野 孝好[1]、兒玉 了祐[1,2] (1.大阪大学レーザー科学研究所、2.大阪大学工学研究科、3.広島工業大学工学部、4.IMPMC, Sorbonne Université、5.LLNL)

16:45 ~ 17:00

[PCG22-12] **Laser shock compression in LFRC**

*Liang Sun[1] (1.Laser Fusion Research Center, CAEP)

Dynamic Compression at Pohang X-ray Free Electron Laser Facility (PAL-XFEL)

*Yongjae Lee[1]

1. Yonsei University, Seoul, Korea

We have successfully commissioned dynamic compression studies at the Pohang X-ray Free Electron Laser facility (PAL-XFEL) in Korea by utilizing instrumentations at FXS (Femtosecond X-ray Scattering) –XSS (X-ray Scattering and Spectroscopy) beamline. As the first experiment, a polycrystalline iron foil has been illuminated by an 800 nm wavelength uncompressed optical laser with ~6 mJ in 150 ps pulse length, focused onto a 100 mm FWHM spot. The shock-compressed sample has then been probed by ca. 50 fs quasi-monochromatic (bandwidth 0.4%) X-ray pulse at an energy of ~10 keV with 10^{11} photons per pulse, focused to ca. 30 mm diameter using a CRL optics. The sample is positioned normal to the X-ray pulse at a distance of ca. 12 cm from a Rayonix mx225 detector in a way to cover 2q angles up to ca. 65 degrees. Single-shot diffraction measurements were performed with ca. 100 ps. increment up to one nanosecond. We demonstrate that PAL-XFEL can provide a unique opportunity in probing ultrafast lattice dynamics with sufficient spatial and temporal resolution in intermediate pressure regime.

Keywords: dynamic compression, laser shock, iron, X-ray free electron laser

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Exploration of extreme melt states of silicate usign high-power laser and XFEL

*尾崎 典雅[1]
*Norimasa Ozaki[1]

1. 大阪大学
1. Osaka University

Recent experimental studies on silicate using high-power lasers and XFEL are reviewed.

キーワード：衝撃圧縮、高強度レーザー、ケイ酸塩化合物、X線自由電子レーザー
Keywords: Shock compression, High power laser, Silicate, X-ray free electron laser

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Hugoniot measurements for silicate: Understanding silicate magma under the planetary impacts

*梅田 悠平[1]、尾崎 典雅[1]、関根 利守[2]、Bruno Albertazzi[3]、Alessandra Benuzzi-Mounaix[3]、Riccardo Bolis[3]、Marco Guaruaglini[3]、片桐 健登[1]、兒玉 了祐[1]、Michel Koeing[3]、宮西 宏併[4]、森岡 信太郎[1]、西川 豊人[1]、大井 修吾[5]、Alessandra Ravasio[3]、坂和 洋一[4]、佐野 孝好[4]、佐藤 友子[6]

*Yuhei Umeda[1], Norimasa Ozaki[1], Toshimori Sekine[2], Bruno Albertazzi[3], Alessandra Benuzzi-Mounaix[3], Riccardo Bolis[3], Marco Guaruaglini[3], Kento Katagiri[1], Kodama Ryosuke[1], Michel Koeing[3], Kohei Miyanishi[4], Shintaro Morioka[1], Toyohito Nishikawa[1], Syugo Ohi[5], Alessandra Ravasio[3], Yoichi Sakawa[4], Takayoshi Sano[4], Tomoko Sato[6]

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1. Graduate School of Engineering, Osaka Univ., 2. Center for High Pressure Science & Technology Advanced Research, 3. Ecole Polytechnique, 4. Institute of Laser Engineering, Osaka University, 5. Shiga Univ., 6. Graduate School of Science, Hiroshima University

Two magnesium silicates of $MgSiO_3$(Enstatite) and Mg_2SiO_4(Forsterite) are primary mantle constitutions in the Earth and major components in Earth-type exoplanets.The ordinary chondrite, which accounts for about 90 % of all flying meteorites, consists of silicates as main components. The impacts at collision velocities exceeding 10 km/s are known as common events in the universe and such high energy phenomena could have played an important role to form planets or planetesimals and to evolve planetary environments. For example, a large-scale impact such as the giant impact related to the formation of moon was estimated to be at impact velocity of 15-20 km/s [Melosh, 1990].

In this study, Hugoniot equation of state (EOS) of enstatite has been determined at pressures of ~400 to 560 GPa by laser shock experiments. A coupling of both the present study and the previous data by Fratanduono et al. (2018) shows a discontinuity in the shock velocity-particle velocity at ~380-400 GPa. The measured reflectivity of shocked enstatite indicates three different trends relative to that of quartz; less steep slope at 300-345 GPa, parallel at 345-400 GPa, and a rapid increasing above ~400 GPa, suggesting different phases of enstatite melt, a mixture of metal-like liquid of $SiO_2$and crystalline MgO, and fluid-like enstatite melt above ~380 GPa. We also calculated the release state of thin enstatite using quartz on it as a reference. These results on enstatite imply that reactions in silicate magma occur at pressures of 300-400 GPa and that they may affect the current planet formation model in terms of the stratification of interior, the mantle convection, and the formation of magnetic field in Super-Earths.

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An experimental design to determine iron melting at the Earth’s core conditions via in-situ X-ray diffraction technique at high power laser facility

*Hao Liu[1]

1. Laser fusion research center

Phase diagram of iron at the Earth’s core conditions is mandatory for determining the states at the core boundaries and the crystal structure of the solid core. Up to date, the iron phase diagram at high pressure has been investigated experimentally by both static compression (diamond-anvil cell) and dynamic compression (shock wave) techniques. However, the discrepancies among different researches on melting line of iron are still irreconciled. Combining in-situ transient X-ray diffraction and laser compression technique, we propose an investigation which could determine the melting line of iron or the high-pressure high-temperature phase from the lattice level. In this research, high power lasers are applied to drive the iron into melting state. X-ray diffraction pattern interpretation and the criteria for judging iron melting are of great importance. Traditionally, the existence of diffraction peak is used as the only criteria to determine if melting occurs. Nevertheless, this is not enough for shock loading with high heating rate, where the pre-melting or superheating phenomenon occurs. Under these conditions, the diffraction peaks could either disappear at temperature below the melting line or remain even above the melting line. This could lead to misinterpretation for melting temperature. However, the two-dimensional shape of diffraction pattern will change. When melting initiates, the shear modulus of the highly stressed material disappears and the diffraction pattern changes into an ideally circled shape. Therefore, with the information of two-dimensional diffraction pattern, we can make the melting criteria, from the lattice level, more sound and clear. This method could provide experimental judgment with higher precision, which might reconcile the discrepancies on melting temperature of iron at the Earth’s core conditions.

Keywords: laser shock, in-situ x-ray diffraction, iron melting, earth core

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Study on transport properties of liquid iron and iron alloy under high temperature and high pressure using the laser shock technique

Study on transport properties of liquid iron and iron alloy under high temperature and high pressure using the laser shock technique

*宮西 宏併[1]、尾崎 典雅[2]、大村 訓史[3]、Marion Harmand[4]、Andy Krygier[5]、西川 豊人[2]、梅田 悠平[2]、重森 啓介[1]、坂和 陽一[1]、佐野 孝好[1]、兒玉 了祐[1,2]
*Kohei Miyanishi[1], Norimasa Ozaki[2], Satoshi Ohmura[3], Marion Harmand[4], Andy Krygier[5], Toyohito Nishikawa[2], Yuhei Umeda[2], Shigemori Keisuke[1], Youichi Sakawa[1], Takayoshi Sano[1], Ryosuke Kodama[1,2]

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1. Institute for Laser Engineering, Osaka University, 2. Graduate school of engineering, Osaka University, 3. Faculty of Engineering, Hiroshima Institute of Technology, 4. IMPMC, Sorbonne Université, 5. LLNL

Information on the thermal and electrical transport properties of iron alloys under high-pressure and high-temperature conditions corresponding to the earth’ s outer core is necessary to clarify the convection phenomena of the earth and the cooling history. In particular, the transport properties in the outer core–mantle boundary condition strongly influence the mantle convection, the outer core convection generating the earth's magnetic field, the growth and inner flow of the inner core, and so on. However, there are very few experimental examples concerning high-pressure and high-temperature liquid iron/iron-alloy which correspond to the outer core conditions, and only a few cases have been reported for pure iron [1]. It is required to investigate transport coefficients of liquid iron alloys containing light elements to simulate actual outer core, experimentally. Laser shock compression technique has several advantages to exploring iron-alloys under high-pressure and high-temperature condition. As there is no mechanical restriction on pressure generation, producing the pressure of even TPa is easy, and high heating rate exceeding 10^{15}K / s is possible, and it is a closed system that is not affected by surroundings. Therefore the technique is effective for generation and observation of high-pressure and high-temperature liquid iron-alloys. In this research, we report optical reflectivity, pressure and temperature measurements of laser shock compressed iron and iron-silicon (Fe-Si) alloy at and above the earth's outer core conditions.

Target assemblies containing polypropylene (CH), aluminum, quartz, iron or iron-silicon alloy and magnesium oxide (MgO) window were shock compressed by laser ablation at the GEKKO XII laser facility, the Institute of Laser Engineering, Osaka University. Iron and iron-silicon alloy were formed by electron beam evaporation on the MgO window. Laser beams with a wavelength of 527 nm were focused onto the target. A focal spot was 1 mm in diameter with a flat-top spatial intensity distribution resulting in a planar shock front. Temporal shape of the laser pulse was approximately a flat-top with a full-width at half-maximum of 2.5 ns. The velocity interferometer system for any reflector (VISAR) measure a particle velocity and a reflectivity at the interface between iron or iron-silicon alloy and MgO. The Ppressure was evaluated using measured particle velocity and a known equation of state of MgO[2]. The optical pyrometer measures the temperature at the interface through the MgO window.

The pressures determined from the measurement results were from 200 to 400 GPa, and the temperatures were up to 15000 K. In the pressure range exceeding 200 GPa, in the case of iron, a

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decrease in reflectivity was observed as the pressure increased, whereas in the case of the iron-silicon alloy, a continuous increase following a discontinuous decrease in the reflectivity was observed. The decrease in reflectivity of iron suggests a decrease in electronic conductivity due to temperature rise with increasing pressure. On the other hand, the continuous rise seems to indicate an increase in the density of free electrons derived from silicon.

[1] K. Ohta, Y. Kuwayama, K. Hirose, K. Shimizu, Y. Ohisi: Nature, 534, 95-98 (02 June 2016).

[2] S. Root, L. Shulenburger, R. W. Lemke et al.: Phys. Rev. Lett, 115, 198501 (2015).

キーワード：iron
Keywords: iron alloy

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Laser shock compression in LFRC

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1. Laser Fusion Research Center, CAEP

Shock compression is a major technique used for achieving high pressures dynamically. High-powered lasers are increasingly being used for dynamic loading of materials, especially for extreme high pressure. Ramp loading, a series of weak compress waves, is an another advantage for laser-based dynamics, which can be realized easily by the laser pulse shape and can be applied to compress material in much lower temperature under exoplanetary condition. In this talk, we will present our shock loading and X-Ray diagnostics abilities in LFRC and our shock experiment results. Our research progress will also be mentioned, especially in laser shock compression of iron and ramp compression of Al to 420 GPa. Several problems in the mineralogy of Super-Earth planets will also be mentioned in the end of this talk.

Keywords: laser shock compression, ramp compression, High-powered lasers

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[E] 口頭発表 | セッション記号 A (大気水圏科学)：A-AS 大気科学・気象学・大気環境

2019年5月28日(火) 13:45 ~ 15:15 | 104 1F

[A-AS03] 大規模な水蒸気場と組織化した雲システム

コンビーナ:三浦 裕亮(国立大学法人 東京大学大学院 理学系研究科 地球惑星科学専攻)、濱田 篤(富山大学)、横井 覚(海洋研究開発機構)、佐藤 正樹(東京大学大気海洋研究所)、座長:三浦 裕亮

水蒸気は放射冷却と凝結による潜熱放出により対流圏の大気大循環を駆動するが、その流れの中には等方的な乱流、層積雲や積乱雲、スコールラインや熱帯低気圧、さらにはマッデン・ジュリアン振動のような大規模現象まで、複雑で豊かな階層構造が形成されている。水蒸気は大きな空間スケールで長い時間をかけて蓄積され、流れに乗って輸送されるが、その凝結は短時間に小さい空間スケールで起こる。また、水蒸気や雲は地球の放射収支にも影響を与えるため、長期の気候変化を調節しているかもしれない。本セッションでは、水蒸気と組織化した雲群の相互作用を記述する湿潤大気科学の確立を将来目標に据え、理論・観測・モデルを問わず幅広い時空間スケールを対象とした研究を募集する。海大陸研究強化年(YMC)の現地観測や放射対流平衡実験のモデル間比較(RCEMIP)などの最新の知見を共有し、研究者間のコミュニケーションを円滑にすることで、長年の困難に対する突破口を開きたい。

13:45 ~ 14:00

[AAS03-01] Boundary-Layer Control on Convective Self-Aggregation

★Invited Papers

*Da YANG[1,2] (1.University of California, Davis、2.Lawrence Berkeley National Laboratory)

14:00 ~ 14:15

[AAS03-02] 高解像度放射対流平衡実験における積雲アンサンブルの統計的性質

*柳瀬 友朗[1,2]、竹見 哲也[2] (1.京都大学大学院理学研究科、2.京都大学防災研究所)

14:15 ~ 14:30

[AAS03-03] The role of interactive SST in the cloud-resolving simulations of aggregated convection

★Invited Papers

*Chien-Ming Wu[1]、Yan-Ting Chen[1] (1.National Taiwan University)

14:30 ~ 14:45

[AAS03-04] Role of coastal convection to moisture buildup during the South China Sea summer monsoon onset

*Wei-Ting Chen[1]、Wei-Ming Tsai[1,2]、Chien-Ming Wu[1]、Peng-Jen Chen[1] (1.National Taiwan University、2.University of Miami)

14:45 ~ 15:00

[AAS03-05] Resolution dependencies of tropical convection in a global cloud/cloud-system resolving model

★Invited Papers

*宮川 知己[1]、三浦 裕亮[2] (1.東京大学大気海洋研究所、2.東京大学大学院理学系研究科)

15:00 ~ 15:15

[AAS03-06] 海洋大陸西部における対流活動が大規模場に及ぼす影響：YMCスマトラ集中観測期間の数値シミュレーション

*那須野 智江[1] (1.国立研究開発法人　海洋研究開発機構)

Boundary-Layer Control on Convective Self-Aggregation

*Da YANG[1,2]

1. University of California, Davis, 2. Lawrence Berkeley National Laboratory

The atmosphere can self-organize into overturning circulations over an ocean surface with uniform temperature in cloud-resolving models. The upwelling branch is associated with humid air and deep convection; the downwelling branch is associated with dry air and clear sky. This phenomenon is referred to as convective self-aggregation, and understanding this phenomenon can advance our understanding of the Madden-Julian Oscillation (MJO). In this talk, I will introduce a boundary-layer centric framework for self-aggregation. This framework helps explain what leads to self-aggregation, and what sets the spatial scale of self-aggregation.

Reference:
1. Yang, D., 2018: JAS, https://doi.org/10.1175/JAS-D-17-0150.1
2. Yang, D., 2018: JAMES, https://doi.org/10.1029/2017MS001261

Keywords: Convection, Boundary layer, Self-aggregation

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高解像度放射対流平衡実験における積雲アンサンブルの統計的性質
Statistical Properties of Cumulus Ensembles in High-Resolution Radiative-Convective Equilibrium Simulations

*柳瀬 友朗[1,2]、竹見 哲也[2]
*Tomoro Yanase[1,2], Tetsuya Takemi[2]

1. 京都大学大学院理学研究科、2. 京都大学防災研究所
1. Graduate School of Science, Kyoto University, 2. Disaster Prevention Research Institute, Kyoto University

本研究では放射対流平衡の場における積雲アンサンブルの統計的性質について調べた。数値実験には非静力学モデルWeather Research and Forecasting (WRF) model ver. 3.8.1を用いた。大気とインタラクティブに短波・長波放射フラックスを計算するRRTMGスキームを用い、水平格子間隔を1600 mから200 mの範囲で変化させて解像度依存性を調べた。水平格子間隔200 mの実験では、積雲対流の日変化や鉛直3モード構造といった特徴が明瞭に表現される一方で、解像度が低くなる(格子間隔が大きくなる)ほど、強い上昇流や降水を伴う間欠的な深い対流が支配的となった。対流圏中・上層の大気は、解像度が低くなるにつれて安定化・乾燥化する傾向にある。さらに、3 次元的な雲検出手法を用いることで、雲の構造について調べた。解像度によって微細規模現象の水平スケールが制約され、雲内特性の鉛直構造や積雲アンサンブルの鉛直発達にも影響が及ぶことが示唆された。さらに、対流間距離や対流雲サイズ分布といった積雲アンサンブルの統計的性質が水蒸気場の水平不均一性とも関係することが示唆される。

キーワード：積雲対流、放射対流平衡、WRF
Keywords: Cumulus Convection, Radiative-Convective Equilibrium, WRF

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The role of interactive SST in the cloud-resolving simulations of aggregated convection

*Chien-Ming Wu[1], Yan-Ting Chen[1]

1. National Taiwan University

This study investigates the role of interactive SST in the early development of aggregated convection using a vector vorticity equation cloud-resolving model (VVM) coupled to a slab ocean. The simulations are initialized by a mock Walker circulation driven by initial SST gradient in the elongated x-axis, with an average of 300K and sinusoidal variation of amplitude ranging from 1.5K to 3K. According to large-scale perturbation strength, which is caused by SST variation, the results can be divided into two groups. Under weak perturbation, convection-SST feedback efficiently eliminates SST gradient and moisture anomaly. The large-scale environment is homogenized within two days. Even though SST in the group with stronger perturbation undergoes a similar process, significant moist static energy (MSE) advection in the boundary produces enough moisture difference to introduce virtual temperature effect and aggregation is triggered. Once dry zone starts to expand, radiative and convective effects regenerate SST gradient, which intensifies circulation and accelerates the process. We further show that the evolution of aggregation or not is captured by the trend of MSE-EIS variance. The results highlight the boundary layer processes on the formation of aggregated convection in the tropics.

Keywords: boundary layer processes, large-scale moisture, aggregated convection

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Role of coastal convection to moisture buildup during the South China Sea summer monsoon onset

*Wei-Ting Chen[1], Wei-Ming Tsai[1,2], Chien-Ming Wu[1], Peng-Jen Chen[1]

1. National Taiwan University, 2. University of Miami

In this study, the climatological characteristics of object-based precipitation systems (OPS) and moisture development are analyzed over the South China Sea (SCS) during the sharp transition of summer monsoon onset. The satellite observed OPS statistics showed that during the pre-onset period, small (<100 km) to medium size (100-300 km) OPS are active over surrounding land, while convection over the ocean is mostly suppressed. During post-onset, large OPS develop over the coastal ocean and contribute to over 60% of the total precipitation. The results suggest that when the convection is strong over the surrounding islands, a local circulation with anomalous subsidence over the ocean can develop and suppress convection. The number of observed large OPS significantly increases along with the sharp moisture buildup during the SCS onset period. The moisture budgets suggested that local contribution from convection vertical mixing is the major moisture source during monsoon onset pentad, while large-scale moisture advection tends to be weak. The relationship between moisture buildup and convection organization is then examined using a set of idealized cloud-resolving model (CRM) experiments, with a land-ocean configuration approximating the SCS basin. The CRM appropriated represents the observed development of coastal convection. With a non-shear environment, the strong basin-scale circulation is formed, which suppresses the ocean moisture development. When large-scale vertical wind shear is imposed to represent the changes of large-scale circulation during the onset pentad, organized convection systems are increased over the coastal ocean and propagate toward the open ocean, accompanied by fast ocean moistening. We identified through the CRM simulations that the moistening time-scale by the transition of coastal convection organization is within 5-10 days.

Keywords: Convective Organization, Coastal convection, Moisture, TRMM, CloudSat, Cloud-Resolving Model

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Resolution dependencies of tropical convection in a global cloud/cloud-system resolving model

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The properties of tropical convection are evaluated using one-month long simulation datasets produced by the non-hydrostatic icosahedral atmospheric model (NICAM) using 3.5-, 7-, and 14-km horizontal meshes with identical cloud-microphysics configurations. The simulations are targeted on the 2nd Madden-Julian oscillation (MJO) event observed in the CINDY2011/DYNAMO field campaign. An increase of high cloud fraction at 200 hPa level and a reduction of surface precipitation occur as the horizontal resolution increases, corresponding to the reduction of precipitation efficiency due to the shorter residence time inside stronger updrafts that occur at the higher resolution. The increase of high cloud fraction is followed by the warming of the troposphere, which results in an increase in the column water vapor and an elevation of the freezing level. The total water condensation is decreased at higher resolutions, which is likely due to a balance with the decreased outgoing longwave radiation (OLR). The reproduced MJOs, which accounted for a large portion of the tropical convections, were similar in the 3.5-km and 14-km simulations in terms of eastward propagation speeds and structures, including the characteristic westward tilt of the moisture anomaly with height. However, the amplitude of the anomalous MJO circulation was considerably smaller in the 3.5-km simulation. The robust resolution dependence and the interpretations presented in this study underline the necessity for a resolution-aware cloud-microphysics optimization method that will have value in the coming era of global cloud-resolving simulations.

キーワード：解像度依存性、全球雲解像モデル、熱帯対流
Keywords: resolution dependency , global cloud-resolving model, tropical convection

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海洋大陸西部における対流活動が大規模場に及ぼす影響：YMCスマトラ集中観測期間の数値シミュレーション

Effects of the local convection over the western Maritime Continent on the large-scale: numerical study during the YMC Sumatra campaigns

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1. Japan Agency for Marine-Earth Science and Technology

The effects of the high-frequency variability on the large-scale, including the intraseasonal oscillation (ISO), over the western Maritime Continent (MC), was quantified using the global nonhydrostatic simulation datasets that marginally resolve mesoscale convective systems. Moisture transport during the Years of the Maritime Continent (YMC) winter field campaigns in 2015 and in 2017 were analyzed, focusing on the land-ocean contrast and their relationship with the ISO events.

The period-mean profiles indicate moistening by low-frequency upward motion in the deep troposphere and drying (moistening) in the lower (middle and upper) troposphere by high-frequency variability. The advection over ocean was greater in 2017 than in 2015, with the opposite occurring over land with smaller interannual differences. These can be related to the longer preconditioning period (rapid transition from the preconditioning to the active, and decaying phases) for the 2015 (2017) case, as well as the relatively suppressed (enhanced) upward motion over ocean under the strong El Niño (moderate La Niña) conditions during 2015 (2017).

The dependence of the land-ocean contrast on the ISO life cycle was more significant in 2015 than in 2017. In the 2015 simulation, moistening over land preceded the major convective period of the ISO, whereas that over ocean preceded the ISO convection not longer than 1 week, consistent with the arguments by previous studies based on precipitation observations. In this case, a nearly in-phase relationship between the moisture advection by high-frequency variability and by low-frequency variability was found over land. In the 2017 case, the land-ocean contrast was weak in low-frequency advection. The relationship between moisture advection by high-frequency variability and by low-frequency variability was indistinct over land, whereas clear relationship was seen over ocean: the high-frequency variability induced lower to middle tropospheric moistening (enhanced upward transport of moisture) during the preconditioning (active) phases of the ISO convection, in common with the 2015 case. These results highlight clear land-ocean contrasts in sensitivity of local convection to background states and its link with the ISO life cycle.

キーワード：Years of the Maritime Conrtinent (YMC)、スケール間相互作用、季節内振動、水蒸気輸送、全球雲システム解像数値モデル
Keywords: Years of the Maritime Conrtinent (YMC), scale interaction, intraseasonal oscillation (ISO), moisture advection, global cloud-system-resolving simulations

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[E] 口頭発表 | セッション記号 A (大気水圏科学)：A-AS 大気科学・気象学・大気環境

2019年5月28日(火) 15:30 ~ 17:00 | 104 1F

[A-AS03] 大規模な水蒸気場と組織化した雲システム

コンビーナ:三浦 裕亮(国立大学法人 東京大学大学院 理学系研究科 地球惑星科学専攻)、濱田 篤(富山大学)、横井 覚(海洋研究開発機構)、佐藤 正樹(東京大学大気海洋研究所)、座長:横井 覚

水蒸気は放射冷却と凝結による潜熱放出により対流圏の大気大循環を駆動するが、その流れの中には等方的な乱流、層積雲や積乱雲、スコールラインや熱帯低気圧、さらにはマッデン・ジュリアン振動のような大規模現象まで、複雑で豊かな階層構造が形成されている。水蒸気は大きな空間スケールで長い時間をかけて蓄積され、流れに乗って輸送されるが、その凝結は短時間に小さい空間スケールで起こる。また、水蒸気や雲は地球の放射収支にも影響を与えるため、長期の気候変化を調節しているかもしれない。本セッションでは、水蒸気と組織化した雲群の相互作用を記述する湿潤大気科学の確立を将来目標に据え、理論・観測・モデルを問わず幅広い時空間スケールを対象とした研究を募集する。海大陸研究強化年(YMC)の現地観測や放射対流平衡実験のモデル間比較(RCEMIP)などの最新の知見を共有し、研究者間のコミュニケーションを円滑にすることで、長年の困難に対する突破口を開きたい。

15:30 ~ 15:45

[AAS03-07] A Mechanism for the Maintenance of Sharp Tropical Margins

★Invited Papers

*増永 浩彦[1]、Brian Mapes[2] (1.名古屋大学、2.マイアミ大学)

15:45 ~ 16:00

[AAS03-08] Observational Evidence of Mixed Rossby-Gravity Waves as a Driving Force for the MJO Convective Initiation and Propagation

*高須賀 大輔[1,2]、佐藤 正樹[1]、横井 覚[2] (1.東京大学大気海洋研究所、2.海洋研究開発機構)

16:00 ~ 16:15

[AAS03-09] A characteristic of the MJO as a part of enhanced large-scale zonal circulation

*末松 環[1]、三浦 裕亮[2] (1.Atmosphere and Ocean Reaserch Institute, The University of Tokyo、2.School of Science, The University of Tokyo)

16:15 ~ 16:30

[AAS03-10] **The role of the moisture on the occurrences and distribution of the Amazonian mesoscale convective systems**

*Amanda Rehbein[1,2]、Masaki Satoh[2]、Tercio Ambrizzi[1] (1.Univ. of Sao Paulo、2.Univ. of Tokyo)

16:30 ~ 16:45

[AAS03-11] Interdecadal Change of the Impact of Eurasian Snow on Spring Precipitation Over Southern China

*Dingrui Cao[1] (1.Zhejiang University)

16:45 ~ 17:00

[AAS03-12] 日本の暖候期の豪雨に影響するAtmospheric Riverとその循環場の解析

末藤 菜保[1]、*谷田貝 亜紀代[1]、高藪 縁[2] (1.弘前大学大学院理工学研究科、2.東京大学大気海洋研究所)

A Mechanism for the Maintenance of Sharp Tropical Margins

*増永 浩彦[1]、Brian Mapes[2]
*Hirohiko Masunaga[1], Brian Earle Mapes[2]

1. 名古屋大学、2. マイアミ大学
1. Nagoya University, 2. University of Miami

The deep tropics characterized by moist air and deep convection are separated from the dry, quiescent subtropics often by a sharp horizontal gradient of moisture only loosely tied to SST or other geographical constraints. Mapes et al. (GRL, 2018) showed that this margin of the moist tropics is a true PDF minimum (a regime separatrix), along a column water vapor (CWV) contour around 48 mm in instantaneous data. Quasi-meridional statistical composites of observations across the poleward-most excursion of this sinuous contour retain the sharpness of the margin while increasing signal to noise ratio. Observations primarily from a suite of the A-Train satellites show the meridional structure of thermodynamic state and budget terms across the margin of the moist tropics. Composites are computed around the PDF-minimum CWV value of 48 mm as well as a range of other thresholds from 35 mm to 60 mm for comparison. Major findings are summarized as follows. (1) CWV increases equatorward from the subtropics for all CWV thresholds but eventually converges to 48 mm deep into the tropical side. Precipitation abruptly intensifies on the tropical side of the margin but declines equatorward to 85 W/m2 regardless of the CWV thresholds. (2) The diabatic forcing to the atmosphere (radiative heating plus surface heat fluxes) changes its sign across the CWV=48 mm border, being positive on the tropical side and negative on the subtropics. This contrast is owing to the meridional gradient of radiative heating, principally the longwave effect of high clouds. (3) Vertical mode decomposition reveals a transition from bottom-heavy to top-heavy subsidence on the subtropical side of the margin. These observed features are interpreted in terms of a simple theory from the moisture and heat budget perspectives. The model explains the abrupt moistening at the margin as a singularity where the vertical displacement of air costs little energy within a column.

キーワード：熱帯力学、衛星データ解析、概念理論モデル
Keywords: Tropical dynamics, Satellite data analysis, Conceptual theory

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Observational Evidence of Mixed Rossby-Gravity Waves as a Driving Force for the MJO Convective Initiation and Propagation

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The Madden-Julian Oscillation (MJO) is known to be the most dominant intraseasonal variability in the tropics, which features large-scale convective envelopes emergening and propagating eastward slowly (~5 m s^{-1}) over the warm pool region. Since its discovery, there have been dedicated efforts to clarify mechanisms about MJO initiation and propagation in terms of large-scale low-frequency dynamics and thermodynamics and a multi-scale interaction with synoptic disturbances. As for the latter standpoint, although some recent observational and idealized numerical studies suggested that mixed Rossby-gravity waves (MRGs) can play a significant role in MJO mechanics, more detailed evidence is necessary because the realistic relationship between MJO and MRGs has had little recognition.

In this study, we examine the contributions of MRGs to the MJO convective initation and propagation in the Indian Ocean during the YMC-Sumatra 2017 field campaign (YMC: Years of the Maritime Continent). The intensive observation captured mid-tropospheric wind variations associated with MRGs, and those signals propagated westward over the Indian Ocean in the MJO suppressed phase. The transition to the MJO active phase follows tight MRG-convection coupling, which is enhanced when the wavelength becomes shorter due to weak mid-level convergence in the western Indian Ocean. Basin-scale anomalous mid-tropospheric moistening caused by MRG shallow circulations is also recognized. These processes lead to the lower-tropospheric MRG wave packet formation and successive triggering of MJO convection, with the eastward MRG group velocity corresponding to MJO propagation. This study suggests that it is worth reconsidering the MJO with a focus on MRG activities at least in the Indian Ocean.

キーワード：マッデン・ジュリアン振動、赤道波、スケール間相互作用、海大陸強化年
Keywords: Madden-Julian Oscillation, equatorial waves, multi-scale interaction, the Years of the Maritime Continent

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A characteristic of the MJO as a part of enhanced large-scale zonal circulation

A characteristic of the MJO as a part of enhanced large-scale zonal circulation

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*Tamaki Suematsu[1], Hiroaki Miura[2]

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The Madden-Julian Oscillation (MJO) is known as the dominant mode of intraseasonal variability in the tropics, characterized a region of enhanced convective activities that propagate from the Indian Ocean (IO) to the Western Pacific(WP). However, our understanding of its fundamental role in the atmosphere, and explanation for why it exists is still limited. Taking this into consideration, this study examined how the MJO propagation speed and the intensity of their events were modulated by the background environment and sought for an intrinsic relationship of the MJO with the background atmospheric states.

To build on our recent finding of MJO enhancement with background zonal sea surface temperature (SST) gradient, we examined how MJO propagation speed was influenced by the background SST. We constructed a tracking method of MJO convection and calculated the propagation speed of each event. We investigated how the characteristics of the MJO and the background SST states that they occur in varied depending on their propagation speed. The analysis revealed that the slower events were associated with a condition of low-frequency SST (> 60 days) distribution with a positive zonal gradient from the IO to WP. In contrast, high-frequency SST (20 –60 days) distributions associated with the MJO events were much the same between the fast and the slow groups with little zonal SST gradient across IO to WP. Furthermore, the extension of the analysis to rest of the events revealed that the relationship between zonal SST gradient and propagation speed was not a tendency restricted to the fastest and the slowest groups, but is an overall relationship that is displayed by all of the events. Taking note that the presence of zonal SST gradient in the low-frequency range has the potential to enhance large-scale zonal circulation, the component of the zonal wind associated with the background circulation was also analyzed. The analysis showed that there is a tendency for MJO to propagate slower when the background large-scale zonal circulation was stronger, implying that slower MJOs are embedded in enhanced large-scale zonal circulation.

キーワード：Madden-Julian Oscillation 、Air-Sea Interaction、Large-Scale Circulation
Keywords: Madden-Julian Oscillation , Air-Sea Interaction, Large-Scale Circulation

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The role of the moisture on the occurrences and distribution of the Amazonian mesoscale convective systems

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1. Univ. of Sao Paulo, 2. Univ. of Tokyo

The mesoscale convective systems (MCSs) are large and long-lived organized cloud systems, which have impacts on climate and weather. Studies on MCSs over the Amazon basin have been driven in recent years. They showed that MCSs occur spreadly during the Amazon’ s wet season (November to March) when the Intertropical Convergence Zone is toward northern South America. The MCSs occurrence during wet season months has variations very little known. For instance, during January and March, the MCSs occurrence is greater than in February, being March the month with most occurrences. A similar pattern occurs with the monthly precipitation. During the dry season (May to September), the number of MCSs decreases to a minimum in August, the same as precipitation. However, these MCSs are larger than those occurred in the wet season. Why these differences in the MCSs behavior and occurrence happens is an open question and very important for understanding and improving the MCSs simulations over the Amazon basin. Also, we know very few about the MCSs’ mechanism of genesis and maintenance over that region, mainly due to the lack of data on the Amazon capable of representing the convection time scale. Recently (Jan. 17th, 2019), the European Centre for Medium-Range Weather Forecasts (ECMWF) turn available the highest spatial and temporal reanalysis data (ERA5; hourly temporal and 0.5º spatial resolutions) for global range and long-term data (since 1979 to the present). Therefore, our objective is to use this dataset to investigate the moisture’ s role to the MCSs occurrences on the diurnal, seasonal and interannual scales. To achieve it, we will present temporal and spatial statistical analysis in the hourly, monthly, and annual scales, including vertical moisture profiles. The target period is 2000 to 2013 because of this is the same period of the available MCSs climatology by Rehbein et al. (2017). This investigation is complimentary for a major study where the Amazonian MCSs present and future climates are being investigated.

Keywords: Mesoscale convective systems, Moisture, Amazon basin

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Interdecadal Change of the Impact of Eurasian Snow on Spring Precipitation Over Southern China

*Dingrui Cao[1]

1. Zhejiang University

In this study, the relationship between interdecadal and interannual changes of snow cover over Eurasia and precipitation over southern China are investigated. The results show that, the spring precipitation over southern China has experienced a change of positive to negative trend since the end of 1980s. The interannual change of spring precipitation over southern China has a significant positive correlation with the Eurasian snow cover (SCE) anomalies in northwest Lake Baikal. Baroclinic Atmosphere Model (LBM) was utilized in numerical simulation experiment. The results show that The SCE anomalies near northwest Lake Baikal can affect the spring precipitation over southern China by regulating the atmospheric circulation in East Asia and the Northwest Pacific. Further study indicates that the SCE anomalies near Lake Baikal have different contributions to the change of spring precipitation in south China around the end of 1980s. The whole dataset is divided into two periods, 1972-1987 (P1) and 1988-2009 (P2). During P1, the SCE anomalies around Lake Baikal contribute to the formation of regional mono-sign of spring precipitation over southern China. During P2, the SCE anomalies around Lake Baikal are conducive to the formation of north-south dipole modes of spring precipitation. Meanwhile, the SCE anomalies also have experienced an interdecadal change and contributes to precipitation mode over China. During P1, The SCE anomalies near Lake Baikal and its southeast side contribute to the formation of mono-sign of spring precipitation over southern China. During P2, the SCE anomalies near Lake Baikal and its northeast side are favorable for the south China spring precipitation to present the north-south dipole modes of spring precipitation.

Keywords: spring precipitation, snow cover, interdecadal changes

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日本の暖候期の豪雨に影響するAtmospheric Riverとその循環場の解析
Atmospheric Rivers and related atmospheric circulations associated with Japanese disastrous precipitation in warm season

末藤 菜保[1]、*谷田貝 亜紀代[1]、高藪 縁[2]
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Atmospheric Rivers (ARs) refer to the flow of moisture like an elongated river that reach the mid-troposphere, and water vapor evaporated in the tropics is transported rapidly by subtropical jet streams and extends to mid-latitudes. ARs play an important role in the meridional moisture (i.e. energy) transport in the mid-latitudes; besides bringing down heavy rain on the west coast of North America and the western coast of Europe. Recently, it was found that ARs could emerge around Japan, and the AR occurrence in Hiroshima in August 2014 was reported as one of the factors of heavy rain. However, there are few studies about a relation between heavy precipitation and ARs occurred in Japan. However, previous studies counted the AR occurrence among the heavy precipitation events in entire Japan (longitude 123˚-146˚ and latitude 24˚-46˚). The result during the warm season (April-October) was approximately 70%, which was a high value. It was considered that it included the location of heavy rain did not coincide with the occurrence spot of ARs, because the AR occurrence rate was calculated over a wide range. Therefore, this study analyzed it by dividing Japan into sub-regions, calculating the rate of ARs for heavy rain days that cause disasters in each region, and clarifying the atmospheric circulation field of the day when ARs occurred on heavy rain days.

The target period was 35 years from 1980 to 2014, and a year was divided into two seasons, the warm season (April-October) and the cold season (November-March). This study extracted heavy rain days and detected ARs in the warm season after defined conditions for extracting heavy rain days that cause disasters and conditions for detecting ARs that pass through around Japan. Then, Japan was divided into 13 regions, and it was sorted out the extraction of heavy rain days and AR detection in each region. At this time, AR detection in each area was the detection area up to 100 km in four directions of the area targeted, considering the remote influence of ARs. Only the AR occurrence rate of the warm season was targeted to be analyzed.

The AR occurrence rate in each area was lower than the value calculated in entire Japan. The area with the highest AR occurrence rate was 64.6 % in North Kyushu Region, and the areas with many heavy rain days but a low AR occurrence rate were in Shikoku-Kii Peninsula Region (44.1 %) and South Kyushu Region (45.8%).
This study compared Shikoku-Kii Peninsula Region and North Kyushu Region, and investigated the circulation field. First, the monthly value of AR occurrence rate was the highest in September (61.9 %) in Shikoku-Kii Peninsula Region and in June (83.3 %) in North Kyushu Region. Although the month that took the highest value was different, what common for these two regions were that it was relatively low in July and August and high in rainy seasons.

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Regarding the circulation field, the moisture flux in both regions converged on the target areas; however, it diverged over water in the east in Shikoku-Kii Peninsula Region and over water in the south in North Kyushu Region. Both moisture flow comes along the western periphery of the Pacific high where moisture diverges. It is found that there is a trough near the Korean Peninsula in Shikoku-Kii Peninsula Region.

Next, looking into the vertical cross section of the relative humidity and the wind field, the area with high specific humidity anomaly in both regions extended to the mid-troposphere. Also, looking into the specific humidity anomaly and the wind anomaly at the 2 pressure altitudes (500 hPa and 700 hPa) of the mid-troposphere, the areas with high in the specific humidity anomaly existed roughly at the same position as the moisture flux convergence, and the wind anomaly was similar to the flow of the moisture flux in the both regions. The flow of this wind and the moisture flux flown from the southwest to the northeast passing through the sea near Taiwan in Shikoku-Kii Peninsula Region, and from the west-southwest to the east-northeast passing through the mainland of China in North Kyushu Region.

Lastly, from the vertical cross section of the Omega (vertical p-velocity) anomaly, it was seen a strong ascending flow area that was narrow in the east and west and long in the north and south in Shikoku-Kii Peninsula Region, and that was wide in the east and west and narrow in the north and south.

キーワード：Atmospheric River、APHRO_JP、水蒸気輸送
Keywords: AR, APHRO_JP, moisture transport

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[E] 口頭発表 | セッション記号 A (大気水圏科学)：A-HW 水文・陸水・地下水学・水環境

2019年5月28日(火) 13:45 ~ 15:15 | 103 1F

[A-HW23] 水循環・水環境

コンビーナ:町田 功(産業技術総合研究所地質調査総合センター)、山崎 大(東京大学生産技術研究所)、林 武司(秋田大学教育文化学部)、福士 圭介(金沢大学環日本海域環境研究センター)、座長:町田 功(産業技術総合研究所地質調査総合センター)

We focus on various issues of water cycle and environment and aim to answer questions of hydrological and earth system sciences including 1) surface, subsurface and evapotranspiration processes of water cycle; 2) natural and anthropogenic hydrothermal systems, 3) environments issues and studies on a watershed or global scale, 4) water-related issues with ecological, environmental, and geochemical aspects, and 5) other issues in hydrological sciences. This session welcomes presentations regarding various kinds of approaches and techniques such as field survey, remote sensing, isotope tracers, numerical simulation, and theoretical analysis.

13:45 ~ 14:00

[AHW23-01] 降雨流出過程に関する山地斜面での観測における斜面内圧（間隙空気圧）の測定方法の検討

★招待講演

*岩上 翔[1]、野口 正二[1]、清水 貴範[1]、久保田 多余子[1]、飯田 真一[1]、荒木 誠[1] (1.国立研究開発法人 森林研究・整備機構 森林総合研究所)

14:00 ~ 14:15

[AHW23-02] **A method to quantify the influence of total water storage change on climate elasticity of streamflow**

*Yin Tang[1] (1.Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Science)

14:15 ~ 14:30

[AHW23-03] **Trade-off analysis of discharge-desiltation-turbidity and sediment simulation of a combined reservoir–river system under multi-phase and multi-layer conjunctive releasing operation**

*Chien-Lin Huang[1]、Nien-Sheng Hsu[1]、Gene Jiing-Yun You[1] (1.National Taiwan University, Taiwan)

14:30 ~ 14:45

[AHW23-04] Gradient change of soil moisture effect on next-day precipitation identified via a Random Forest-Granger causality model

*Lu Li[1]、Wei ShangGuan[1]、Shu Peng Zhang[1]、Jin Jing Pan[1]、Nan Wei[1]、Yong Jiu Dai[1] (1.Guangdong Province Key Laboratory for Climate Change and Natural Disaster Studies, School of Atmospheric Sciences, Sun Yat-sen University)

14:45 ~ 15:00

[AHW23-05] **Using data-driven methods to explore the predictability of surface soil moisture with FLUXNET site data**

*jinjing Pan[1] (1.Guangdong Province Key Laboratory for Climate Change and Natural Disaster Studies, School of Atmospheric Sciences, Sun Yat-sen University.)

15:00 ~ 15:15

[AHW23-23] Global Analyis of the Hydrological Sensitivity to Climate Variability

*Marisol Dominguez[1]、Hugo Alberto Gutierrez-Jurado[1] (1.University of Texas at El Paso)

降雨流出過程に関する山地斜面での観測における斜面内圧（間隙空気圧）の測定方法の検討

Method for measuring the pore air pressure in the mountainous slope for rainfall-runoff processes research

*岩上 翔[1]、野口 正二[1]、清水 貴範[1]、久保田 多余子[1]、飯田 真一[1]、荒木 誠[1]
*Sho Iwagami[1], Shoji Noguchi[1], Takanori Shimizu[1], Tayoko Kubota[1], Shin'ichi Iida[1], Makoto Araki[1]

1. 国立研究開発法人 森林研究・整備機構 森林総合研究所
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Many researches have been conducted to clarify the mechanism of rainfall-runoff process in a forested catchment in humid warm-temperate regions. Some results obtained from hydrograph separation using isotopic tracer showed that stream discharge is mainly composed of pre-event old water rather than new water (rainwater). Since the 1980’s, the important issue in rainfall-runoff process studies has been solving how pre-event old water stored in the slope discharge in rapid response during rainstorm event. After 1990’s the role of bedrock groundwater contribution to rainfall-runoff process became to be illustrated. Iwagami et al. (2010) described the contribution of bedrock groundwater during rainfall events in a headwater catchment, however there were some large scale events which were not enough to be explain by the bedrock groundwater contribution. Further possible ideas to explain the rapid outflow of pre-event old water might be effect of pressure wave (Torres et al., 1998) and effect of entrapped air (Marui et al., 1993; Delfs et al., 2013).
Role of pore air effects (e.g., entrapped air and, pressure wave) on rainfall-runoff process are pointed out by previous studies however field evidence of pore air behavior or pore air pressure in the slope scale are still lacking. Also method for pore air pressure observation is not established and not discussed fully. In present study, in order to investigate the behavior of pore air under mountainous slopes, measurements of pore air pressure were conducted at two small headwater catchment in Hitachi Ohta Experimental Watershed and Tsukuba Experimental Watershed, Ibaraki Prefecture, Japan. We measured pore air pressure by detecting the inner pressure of borehole and piezometer. Focusing on the pressure difference between pore air and atmosphere (hereafter we call this as “pressure gap”), it is expected that during a dry period (not during rainfall and ground surface is unsaturated), shallow pore air pressure in the slope is almost at equilibrium state with the atmospheric pressure and the pressure gap might be zero. On the other hand, when the pressure gap was raised remarkably during the rainfall event, pore air is supposed to be entrapped and compressed by infiltrating rainwater (wetting front) and groundwater table (or underlying low permeability layer). During the observation from July 2018 to January 2019, pressure gap rising event have observed in both sites. Also negative pressure gap was observed after the pressure gap rising event. Further observation studies are needed for understanding the effect of entrapped air to rainfall-runoff process which could potentially contribute to the prediction of flash flood or corresponding slope instability.

キーワード：降雨流出過程、間隙空気、封入空気、差圧
Keywords: Rainfall-runoff processes, pore air, entrapped air, pressure gap

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A method to quantify the influence of total water storage change on climate elasticity of streamflow

*Yin Tang[1]

1. Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Science

Numerous studies documented the climate elasticity of streamflow (i.e., precipitation elasticity and potential evapotranspiration elasticity) without considering the total water storage change (dS) based on long-term Budyko framework. However, the values of dS have been found to be a significant component of water balance at short time scales (e.g., annual) and some specific watersheds (e.g., arid regions). The purpose of this paper is to develop a new approach based on the extended Budyko framework to quantify the climate elasticity of streamflow with the influence of dS . The available water under the extended Budyko framework is the effective precipitation (Pe), i.e. the difference between precipitation and dS. The climate elasticity of streamflow with the influence of dS are derived from one recent proposed Budyko-type equation based on proportionality relationship under the extended Budyko framework. The performance of this new approach at annual scale as an example is evaluated for 273 MOPEX watersheds in the United States. Results show that climate elasticity of streamflow with the influence of dS are generally larger than that without considering the influence of dS for study watersheds. Results also indicates that the modeled proportional changes in annual streamflow are significantly biased by using the methods without considering the influence of dS, especially for peak values. This study highlights the needs to consider the influence of dS on climate elasticity of streamflow and provides a framework to quantify the climate elasticity of streamflow with the influence of dS.

Keywords: climate elasticity, total water storage change, MOPEX

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Trade-off analysis of discharge-desiltation-turbidity and sediment simulation of a combined reservoir–river system under multi-phase and multi-layer conjunctive releasing operation

*Chien-Lin Huang[1], Nien-Sheng Hsu[1], Gene Jiing-Yun You[1]

1. National Taiwan University, Taiwan

Multi-objective reservoir operation considering the trade-off of discharge-desiltation-turbidity during typhoons and sediment concentration simulation modeling are the vital components for sustainable reservoir management. The purpose of this study is to analyze the multi-layer release trade-offs between reservoir desiltation and intake turbidity of downstream purification plants and thus propose a superior conjunctive operation strategy. To this end, this study proposed a methodology to develop (1) a series of multi-phase and multi-layer sediment-flood conjunctive release modes and (2) a specialized sediment concentration numerical model for a combined reservoir–river system. The conjunctive release modes involve (1) an optimization model where the decision variables are multi-phase reduction/scaling ratios and the timings to generate a superior total release hydrograph for flood control (Phase I: phase prior to flood arrival, Phase II/III: phase prior to/subsequent to peak flow) and (2) a combination method with physical limitations regarding separation of the singular hydrograph into multi-layer release hydrographs for sediment control. This study employed the featured signals obtained from statistical quartiles/sediment duration curve in mesh segmentation, and an iterative optimization model with a sediment unit response matrix and corresponding geophysical-based acceleration factors, for efficient parameter calibration. This study applied the developed methodology to the Shihmen Reservoir watershed in Taiwan. The trade-off analytical results using Typhoons Sinlaku and Jangmi as case examples revealed that owing to gravity current and re-suspension effects, Phase I+II can de-silt safely without violating the intake's turbidity limitation before reservoir discharge reaches 2238 m^3/s; however, Phase III can only de-silt after the release at spillway reaches 827 m^3/s, and before reservoir discharge reaches 1924 m^3/s, with corresponding maximum desiltation ratio being 0.221 and 0.323, respectively.

Keywords: Multi-phase sediment-flood management, Sediment concentration modeling, Sediment duration curve, Hydrological statistic, Multi-objective trade-off analysis, Multi-layer conjunctive releasing

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Gradient change of soil moisture effect on next-day precipitation identified via a Random Forest-Granger causality model

*Lu Li[1], Wei ShangGuan[1], Shu Peng Zhang[1], Jin Jing Pan[1], Nan Wei[1], Yong Jiu Dai[1]

1. Guangdong Province Key Laboratory for Climate Change and Natural Disaster Studies, School of Atmospheric Sciences, Sun Yat-sen University

Surface soil moisture influences precipitation through its impact on water and energy cycles. Understanding of soil moisture-precipitation (SM-P) coupling on synoptic scale is important for improving short-term weather forecasting. However, the sign and pattern of SM-P feedback are still controversial, mainly caused by the difficulty to establish causal relationship. In this paper, we use empirical models to separate local land-atmosphere coupling effect from low frequency variation and persistence effects, and use Granger causality to identify the casual relationship between surface soil moisture and subsequent precipitation over China. Five experiments are designed to investigate the impact of the discrepancy of datasets and empirical models on SM-P feedback. Differences of SM-P feedback using different SM-P datasets are minor compared to those of empirical models. We improved the SM-P feedback model by using random forest to eliminate low frequency variation and persistence effects instead of generalized linear model. Moreover, we present a novel SM-P feedback framework by considering spatial impact of data, raising a new feature selection method and a new SM-P coupling index. The corresponding pattern of SM-P feedback shows that (1) positive SM-P feedback appears almost all over China. (2) The effect of surface soil moisture on next-day precipitation probability decreases from arid to humid regions over China. (3) The effect of low frequency variation and persistence on precipitation is larger than the effect of soil moisture, but we must emphasize that soil moisture also plays an important role in arid and semi-arid regions. Our finding statically supports the hypothesis that strong SM-P feedback locates in transition zones and SM-P coupling is higher during wet periods for dry regions.

Keywords: Soil moisture-precipitation feedback, random forest, granger causality

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Using data-driven methods to explore the predictability of surface soil moisture with FLUXNET site data

*jinjing Pan[1]

1. Guangdong Province Key Laboratory for Climate Change and Natural Disaster Studies, School of Atmospheric Sciences, Sun Yat-sen University.

Soil moisture (SM) is a key variable of land surface-atmosphere interactions. Data-driven methods have been widely used to predict SM, but the predictability of SM has not been well evaluated. This study investigated what variables and methods can be used to better predict SM for leading times of 7 days or longer with a global coverage of FLUXNET site data for the first time. Three machine-learning models, i.e., Bayesian linear regression, random forest and gradient boosting regression tree, are used for the prediction. Variables including atmospheric forcing, surface soil temperature, time variables (year, day of year (DOY) and hour), the Fourier transformation of time variables and lagged SM (7-14 day lagged) were sequentially added into models. A framework with five experiments is designed for factorial exploration of SM predictability. A stepwise method was used to build the best models for each site. The performance of regression models became better when adding more explaining variables in most cases. The results showed that from 47 % to 95% of variation of the best models can be explained. The important explaining variables are lagged surface SM, followed by DOY, year, soil temperature and atmospheric forcing. The predictability of SM depends highly on SM memory characteristics and the persistence of seasonality. The effect of SM memory characteristics on SM prediction as an initial condition question has been widely discussed in this paper. Our results also provide an insight that mechanisms of seasonality effects on SM should be also paid more attention to.

Keywords: A framework with five contrasting experiments is designed to investigate the factors affecting the predictability of soil moisture, The best models can explain between 47% and 95% of variation with different explaining variable combinations at different sites, The most important explaining variable is lagged surface soil moisture, followed by time variables, soil temperature and atmospheric forcing, The predictability of soil moisture depends highly on soil moisture memory characteristics and the persistence of seasonality

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Global Analyis of the Hydrological Sensitivity to Climate Variability

*Marisol Dominguez[1], Hugo Alberto Gutierrez-Jurado[1]

1. University of Texas at El Paso

Projected climate changes in the 21st century is expected to have a profound impact in the functioning of Earth's water cycle. Therefore, identifying the components contributing to the sensitivity and resilience of water resources constitutes a research priority of global relevance. Here we present a practical approach to globally assess the hydrologic sensitivity of regions to climate variability. The aim is to identify the regions most vulnerable to changes in their hydrologic functioning as they experience external climatic shifts. For this purpose we present a new metric, the Hydrologic Sensitivity Index (HSI). HSI is calculated for any given location within 50 degrees North and South of the equator using annual values of Potential and Actual Evapotranspiration (PET and AET) obtained from the Moderate Resolution Imaging Spectrometer (MODIS), and Precipitation (P) from the Tropical Rainfall Measuring Mission (TRMM) for all continents for the last 16 years (2001-2016). The HSI defines the hydrologic behavior under a given climatic condition by calculating the change in the Evaporative Index (DAET/P) against the change in the Dryness Index (DPET/P) between consecutive years. For HSI values >=1, regions are classified as Sensitive and for values of <1, Resilient. We calculated the mean, frequency and intensity of the HSI and analyzed the distribution of sensitive areas (HSI >=1) against changes in latitude, elevation, slope and aspect conditions using a 90m elevation dataset from the Shuttle Radar Topography Mission (STRM), as well as according to land cover properties defined by different biome types. Our analysis show the most hydrologically sensitive regions to climate variability occur in Temperate Grasslands along the Great Plains in North American and the Great Dividing Range in Australia, in parts of eastern Asia, in European Temperate Forests, parts of Tropical and Subtropical pampas east of the Amazonian forest and Tropical and Subtropical African Savannas. We also observe a combined latitudinal-elevation control on the HSI that is particularly noticeable along equatorial regions of the globe.

Keywords: Budyko Curve, Climate Variability , Hydrologic Sensitivity, Evapotranspiration, Global Analysis, Elevation and Aspect

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[E] 口頭発表 | セッション記号 A (大気水圏科学)：A-HW 水文・陸水・地下水学・水環境

2019年5月28日(火) 15:30 ~ 17:00 | 103 1F

[A-HW23] 水循環・水環境

コンビーナ:町田 功(産業技術総合研究所地質調査総合センター)、山崎 大(東京大学生産技術研究所)、林 武司(秋田大学教育文化学部)、福士 圭介(金沢大学環日本海域環境研究センター)、座長:渡辺 恵

We focus on various issues of water cycle and environment and aim to answer questions of hydrological and earth system sciences including 1) surface, subsurface and evapotranspiration processes of water cycle; 2) natural and anthropogenic hydrothermal systems, 3) environments issues and studies on a watershed or global scale, 4) water-related issues with ecological, environmental, and geochemical aspects, and 5) other issues in hydrological sciences. This session welcomes presentations regarding various kinds of approaches and techniques such as field survey, remote sensing, isotope tracers, numerical simulation, and theoretical analysis.

15:30 ~ 15:45

[AHW23-06] **A review on the global soil property maps for Earth system model**

Yongjiu Dai[1]、*Wei Shangguan[1]、Dagang Wang[2]、Nan Wei[1]、Qinchuan Xin[2]、Hua Yuan[1]、Shupeng Zhang[1]、Shaofeng Liu[1]、Fapeng Yan[3]、Xingji Lu[1] (1. Guangdong Province Key Laboratory for Climate Change and Natural Disaster Studies, School of Atmospheric Sciences, Sun Yat-sen University、2.School of Geography and Planning, Sun Yat-sen University、3.College of Global Change and Earth System Science, Beijing Normal University)

15:45 ~ 16:00

[AHW23-07] **Estimating near surface soil moisture at a high spatial resolution using an in-situ data based model**

*Indishe Prabath Senanayake[1]、In-Young Yeo[1,2]、Natthachet Tangdamrongsub[3,4]、Garry R Willgoose[1]、Gregory R Hancock[5]、Tony Wells[1]、Bin Fang[6]、Venkataraman Lakshmi[6]、Jeffrey P Walker[7] (1.School of Engineering, Faculty of Engineering and Built Environment, The University of Newcastle, Callaghan, NSW 2308, Australia.、2.Department of Geographical Sciences, University of Maryland, College Park, MD 20742, USA.、3.Earth System Science Interdisciplinary Center, University of Maryland, College Park, Maryland, USA.、4.Hydrological Sciences Laboratory, NASA Goddard Space Flight Center, Greenbelt, Maryland, USA.、5.School of Environmental and Life Sciences, Faculty of Science, The University of Newcastle, Callaghan, NSW 2308, Australia.、6.School of Earth Ocean and Environment, University of South Carolina, Columbia, SC 29223, United States.、7.Department of Civil Engineering, Monash University, Clayton, Victoria 3800, Australia.)

16:00 ~ 16:15

[AHW23-08] Representation of dams in global flood inundation simulations by coupling the global hydrological model H08 and the global hydrodynamic model CaMa-Flood

*Julien Eric Boulange[1]、Naota Hanasaki[1] (1.National Institute for Environmental Studies)

16:15 ~ 16:30

[AHW23-09] An investigation into a potential long subglacial river beneath the Greenland ice sheet using SICOPOLIS simulations.

*Christopher Chambers[1]、Ralf Greve[1]、Bas Altena[2]、Pierre-Marie Lefeuvre[2] (1.Hokkaido University、2.University of Oslo)

16:30 ~ 16:45

[AHW23-10] **Changes in Annual Rainfall patterns in the Democratic Republic of Congo: Congo river basin**

*Chetan Sharma[1]、Chandra Shekhar Prasad Ojha[1] (1.Indian Institute of Technology Roorkee)

16:45 ~ 17:00

[AHW23-11] Seasonality in the extreme precipitation events linked to temperature over Japan

*Sridhara Nayak[1]、Tetsuya Takemi[1] (1.Disaster Prevention Research Institute, Kyoto University)

A review on the global soil property maps for Earth system model

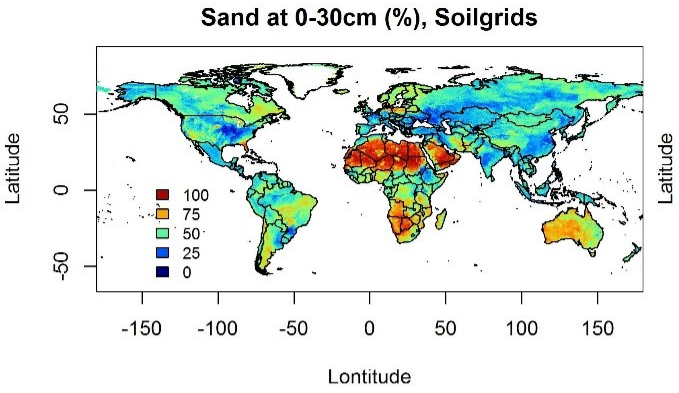
Yongjiu Dai[1], *Wei Shangguan[1], Dagang Wang[2], Nan Wei[1], Qinchuan Xin[2], Hua Yuan[1], Shupeng Zhang[1], Shaofeng Liu[1], Fapeng Yan[3], Xingji Lu[1]

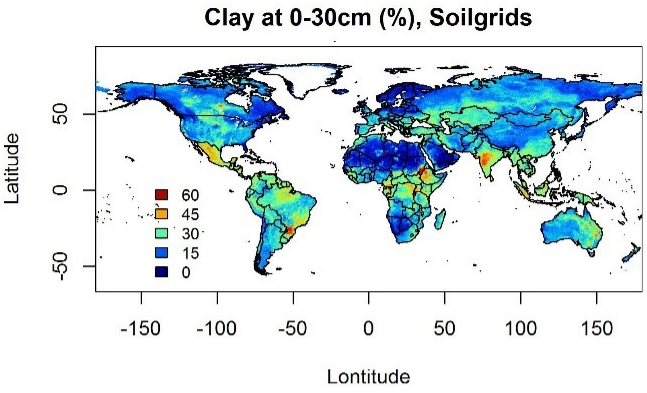
1. Guangdong Province Key Laboratory for Climate Change and Natural Disaster Studies, School of Atmospheric Sciences, Sun Yat-sen University, 2. School of Geography and Planning, Sun Yat-sen University, 3. College of Global Change and Earth System Science, Beijing Normal University

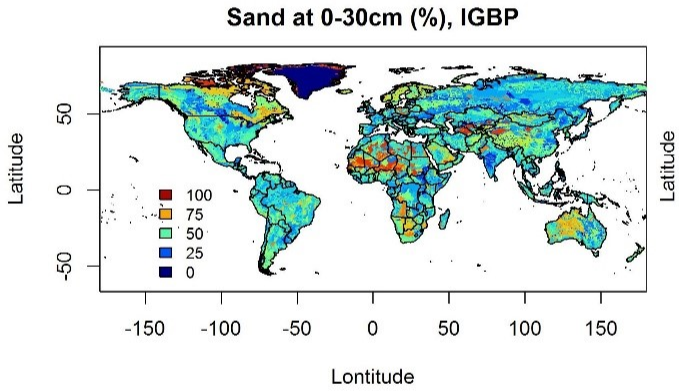
Soil is an important regulator of Earth system processes, but remains one of the least well-described data layers in Earth System Models (ESMs). We reviewed global soil property maps from the perspective of ESMs, including soil physical and, chemical and biological properties. These soil datasets provide model inputs, initial variables and benchmark datasets. For modeling use, the dataset should be geographically continuous, scalable and with uncertainty estimates. The popular soil datasets used in ESMs are often based on limited soil profiles and coarse resolution soil type maps. Updated and comprehensive soil information needs to be incorporated in ESMs. New generation soil datasets derived by digital soil mapping with abundant, harmonized and quality controlled soil observations and environmental covariates are preferred to those by the taxotransfer rule-based method for ESMs. Because there is no universal pedotransfer function, an ensemble of them may be more suitable to provide derived soil properties to ESMs. Aggregation and upscaling of soil data are needed for model use but can be avoid by taking a subgrid method in ESMs at the cost of increases in model complexity. Uncertainty of soil data needs to be incorporated in ESMs.

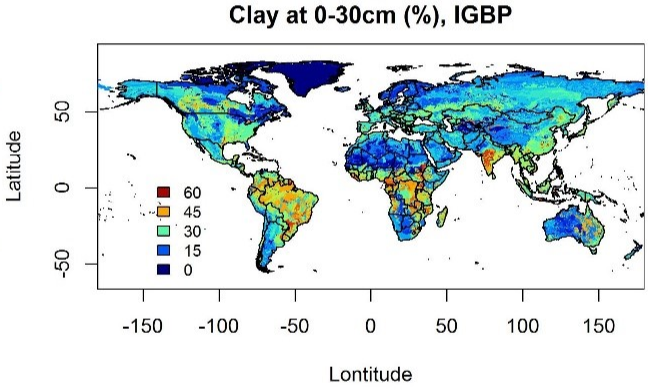
Keywords: Earth system model, soil hydrology, soil data, pedotransfer function

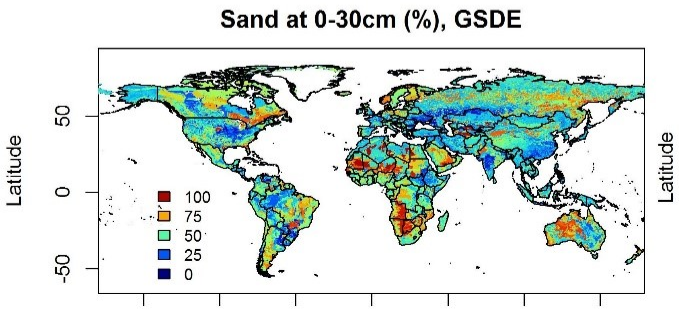
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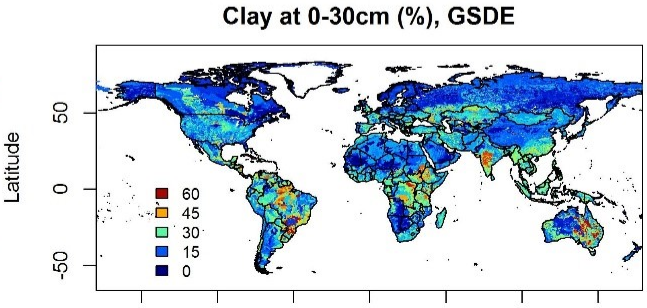












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Estimating near surface soil moisture at a high spatial resolution using an in-situ data based model

*Indishe Prabath Senanayake[1], In-Young Yeo[1,2], Natthachet Tangdamrongsub[3,4], Garry R Willgoose[1], Gregory R Hancock[5], Tony Wells[1], Bin Fang[6], Venkataraman Lakshmi[6], Jeffrey P Walker[7]

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Soil moisture is a key variable in the hydrologic cycle. Therefore, soil moisture information is important for hydrologic and climatic modelling, and for agricultural applications. However, the available point-scale in-situ observations and coarse resolution (10s of km) satellite soil moisture retrievals are unable to capture the spatial variability of soil moisture at high spatial resolutions as required by many of the local and regional scale applications. The lack of high resolution soil moisture data has resulted uncertainties in the model outcomes in these applications. Downscaling coarse spatial resolution L-band microwave satellite soil moisture products using high spatial resolution optical/thermal satellite data appears to be a feasible option to estimate near surface (~top 5 cm) soil moisture at a high spatial resolution. In this study a model was developed to estimate soil moisture at 1 km spatial resolution by downscaling coarse resolution satellite soil moisture products. This downscaling model was built by using in-situ observations from a long term monitoring network (2004-2015) over two sub-catchments, Krui and Merriwa River, located in the Upper Hunter Region of south-eastern Australia. The model was based on the soil thermal inertia relationship between the diurnal temperature difference (ΔT) and daily mean soil moisture (μSM). A regression tree (RT) was built between ΔT and μSM and classified based on the season, vegetation density and soil clay content. Moderate Resolution Imaging Spectroradiometer (MODIS) land surface temperature (LST) and Normalized Difference Vegetation Index (NDVI) values at 1 km spatial resolution were input to the model to estimate soil moisture at 1 km resolution. Subsequently, SMAP-Enhanced 9 km (L3SMP-E) and SMOS 25 km grid (SMOS CATDS L3 SM 3-DAY) soil moisture products over the study area were downscaled and then compared against in-situ observations. Further, the downscaling algorithm was applied to aggregated soil moisture observations from National Airborne Field Experiment 2005 (NAFE’05) over a 40 x 40 km land area over Krui and Merriwa River catchments. The downscaled products were validated using 1 km airborne data. The SMAP L3SMP-E and SMOS CATDS L3 SM 3-DAY products show unbiased root mean square errors (ubRMSEs) of 0.068 and 0.051 cm^3/cm^3 (R^2 values of 0.40 and 0.61), respectively, against in-situ observations. The downscaled airborne soil moisture data shows an RMSE of 0.07 cm^3/cm^3 (with R value of 0.4). The model performed well in dry conditions compared to wet conditions. This method shows a good potential in developing a long time series of high spatial resolution soil moisture information over arid and semi-arid regions using SMOS and SMAP soil moisture products.

Keywords: Downscaling, remote sensing, SMAP, SMOS, soil moisture, thermal inertia

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Representation of dams in global flood inundation simulations by coupling the global hydrological model H08 and the global hydrodynamic model CaMa-Flood

*Julien Eric Boulange[1], Naota Hanasaki[1]

1. National Institute for Environmental Studies

Dams and reservoirs regulate the flow of rivers, storing and releasing water to maximize its availability for human and environmental needs[1]. While regulating water flow is beneficial regarding human water security, it was reported to have rather dire consequences for the environment such as aquatic biota[2,3]. Nevertheless, currently about half of the major global river systems are affected by dams[4].
Global hydrodynamic models have greatly improved in terms of accuracy and computational efficiency in reproducing flood inundation extent[5]. However, to this day, still few such models successfully simulated flood inundation considering the influence of dams.
In this research, the global hydrological model H08[6,7] is coupled to the global hydrodynamic model CaMa-Flood[8] for representing dams in global flood inundation simulation. The input meteorological dataset used in this study were provided by the ISIMIP2b project[9] and consisted of 4 GCMs and 4 scenarios.

The coupled model simulates river discharge and inundation globally at a daily interval, at a spatial resolution of 0.5˚ ×0.5˚. Discharge predicted with the original CaMa-Flood model were compared to those obtained with the coupled model. The seasonal discharge in rivers heavily affected by reservoir operation were very different between the two simulations. Generally, annual minimum (maximum) 7-day discharge was significantly higher (lower) for the simulation explicitly representing dams. In addition, timings of the discharge peaks were also different between the 2 simulations. We deeply investigated the results in several selected river basins.

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Keywords: Global hydrology, Flood, H08 model, CaMa-Flood model

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An investigation into a potential long subglacial river beneath the Greenland ice sheet using SICOPOLIS simulations.

*Christopher Chambers[1], Ralf Greve[1], Bas Altena[2], Pierre-Marie Lefeuvre[2]

1. Hokkaido University, 2. University of Oslo

The Greenland ice sheet appears to be hiding large geographical features at its base that have the potential to affect ice sheet simulations to an unknown degree. One feature is a broken valley extending from Petermann Fjord far into the center of Greenland revealed by the widely used BedMachine basal topographic dataset. The valley appears to be blocked by topographic rises at many points along its route, however it will be demonstrated that these blockages are entirely artificial consequences of data interpolation and that all available data indicate that the valley is not blocked. To test whether opening up this valley could affect ice sheet sliding, SImulation COde for POLythermal Ice Sheets (SICOPOLIS) simulations are used. The simulations show that opening up this valley creates an uninterrupted potential subglacial water pathway from central Greenland to Petermann Fjord (Figure 1) suggesting that water could flow along its length. The reason this is possible is because the valley tracks down a gentle ice thickness gradient as it roughly follows the ice divide. The redistribution of water towards Petermann Glacier focuses increased sliding there. There is also a small reduction of sliding in central west Greenland. Other effects of this valley on the ice-sheet hydrology and dynamics will be presented. If confirmed with further radar bed observations, this would be a great world river the runs under ice for its entire length, a distance that could be up to 1600 km.

Keywords: ice, glacier, river, Greenland, climate

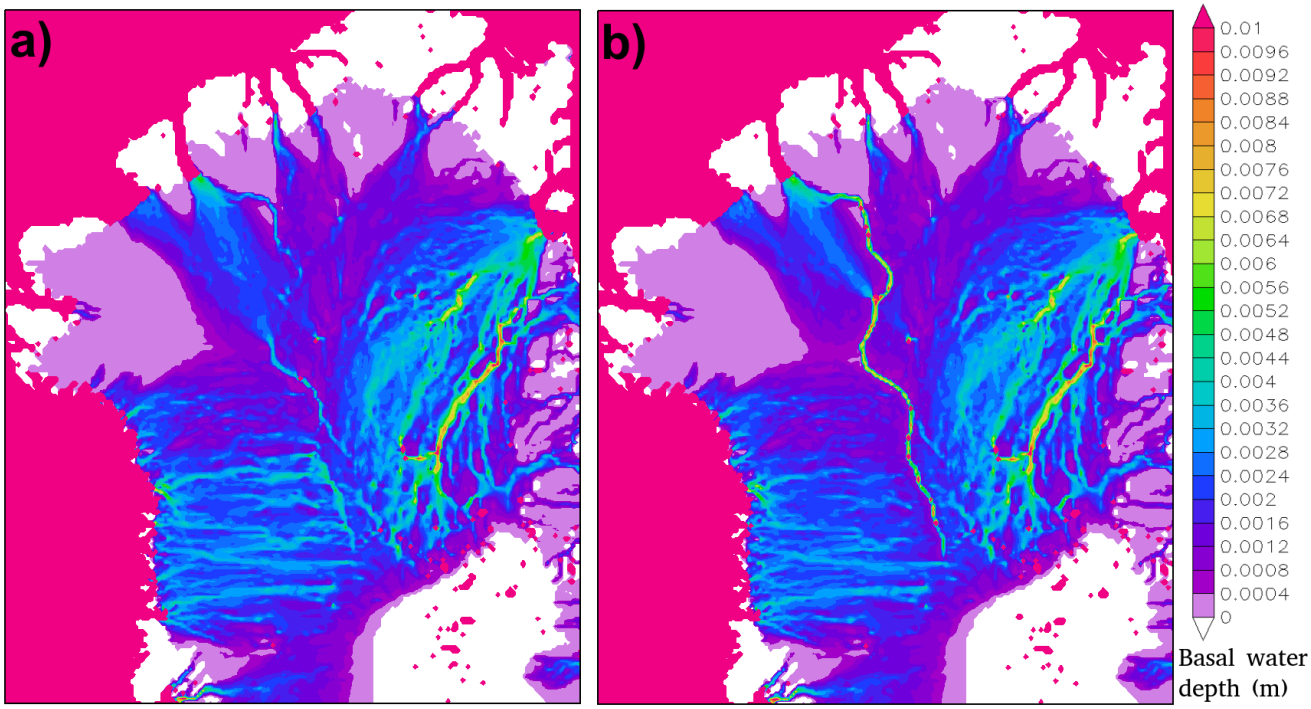


Figure 1: Basal water depth (m) for a) standard bed and b) valley inserted.

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Changes in Annual Rainfall patterns in the Democratic Republic of Congo: Congo river basin

*Chetan Sharma[1], Chandra Shekhar Prasad Ojha[1]

1. Indian Institute of Technology Roorkee

This study focuses on the change detection in annual rainfall in the Democratic Republic of Congo (DRC) in the Congo river basin. High resolution gridded rainfall provided by Climate Research Unit (CRU) is used in this study. Trends in the annual rainfall patterns are calculated and the significance of the trends are found out using non-parametric Mann-Kendal test at 10% significance level. It is found that high negative trends are prevailing in Northern and Southern parts and high positive trends are in the Eastern and Western parts of the Congo river basin. Almost all of these locations show a significant trend. Central wetlands don’ t show a significant change in annual rainfall pattern. Change detection studies are carried out to detect year of change when annual rainfall starts showing deviation from its natural state. Mann-Whitney-Pettit method is used to detect year of change at 5% significance level in this study. Change is detected for almost all of the locations where the trend of annual rainfall is significant. Much earlier change is detected in the Eastern regions of the basin, i.e., the change year 1941-1960, while most of the Northern, Southern and Westerns shows change detection year from 1981-1995.
It is evident from this study that rainfall patterns in the Congo river basin are changing and the changes are non-uniform. There is no change detected in the central regions, while Northern and Southern areas show a significant decrease in rainfall and Eastern and Western regions are showing an increase in total annual rainfall. Change detection year also have non-uniform spatial patterns and Eastern regions are found to be affected much earlier by climate change.

Keywords: Change Detection, Congo river basin, Rainfall

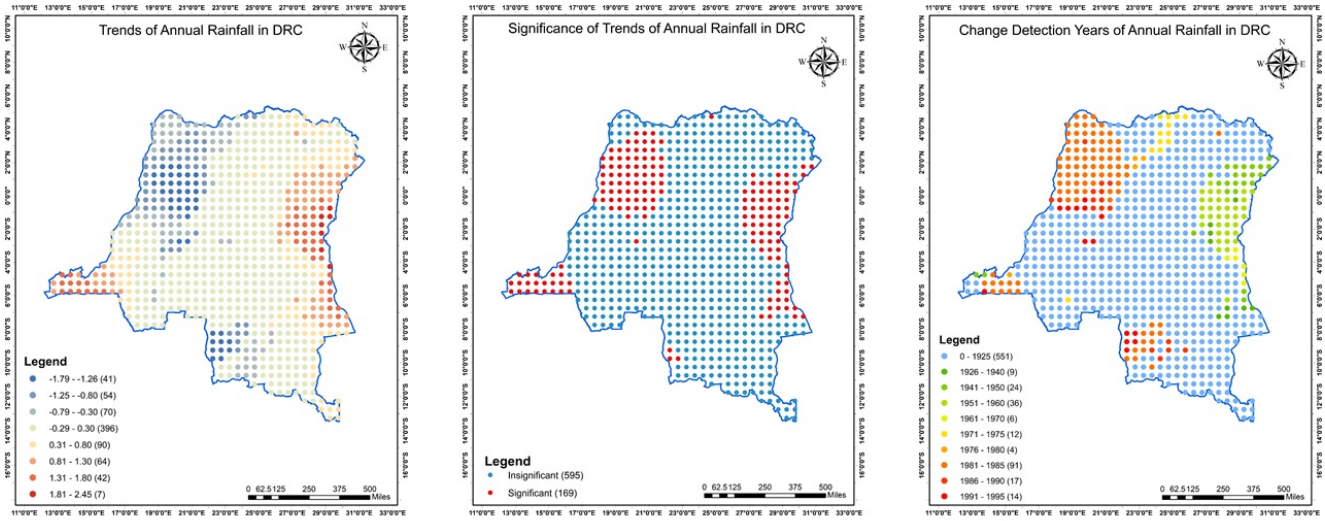


Fig-1. Annual Rainfall Patterns and Changes in Democratic Republic of Congo (DRC): Congo River basin (a) Trends (b) Significance of rends (c) Change Detection Year

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Seasonality in the extreme precipitation events linked to temperature over Japan

*Sridhara Nayak[1], Tetsuya Takemi[1]

1. Disaster Prevention Research Institute, Kyoto University

The frequency of extreme precipitation events is expected to increase in future warmer climate according to the Clausius-Clapeyron (CC) equation which states that atmosphere can hold more moisture in warmer air temperature (about 7 percent per increase of 1ºC). In this study, the extreme precipitation intensities linked to temperature are investigated for different seasons over seven sub-regions of Japan by analyzing the d4PDF dataset at 20 km in present (1951-2010) and future climate (2051-2110). To do this we stratified the precipitation intensities of wet days (defined as excess of 1 mm per day) in different temperature bins at 1º intervals and computed the 99-percentile of the precipitation intensities from each temperature bin. We find that the extreme precipitation intensities linked to temperature is strongly influenced by the seasons and regions of Japan. The extreme precipitation intensities increase with temperature up to 21º over northern Japan, while the extreme precipitation intensities over Okinawa increase up to 24º. Intensities of extreme precipitation events over northern parts of Japan including Hokkaido and Tohoku regions are increased by about 10 mm per day in future warming climate, while over western regions of Japan it is increased by about 20 mm per day. Seasonal analysis indicates a super CC relationship in winter season and a sub CC relationship in summer. Overall results suggest that Japanese regions may experience more extreme precipitations in future warming climate.

Keywords: Extreme Precipitation Events, d4PDF, Clausius-Clapeyron Equation

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[E] 口頭発表 | セッション記号 A (大気水圏科学)：A-CG 大気海洋・環境科学複合領域・一般

2019年5月28日(火) 13:45 ~ 15:15 | 301A 3F

[A-CG32] Global Carbon Cycle Observation and Analysis

コンビーナ:市井 和仁(千葉大学)、Patra Prabir(Research Institute for Global Change, JAMSTEC)、Forrest M. Hoffman(Oak Ridge National Laboratory)、Makoto Saito(National Institute for Environmental Studies)、座長:市井 和仁

The landmark Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC) aims at reduction of greenhouse gases (GHGs) emission to keep the global warming below 2 degC. As per the agreement the nationally determined commitments (NDCs) and their progresses should be carefully monitored and verified by international bodies. The emission verification will be based on observation of the time evolution of greenhouse gases and model-based estimations of emissions from time to time.
In recent years, the number of observations and new techniques to monitor GHGs budget have been increasing. The improvements includes observational platforms for monitoring atmospheric GHGs, national or regional emission inventories, top-down models (e.g. atmospheric inverse models), and bottom-up models (e.g. process-based models). However, due to uncertainties in modeling and sparse observation network, high uncertainty exists in GHGs sources/sinks estimations at global and regional scales. These uncertainties lead to large variations in future projection of GHG budgets and climate changes.
The purpose of the session is to discuss state-of-the-art techniques for estimations of GHGs (e.g. CO2, CH4, N2O) budget at global and regional scales. The topic includes natural and anthropogenic processes, various methodologies (e.g. in-situ observation, aircraft monitoring, remote sensing, modeling), and various targets (e.g. atmosphere, terrestrial, and ocean), various spatial and temporal coverage (e.g. regional to global scales and past-present-future). Improved estimates of emissions from land use change, forest fires, and other anthropogenic sources (urban developments and thermal power station etc.) are also of interest. We also welcome discussions for designs and plans for future studies targeting city and country scale emission estimations using sophisticated modeling tools.

13:45 ~ 14:00

[ACG32-01] A high-resolution fossil fuel CO2 emission gridded dataset for tracer transport simulations and flux inversions: An overview, evaluations, applications and future perspectives

★Invited Papers

*Tomohiro Oda[1,2]、Shamil Maksyutov [3]、Miguel O. Roman [2,4]、Zhousen Wang [4]、Thomas Lauvaux[6,5]、Sha Feng [5]、Rostyslav Bun [7,8]、James Wang [2,1]、Randy Kawa [1]、Lesley Ott[1]、Steven Pawson[1] (1.NASA Goddard Space Flight Center, Greenbelt, MD, USA 、2.Universities Space Research Association, Columbia, MD, USA 、3.Center for Global Environmental Research, National Institute for Environmental Studies, Tsukuba, Ibaraki, Japan 、4.Terrestrial Information Systems Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD, USA 、5.Department of Meteorology and Atmospheric Science, Penn. State University, State College, PA, USA 、6.Laboratoire des sciences du climat et de l'environnement, Gif sur Yvette, France、7.Lviv Polytechnic National University, Lviv, Ukraine 、8.University of Dąbrowa Górnicza, Górnicza, Poland)

14:00 ~ 14:15

[ACG32-02] グローバル二酸化炭素排出インベントリーの不確実性の低減に向けて

*叢 日超[1]、齊藤 誠[1]、平田 竜一[1]、伊藤 昭彦[1] (1.国立環境研究所　地球環境研究センター)

14:15 ~ 14:30

[ACG32-03] Evaluation of MIROC4-ACTM reanalysis of GHGs concentrations using aircraft

*Jagat Bisht[1]、Prabir Patra[1]、Naveen Chandra[1]、Sergey Gromov[2]、Taku Umezawa[3]、Andreas Zahn[4]、cARL A. M. Brenninkmeijer[5] (1.Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Yokohama, Japan、2.Max Planck Institute for Chemistry, Mainz, Germany、3.National Institute for Environmental Studies, Tsukuba, Japan、4.Karlsruhe Institute of Technology (KIT), Institute for

Meteorology and Climate Research, Karlsruhe, Germany、5.Max Planck Institute for Chemistry, Air Chemistry Division, Mainz, Germany)

14:30 ~ 14:45

[ACG32-04] **Carbon flux estimation using NICAM-TM 4D-Var and GOSAT data towards GOSAT-2 Level 4 product**

*佐伯 田鶴[1]、丹羽 洋介[1]、齊藤 誠[1] (1.国立研究開発法人 国立環境研究所)

14:45 ~ 15:00

[ACG32-05] **Attribution of the ambiguity in methane's growth rate shifts during 1988-2016.**

*Naveen Chandra[1]、Prabir Patra[1] (1.Japan Agency for Marine Earth Science and Technology)

15:00 ~ 15:15

[ACG32-06] **Ocean uptake and land use change emissions suppressed atmospheric CO_2 growth in the 2015/16 El Niño**

*近藤 雅征[1]、Landschützer Peter [2]、Iida Yousuke [3]、Houghton Richard [4]、Sitch Stephen [5] (1.千葉大学　環境リモートセンシング研究センター、2.Max Planck Institute for Meteorology、3.Global Environment and Marine Department, Japan Meteorological Agency、4.Woods Hole Research Center、5.University of Exeter)

A high-resolution fossil fuel CO2 emission gridded dataset for tracer transport simulations and flux inversions: An overview, evaluations, applications and future perspectives

*Tomohiro Oda[1,2], Shamil Maksyutov [3], Miguel O. Roman [2,4], Zhousen Wang [4], Thomas Lauvaux[6,5], Sha Feng [5], Rostyslav Bun [7,8], James Wang [2,1], Randy Kawa [1], Lesley Ott[1], Steven Pawson[1]

1. NASA Goddard Space Flight Center, Greenbelt, MD, USA , 2. Universities Space Research Association, Columbia, MD, USA , 3. Center for Global Environmental Research, National Institute for Environmental Studies, Tsukuba, Ibaraki, Japan , 4. Terrestrial Information Systems Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD, USA , 5. Department of Meteorology and Atmospheric Science, Penn. State University, State College, PA, USA , 6. Laboratoire des sciences du climat et de l'environnement, Gif sur Yvette, France, 7. Lviv Polytechnic National University, Lviv, Ukraine , 8. University of Dąbrowa Górnicza, Górnicza, Poland

Carbon dioxide (CO_2) emissions from fossil fuel combustion (Fossil fuel CO_2, FFCO2) is the largest input to the global carbon cycle over the decadal time scales. FFCO2 needs to be accurately quantified and monitored in order to deduce the carbon uptakes by natural sinks from atmospheric measurements as well as support the emission reduction and management. The Open-source Data Inventory for Anthropogenic CO_2 (ODIAC) is a global, high-spatial resolution (1x1km) gridded FFCO2 emission data product. We first pioneered the combined use of the point source information and satellite-observed nighttime lights data for emission downscaling in order to achieve global 1×1 km spatial resolution emission fields. The use of nightlight data allows us to observe dynamic changes in emissions spatial distributions in a timely manner and incorporate these into the emission field. Since its establishment in 2009, ODIAC has been extensively used in global and regional flux inversions especially with CO_2 data collected by carbon observing satellites, such as the Japanese Greenhouse gas Observing SATellite (GOSAT) and NASA’s Orbiting Carbon Observatory 2 (OCO-2). ODIAC has been also successfully applied to studies for localized emissions point sources such as power plants and cities. In order to further improve the accuracy of the emission downscaling, we have examined NASA’s new Visible Infrared Imaging Spectrometer Suite (VIIRS) Nighttime Environmental Product. An accurate global emission disaggregation is one of the key elements of future Monitoring and Verification Support (MVS) scientific systems that consist of the carbon modeling and data assimilation. Our advanced satellite-based emission downscaling model holds the promise of playing a critical role in such future systems.

Keywords: CO2, fossil fuel CO2 emissions, Carbon cycle, Remote sensing, GOSAT, OCO-2

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グローバル二酸化炭素排出インベントリーの不確実性の低減に向けて
Towards Decreasing the Uncertainty in Global Carbon Dioxide Emission Inventory

*叢 日超[1]、齊藤 誠[1]、平田 竜一[1]、伊藤 昭彦[1]
*Richao Cong[1], Makoto Saito[1], Ryuichi Hirata[1], Akihiko Ito[1]

1. 国立環境研究所　地球環境研究センター
1. Center for Global Environmental Research, National Institute for Environmental Studies

　グローバル二酸化炭素排出インベントリーには大きな不確実性が含まれたと考えられる。それを低減するため、本研究では既存の信頼性の高い機構が公開した排出インベントリデータを上下四分位手法で補正してニュー排出マップを作り、その時空間の変動を国、地域、地球規模で分析した。まず、既存の主要な二酸化炭素の排出インベントリーを収集してその中に2000から2010年133ヵ国の排出量有する10データセットをピックアップした。これらの値が四分位の上下分位内に位置するものの平均値を取って補正値とした。時空間の変動の可視化分析するため、地理情報システム（GIS）を用いて排出量と該当する国の境界とリンクさせた。本研究による133ヵ国2010年の二酸化炭素排出量の合計値が31,595テラグラム、この値がIEAの公表値（30,434Tg, 化石燃料の使用のみ）より多くてCDIACの公表値（33,469Tg, 化石燃料の使用とセメント製造並びにガスフラーリング由来）より少なく、EDGARの公表値の94%を占めた。さらに、補正した排出量に世界銀行が公表した国ごとの2000年から2010年の人口、GDP、面積をリンクし、それらの指標に関する排出量のトレンド分析をした。

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Evaluation of MIROC4-ACTM reanalysis of GHGs concentrations using aircraft

*Jagat Bisht[1], Prabir Patra[1], Naveen Chandra[1], Sergey Gromov[2], Taku Umezawa[3], Andreas Zahn[4], cARL A. M. Brenninkmeijer[5]

1. Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Yokohama, Japan, 2. Max Planck Institute for Chemistry, Mainz, Germany, 3. National Institute for Environmental Studies, Tsukuba, Japan, 4. Karlsruhe Institute of Technology (KIT), Institute for Meteorology and Climate Research, Karlsruhe, Germany, 5. Max Planck Institute for Chemistry, Air Chemistry Division, Mainz, Germany

Using the “Atmospheric Chemistry Transport Model” being part of the “Model for Interdisciplinary Research On Climate Earth System Model, version 4” (MIROC4-ACTM), simulations of several important greenhouse gases, such as CH_4, CO_2, SF_6, and N_2O, have been conducted using optimized emissions by inverse modelling of surface measurements for the period 1996-2016 (referred to as “reanalysis data”). Aircraft observations, conducted on board passenger aircraft (projects: CARIBIC and CONTRAIL) over diverse latitude and longitude regions offer independent constraints for evaluating the quality of reanalysis data. MIROC4-ACTM captures the variations in CO_2 and SF_6 observed by CARIBIC and CONTRAIL very well, with a correlation coefficient of above 0.96 and a slope of 0.92 at all atmospheric conditions. However, for CH_4 and N_2O the agreement was worse, with correlation coefficients (slopes) between CONTRAIL observations and model simulations of 0.80(0.49)-0.87(0.66) and 0.74(0.55)-0.77(0.75), respectively, at 0-140°E and poleward of 40°N. Further south, that is between 30° S-40°N latitude (for the Tokyo-Australia flights), the correlation coefficients (slopes) was 0.76(0.83)-0.88(0.89) and 0.92(0.87)-0.98(1.05), respectively. Similarly, the agreement with the CARIBIC observations was moderate for CH_4 and N_2O, with correlation coefficients (slopes) of 0.81(0.55) and 0.88(0.65), respectively.

Keywords: MIROC4-ACTM, CONTRAIL, CARIBIC

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Carbon flux estimation using NICAM-TM 4D-Var and GOSAT data towards GOSAT-2 Level 4 product

*佐伯 田鶴[1]、丹羽 洋介[1]、齊藤 誠[1]
*Tazu Saeki[1], Yosuke Niwa[1], Makoto Saito[1]

1. 国立研究開発法人 国立環境研究所
1. National Institute for Environmental Studies

Greenhouse gases (GHG) observations from satellites have contributed to expanding spatial coverage of observational networks for GHGs over the globe. Greenhouse gases Observing SATellite (GOSAT) has been monitoring the column-averaged dry-air mole fractions of atmospheric carbon dioxide (XCO_2) and methane (XCH_4) from space since its launch in January 2009. Its successor GOSAT-2 was successfully launched on 29 October 2018, and the observational data are being processed at GOSAT-2 ground systems. The GOSAT-2 mission aims to continue and enhance spaceborne measurement of GHGs started by GOSAT, and to monitor the impacts of climate change and human activities on the carbon cycle. Both satellites are jointly developed and operated by Ministry of the Environment, Japan Aerospace Exploration Agency (JAXA), and National Institute for Environmental Studies (NIES). NIES is responsible for producing and distributing higher level data products, such as Level 2 products (XCO_2 and XCH_4 etc.) and Level 4 products (surface fluxes of CO_2 and CH_4 and three-dimensional global distributions of CO_2 and CH_4 concentrations) (http://www.gosat-2.nies.go.jp).

We are currently developing an inversion system for operational use to produce GOSAT-2 L4 products. The Non-hydrostatic ICosahedral Atmospheric Model (NICAM)-based Transport Model (NICAM-TM; Niwa et al., 2011) is used for simulating atmospheric CO_2 and CH_4 concentrations, and an inversion system based on the four-dimensional variational (4D-Var) method with NICAM-TM (NICAM-TM 4D-Var; Niwa et al., 2017a,b) is adopted to estimate global surface CO_2 and CH_4 fluxes. In this presentation, we will present test results of CO_2 flux estimation with NICAM-TM 4D-Var using GOSAT data (not GOSAT-2 data), ground-based data, prior fluxes, and their error covariances. NICAM-TM is operated with a horizontal resolution of glevel-5 (an average grid resolution of 223 km) and 40 vertical layers, and its meteorological fields are nudged with JRA-55 data to simulate real atmospheric transport. NICAM-TM 4D-Var is run with stored meteorological data, which successfully reduces computational cost. CO_2 surface fluxes have been estimated at every 223 km grid resolution and at monthly time resolution. Preliminary test results with single-year GOSAT data showed that flux differences between the prior fluxes and estimated fluxes from the GOSAT data inversion appear over a broad area of land regions, even over Siberia and South America where ground sites are sparse, while the ocean regions showed relatively fewer flux changes after the inversion. Our ongoing work includes inversions with multi-year data, the inclusion of other data, and tuning model parameters. The details will be presented at the meeting.

Acknowledgments. The model simulations are performed with the NIES supercomputer system and the Research Computation Facility for GOSAT-2 (RCF2). This research is partly supported by the Environment Research and Technology Development Fund (2-1701) of the Environmental Restoration and Conservation Agency of Japan.

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Niwa et al. (2017b), Geoscientific Model Development, 10(6), 2201–2219.

キーワード：Carbon budget、Flux estimations of greenhouse gases、Atmospheric inverse model、Top-down approach、Satellite remote sensing
Keywords: Carbon budget, Flux estimations of greenhouse gases, Atmospheric inverse model, Top-down approach, Satellite remote sensing

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Attribution of the ambiguity in methane’s growth rate shifts during 1988-2016.

*Naveen Chandra[1], Prabir Patra[1]

1. Japan Agency for Marine Earth Science and Technology

Atmospheric (CH_4) is an important greenhouse gas for mitigating climate change in the decadal scale due to its shorter atmospheric lifetime and about 30 times higher warming potential than carbon dioxide. The remarkable shift in CH_4 growth rate (decrease since early 1990s, quasi-stationary state during 1999-2005 and resume increase after 2006) has observed in past three decades (1990s-2010s). However, the attribution of these fluctuations remained highly conflicting. We have used a global inverse modeling system for constraining CH_4 emissions from 53 land regions for the period 1988–2016 using measurements from 19 sites and forward simulation by MIROC4-ACTM. The ACTM realistically represent inter-hemispheric transport and stratospheric age of air, and methyl chloroform concentration decay (proxy for loss OH concentration level) which are key elements for modelling CH4 in atmosphere. A set of 2 inversions is performed for different combinations of a priori emissions due to the wetlands and rice cultivation. We have shown that slowing down of emissions from oil and gas industry in the 1980s and Mt. Pinatubo volcanic eruption in 1991 led to a stabilization in emissions and thus the quasi-stationary state of CH4 concentration. The CH_4 growth after 2006 is attributed to increases in emissions mainly from coal industry and ruminant farming. The climatic variation due to ENSO caused significant interannual variation in the CH_4 growth rate. The role of CH_4 loss by hydroxyl (OH) reaction in CH4 growth rate variability is proposed to be not significant from inter-site differences.

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Ocean uptake and land use change emissions suppressed atmospheric CO_2 growth in the 2015/16 El Niño

Ocean uptake and land use change emissions suppressed atmospheric CO_2 growth in the 2015/16 El Niño

*近藤 雅征[1]、Landschützer Peter [2]、Iida Yousuke [3]、Houghton Richard [4]、Sitch Stephen [5]
*Masayuki Kondo[1], Peter Landschützer[2], Yousuke Iida[3], Richard Houghton[4], Stephen Sitch[5]

1. 千葉大学　環境リモートセンシング研究センター、2. Max Planck Institute for Meteorology、3. Global Environment and Marine Department, Japan Meteorological Agency、4. Woods Hole Research Center、5. University of Exeter
1. Center for Environmental Remote Sensing, Chiba University, 2. Max Planck Institute for Meteorology, 3. Global Environment and Marine Department, Japan Meteorological Agency, 4. Woods Hole Research Center, 5. University of Exeter

Large variability in El Niño-Southern Oscillation (ENSO) induces anomalous CO_2 fluxes both in biosphere and hydrosphere. In the negative phase of ENSO (i.e., El Niño), dryer climate over lower latitudes decreases productivity of land vegetation and increases vulnerability to biomass burning. At the same time, suppressed upwelling of carbon-rich water near the Pacific South America reduces outgassing of oceanic CO_2 to atmosphere. In years of a strong El Niño, anomalous land and ocean CO_2 fluxes account for a large part of interannual variability of the total net CO_2 flux of the Earth surface. Thus, anomalously large atmospheric CO_2 growth rates co-occur with periods of El Niño events.

Biomass burning is believed to be the dominant component of variability in atmospheric CO_2 growth rate during El Niño. The 1997/98 El Niño induced the most significant anomalous CO_2 release on record, largely due to forest and peat fires in Southeast Asia. Likewise, a massive fire haze over Southeast Asia was found during the recent 2015/16 El Niño. Despite the seemingly large impact of biomass burning in the two events, the 2015/16 El Niño accompanied substantially less atmospheric CO_2 growth compared with that in the 1997/98 El Niño. It turns out that CO_2 emission from biomass burning in 2015 was substantially less than that in 1997 because precipitation before the peak of fire emission (Sept-Oct) shortened the drought length of 2015.

However, it is still arguable that the insignificant biomass burning is the dominate cause behind no obvious signs of large CO_2 release in the 2015/16 El Niño. In the recent decades, both biospheric and hydrospheric CO_2 fluxes has shown trends towards a net sink of CO_2, which suggest a possibility of that increasing CO_2 uptake has suppressed the atmospheric CO_2 growth in the 2015/16 El Niño. To evaluate this possibility, a synthesis of land-ocean CO_2 flux over the period of the two El Niño events is necessary. Here, we explore mechanisms behind differences in the atmospheric CO_2 growth in the 1997/98 and 2015/16 El Niño. The aim of this study is to fully characterize the causes for insignificant atmospheric CO_2 growth in 2015/16 through analyzing types (anomaly/trend) of relative contributions of land-ocean fluxes to atmospheric CO_2 growth between the two El Niño events. Through the analysis, we discuss about components that would likely continue to mitigate atmospheric CO_2 growth in future El Niño.

キーワード：Carbon Cycle、El Nino、Attribution analysis
Keywords: Carbon Cycle, El Nino, Attribution analysis

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[E] 口頭発表 | セッション記号 A (大気水圏科学)：A-CG 大気海洋・環境科学複合領域・一般

2019年5月28日(火) 15:30 ~ 17:00 | 301A 3F

[A-CG32] Global Carbon Cycle Observation and Analysis

コンビーナ:市井 和仁(千葉大学)、Patra Prabir(Research Institute for Global Change, JAMSTEC)、Forrest M. Hoffman(Oak Ridge National Laboratory)、Makoto Saito(National Institute of Environmental Studies)、座長:Prabir Patra

The landmark Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC) aims at reduction of greenhouse gases (GHGs) emission to keep the global warming below 2 degC. As per the agreement the nationally determined commitments (NDCs) and their progresses should be carefully monitored and verified by international bodies. The emission verification will be based on observation of the time evolution of greenhouse gases and model-based estimations of emissions from time to time.

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The purpose of the session is to discuss state-of-the-art techniques for estimations of GHGs (e.g. CO2, CH4, N2O) budget at global and regional scales. The topic includes natural and anthropogenic processes, various methodologies (e.g. in-situ observation, aircraft monitoring, remote sensing, modeling), and various targets (e.g. atmosphere, terrestrial, and ocean), various spatial and temporal coverage (e.g. regional to global scales and past-present-future). Improved estimates of emissions from land use change, forest fires, and other anthropogenic sources (urban developments and thermal power station etc.) are also of interest. We also welcome discussions for designs and plans for future studies targeting city and country scale emission estimations using sophisticated modeling tools.

15:30 ~ 15:45

[ACG32-07] Observing vegetation seasonal dynamics in Japan with Himawari-8 hypertemporal data

*Tomoaki Miura[1,2]、Shin Nagai[2]、Kazuhito Ichii[3]、Hiroki Yoshioka[4] (1.University of Hawaii at Manoa、2.Japan Agency for Marine-Earth Science and Technology、3.Center for Environmental Remote Sensing, Chiba University、4.Aichi Prefectural University)

15:45 ~ 16:00

[ACG32-08] Carbon and Water Fluxes at High spatial Resolutions through Down-Scaling

*Jiquan Chen[1]、Pietro Sciusco[1]、Ranjeet John[1]、Zutao Ouyang[1] (1.Michigan State University)

16:00 ~ 16:15

[ACG32-09] **Connecting Satellite Based Spectral Modelling Approach and Forest Inventory to Model Biomass and Carbon Stocks in Natural and Planted Forest over part of Semi-arid zone, India**

*SWATI UNIYAL[1]、Siti Raju Rao (1.Andhra University)

16:15 ~ 16:30

[ACG32-10] **Allocation of forest net primary production varies by forest age and air temperature**

*Xiang Song[1]、Xiaodong Zeng[1]、Dongxiao Tian[2] (1.IAP, CAS、2.Beijing Meteorological Information Center)

16:30 ~ 16:45

[ACG32-11] Analyzing Model Biases in Terrestrial Carbon Cycle Submodels in Earth System Models and Offline Models

*市井 和仁[1]、村上 和隆[2]、高山 宏明[3]、羽島 知洋[3]、立入 郁[3] (1.千葉大学、2.国立環境研究所、3.海洋研究開発機構)

16:45 ~ 17:00

[ACG32-12] Assessing terrestrial biogeochemical feedbacks in a strategically geoengineered climate

*Forrest M. Hoffman[1,2]、Cheng-En Yang[2,1]、Joshua S. Fu[2,1]、Simone Tilmes[3]、Lili Xia[4]、Douglas G. MacMartin[5]、Jadwiga H. Richter[3]、Michael Mills[3]、Ben Kravitz[6] (1.Oak Ridge National Laboratory、2.University of Tennessee、3.National Center for Atmospheric Research、4.Rutgers University、5.Cornell University、6.Pacific Northwest National Laboratory)

Observing vegetation seasonal dynamics in Japan with Himawari-8 hypertemporal data

*Tomoaki Miura[1,2], Shin Nagai[2], Kazuhito Ichii[3], Hiroki Yoshioka[4]

1. University of Hawaii at Manoa, 2. Japan Agency for Marine-Earth Science and Technology, 3. Center for Environmental Remote Sensing, Chiba University, 4. Aichi Prefectural University

Spectral vegetation index (VI) time series data derived from moderate resolution, polar-orbiting satellite sensors, have been used to monitor and characterize the Earth’ s vegetative cover and its dynamics in regional to global scales. Unities of these VI time series data are, however, constrained by frequent cloud covers. That is, the derived VI products from these sensor data are at a weekly or bi-weekly temporal resolution due to the availability of cloud-free observations, resulting in relatively high uncertainties in their seasonal dynamics characterization. A new generation of geostationary satellite sensors equipped with spectral bands suitable for VIs, such as Himawari-8/9, have been launched during the last decade. As they are on geostationary orbit, they can image an Earth’ s hemisphere at 10-15 min intervals, potentially serving as another significant data source for the studies of vegetation dynamics.

In this study, we assessed the utilities of Himawari-8 “hypertemporal” NDVI data for characterizing seasonal dynamics of vegetation and land cover conditions. We compared Himawari NDVI temporal signatures to those derived from a new generation polar-orbiting satellite sensor, Visible Infrared Imaging Radiometer Suite (VIIRS), at select sites in Japan. Our analysis showed that cloud-free observations were available for ~24 days during the 45-day green-up period with Himawari, but ~12 days with VIIRS. In other words, the number of days with cloud-free observations could double with Himawari data compared to VIIRS data. These results indicate the potential of Himawari data for providing higher temporal resolution NDVI time series data and, thus, improved monitoring and characterization of vegetation dynamics in Japan compared to the current polar-orbiting satellite data. One potential drawback would be the fixed view zenith and azimuth angles which might become problematic when one is interested in analyzing vegetation dynamics across space. Validation of Himawari-observed NDVI temporal profiles with ground observational NDVI and carbon flux data will be one required step.

Keywords: Himawari, geostationary satellite, vegetation phenology, land surface phenology, NDVI

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Carbon and Water Fluxes at High spatial Resolutions through Down-Scaling

*Jiquan Chen[1], Pietro Sciusco[1], Ranjeet John[1], Zutao Ouyang[1]

1. Michigan State University

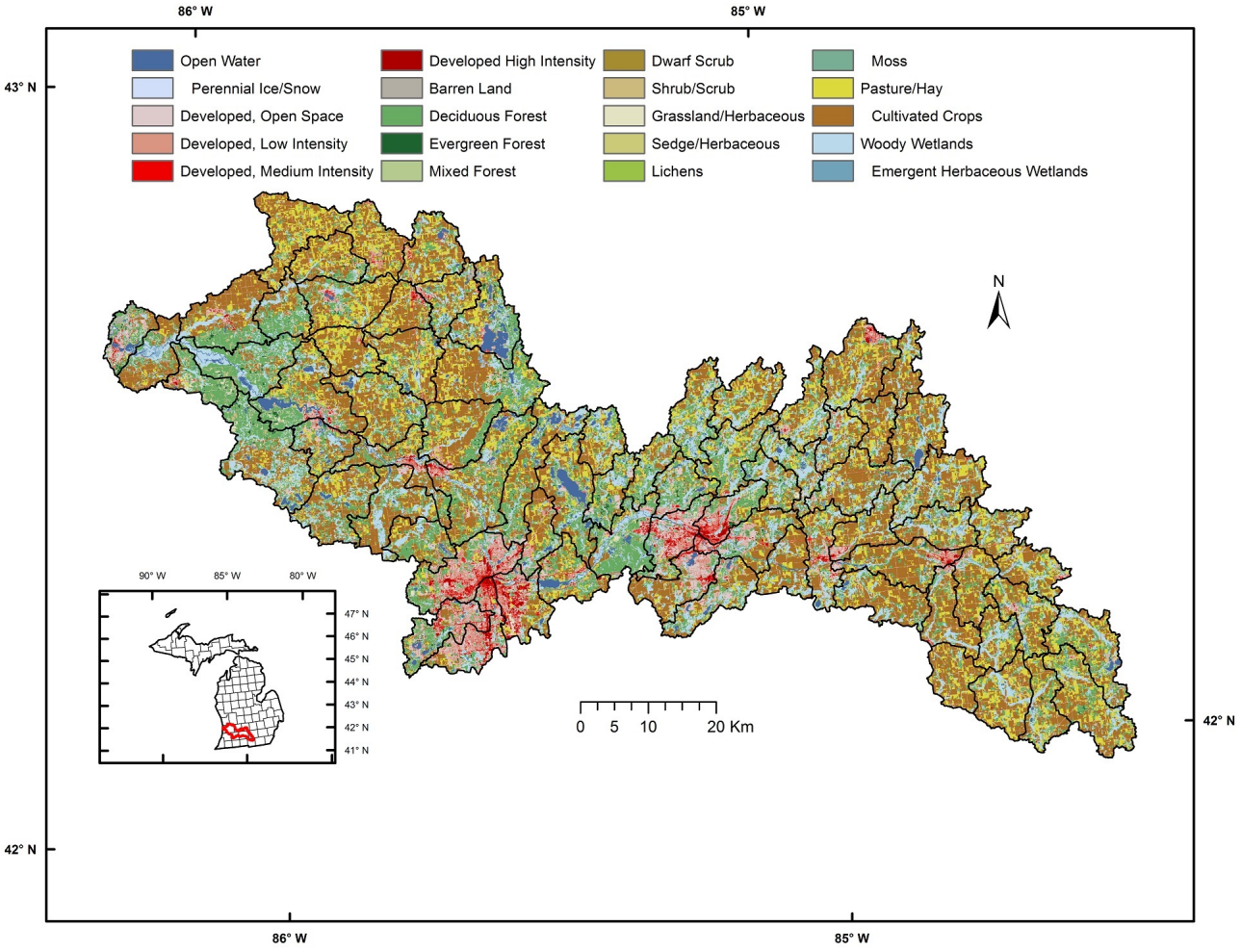
We propose an innovative top-down modeling approach to estimate high resolution (30 m) net primary production (NPP), evapotranspiration (ET) and *albedo* from MODIS products by integrating accurately classified land cover from Landsat/Sentinel and MODIS. Assuming that a measure of ecosystem ET in a landscape is a linear sum of ET of cover type (i), MODIS ET of a pixel can be expressed as:

$ET = sum(a_i * ET_i) + e$ [1]

where a_i is the compositional portion of cover type i within a MODIS pixel (where $sum(\alpha_i) = 1$) that can be calculated from classified land cover for the year; ET_i is the ET value of cover type i and can be estimated through multi-linear regression analysis with a zero intercept; and e is the residuals from the empirical model [1] and will be further examined for the potential influences of biophysical and socioeconomic driving forces. MODIS products of NPP, ET, and *albedo* of a landscape are estimated for their monthly and annual values by assuming that land cover during an individual year remains unchanged. This downscaling approach, currently tested for the Kalamazoo watershed in the southwestern Michigan, is only valid at a scale where similar climate, soil, and landforms exist (i.e. value of the same cover type in isolated patches are the same). To assure the validity of this approach, a multilinear regression analysis is performed with external factors such as soil type, climatic zone, and/or disturbance regime. Estimated ecosystem functions is then scaled up based on the 30 m resolution land cover of Landsat imagery for their high resolution spatiotemporal changes.

Keywords: carbon flux, down scaling, MODIS and Landsat

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Connecting Satellite Based Spectral Modelling Approach and Forest Inventory to Model Biomass and Carbon Stocks in Natural and Planted Forest over part of Semi-arid zone, India

*SWATI UNIYAL[1], Siti Raju Rao

1. Andhra University

Forests have been recognized as having important mitigation potential because of their critical role in the global carbon cycle and significant potential to capture and hold carbon. Biomass is an important parameter to assess the atmospheric carbon that is harvested by trees.

This study describes an effort to estimate regional level Above Ground Biomass (AGB) and carbon from plot to point from multi-season MODIS data for a part of semi-arid zone i.e. Madhya Pradesh state by establishing a correlation with field observed data. Using clustered sampling approach a total number of 1200 plots were laid on ground for natural forests and planted forests/tress. Stand biomass for each plot was computed from ground inventory using diameter, height, generalized species and interspecies allometric equations.

Spectral modelling was done with red, infra-red and NDVI of different seasons with observed AGB using statistical functions like linear, logarithmic, power and exponential. Various linear and multiple regression models were tested among all seasons and bands, and the best fit model from those was used for predicting biomass and carbon at regional level.

Red band and NDVI spectral reflectance combined with logarithmic function in multiple regression was found to be the best model (r^2=0.5784) for model Y= a +b1* ln (NDVI) + b2 *1/x*(Red) +b3 *sqrt (NDVI) for predicting biomass and Carbon. Predicted biomass value is in the range of 0-134.836t/ha, while total biomass of the area is 5950Tg. Similarly Predicted Carbon content is in the range of 0-64.04tC/ha and total carbon content in the range of 2690TgC.

Results were validated using 50 random points. The observed ABG of these 50 points validated with predicted AGB, a correlation R^2= 0.6003 was obtained indicating biomass and carbon obtained through spectral modelling has given good estimation at regional level.

Comparing biomass and carbon value for natural forest and plantation study explicitly noted that planted forest/trees sequester more carbon because results from a combination of site factors and adaptation of good silvicultural practices, while for natural forest wide variation in stand structure, tree growth, different stages of forest growth cycle, and varying tree density resulted in lower carbon content.

Keywords: Biomass, Spectral Modelling, Carbon Cycle, MODIS

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Allocation of forest net primary production varies by forest age and air temperature

*Xiang Song[1], Xiaodong Zeng[1], Dongxiao Tian[2]

1. IAP, CAS, 2. Beijing Meteorological Information Center

Carbon partition among plant parts has a vital influence not only on the growth of individual plants but also on decomposition, carbon and nitrogen sequestration, and plant-atmosphere water exchange. Although many studies have tried to reveal plant growth mechanisms using observational living biomass or the biomass ratio among different organs, knowledge and understanding about carbon partition is still scarce and exists much uncertainty. In this work, a dataset from the Chinese Ecosystem Research Network (CERN) was used to explore the dependences of net primary production (NPP) partition among foliage, stem and branch, and root on forest age, and mean annual temperature (MAT). The results found that (1) younger plants usually allocated a higher proportion of the NPP to stems, branches, and roots; (2) MAT was negatively correlated with the proportions of the NPP allocated to foliage (F_{leaf}; %) and roots (F_{root}; %), while proportions of the NPP allocated to stems and branches (F_{stbr}; %) were positively dependent on MAT; (3) forest age had a larger direct influence on F_{leaf} and F_{root}, while MAT was relatively important for F_{stbr}. This work not only is important for understanding the contribution of climatic factor and forest age on forest NPP partition, but also provides valuable ideas for developing ecological models.

Keywords: net primary production partition, forest age, climate, China’s forest

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Analyzing Model Biases in Terrestrial Carbon Cycle Submodels in Earth System Models and Offline Models

*市井 和仁[1]、村上 和隆[2]、高山 宏明[3]、羽島 知洋[3]、立入 郁[3]
*Kazuhito Ichii[1], Kazutaka Murakami[2], Hiroaki Takayama[3], Tomohiro Hajima[3], Kaoru Tachiiri[3]

1. 千葉大学、2. 国立環境研究所、3. 海洋研究開発機構
1. Chiba University, 2. National Institute for Environmental Studies, 3. Japan Agency for Marine-Earth Science and Technology

Improvement of terrestrial models in earth system models (ESMs) is important to reduce uncertainties in future projections of global carbon cycle and climate. Toward an improvement of ESMs, we need to evaluate current performance of terrestrial components in current ESMs and analyze their causes of biases. Therefore, using available observation based products (e.g. satellite-based products), offline ecosystem model outputs, and CMIP-5 ESM outputs, we attempted to characterize causes of biases of modeled terrestrial carbon flux and pools. We found that key climate variables, such as precipitation, is one of the causes of biases in ESM-based carbon fluxes. For example, positive precipitation biases in Africa and Oceania results in positive biases of gross primary productivity (GPP), biomass, and net biome productivity (NBP). Negative precipitation bias in tropical South America leads to negative GPP, biomass and NBP biases. Therefore, improvement of spatial patterns are one of the important next step toward ESM, in particular toward realistic simulations of sub-continental scale terrestrial variations.

キーワード：陸域炭素循環、リモートセンシング、モデル、データ駆動モデル推定
Keywords: Terrestrial Carbon Cycle, Remote Sensing, Model, Data-driven estimation

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Assessing terrestrial biogeochemical feedbacks in a strategically geoengineered climate

*Forrest M. Hoffman[1,2], Cheng-En Yang[2,1], Joshua S. Fu[2,1], Simone Tilmes[3], Lili Xia[4], Douglas G. MacMartin[5], Jadwiga H. Richter[3], Michael Mills[3], Ben Kravitz[6]

1. Oak Ridge National Laboratory, 2. University of Tennessee, 3. National Center for Atmospheric Research, 4. Rutgers University, 5. Cornell University, 6. Pacific Northwest National Laboratory

Stratospheric geoengineering by injecting sulfur dioxide into the lower stratosphere has been suggested as a possible means of reducing anthropogenic warming. While the impacts of stratospheric aerosol geoengineering on climate change have been investigated in the past few decades, only a few studies have considered the terrestrial biogeochemical feedbacks resulting from such treatment. These feedbacks can alter the atmospheric carbon dioxide concentration by storing or releasing additional carbon in terrestrial and marine ecosystems, thus, changing the climate trajectory and aerosol injection strategy for geoengineering. In this study, we analyzed model output from the recent Stratospheric Aerosol Geoengineering Large Ensemble project to assess the changes in terrestrial biogeochemical feedbacks on climate, particularly the carbon sink strength (CSS), in response to stratospheric aerosol geoengineering. Our results showed that the terrestrial CSS increased globally by 5.2 Pg C during 2070–2089 compared to that during the first twenty years of geoengineering starting from 2020, *i.e.*, an additional 11 ppm CO_2 -equivalent amount of carbon in the atmosphere would be stored on land. Among seven latitude bands, the midlatitudes in the Northern Hemisphere (35˚N–60˚N) had the largest CSS increase (+8.0 Pg C) whereas the Tropics (23.5˚S–23.5˚N) released carbon back to the atmosphere (–2.9 Pg C). Hypotheses regarding the causes of the variations in the differences in regional responses will be presented.

Keywords: geoengineering, biogeochemistry-Earth system interactions, carbon sink strength

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[E] 口頭発表 | セッション記号 H (地球人間圏科学)：H-DS 防災地球科学

2019年5月28日(火) 9:00 ~ 10:30 | 304 3F

[H-DS09] 地すべりおよび関連現象

コンビーナ:千木良 雅弘(京都大学防災研究所)、王 功輝(京都大学防災研究所)、今泉 文寿(静岡大学農学部)、座長:今泉 文寿

Mass movements, such as landslides, rockfalls, and debris flows, have been occurring extensively in a large number of countries, causing heavy damage. In order to understand them and mitigate induced disasters, we invite contributions that report and discuss on mass movements and related phenomena, focusing on improved understanding of their characteristics; new insights into landslide mechanisms; the development of new approaches to monitoring; novel approaches to behavior forecasting and prediction; studies of successful landslide management; and the development of methods for hazard and risk evaluation. In particular, papers about recent landslide hazards, induced by 2017 northern Kyushu rainstorm, 2018 Osaka earthquake, 2018 western Japan rainstorm, and 2018 Hokkaido earthquake are welcome.

9:00 ~ 9:15

[HDS09-01] Mechanical behavior modulated by shear surface morphology of simulated shear zone

*Yao Jiang[1]、Gonghui Wang[2]、Toshitaka Kamai[2] (1.Institute of Mountain Hazards and Environment, Chinese Academy of Sciences, China、2.Research Center on Landslide, Disaster Prevention Research Institute, Kyoto University, Japan)

9:15 ~ 9:30

[HDS09-02] On the Pre-failure Shear Behavior of Clayey Soil

*Chengrui Chang[1]、Gonghui Wang[1] (1.Disaster Prevention Research Institute, Kyoto University)

9:30 ~ 9:45

[HDS09-03] **GeoGuard: low-cost GNSS sensors for the continuous monitoring of landslides and structures**

*Andrea Gatti[1]、Giulio Tagliaferro[1]、Eugenio Realini[1]、Stefano Caldera[1] (1.Geomatics Research & Development srl)

9:45 ~ 10:00

[HDS09-04] **Landslide Susceptibility Analysis in the Chenyulan River Watershed, Taiwan**

*Po-Tsun Yeh[1]、Kuang-Tsung Chang[1] (1.National Chung Hsing University, Taiwan)

10:00 ~ 10:15

[HDS09-05] Investigating the Relationship Between Tree Height and Landslide Occurrence in the Ikawa Catchment, Central Japan

*Jamie Rhys Evans[1]、Fumitoshi Imaizumi [1] (1.Faculty of Agriculture, Shizuoka University)

10:15 ~ 10:30

[HDS09-06] チベット高原南縁と東縁における遷急点遡及による地すべり

*千木良 雅弘[1]、鄒 青穎[2]、チョウ シーユアン[4]、ウー シヨン[3] (1.京都大学防災研究所、2.弘前大学、3.西南交通大学、4.京都大学大学院理学研究科)

Mechanical behavior modulated by shear surface morphology of simulated shear zone

*Yao Jiang[1], Gonghui Wang[2], Toshitaka Kamai[2]

1. Institute of Mountain Hazards and Environment, Chinese Academy of Sciences, China, 2. Research Center on Landslide, Disaster Prevention Research Institute, Kyoto University, Japan

Mechanical behaviors of geologic granular materials in shear provide fundamental insights into the mobility mechanisms related to the dynamics of landslides and tectonic faults. Some previous experimental studies have shown that the mineralogy of constituent materials plays a first-order control on the transitions of mechanical behaviors, including sliding stability or instability. Moreover, other laboratory investigations have demonstrated the importance of shear rate as a primary control on the strength properties, leading to rate-strengthening or rate-weakening. Despite these efforts, however, neither the knowledge of general relationships between material properties and failure modes nor the underlying processes are well understood. Here we report on a series of ring-shear friction experiments designed to investigate the shear surface morphology on the mechanical behaviors along pre-existing granular shear zones. Two kinds of commercial granular materials were used in our experiments, say, halite and silica. Results directly show that only inclusion a low proportion of granular halite can produce the transition from stable sliding to stick-slip instability. The visual observations of shear surfaces further indicate that the variations with halite content form different morphologies. By analyzing the shear displacement and acoustic emission data, the microslip precursors were identified to stick-slip instability. It is expected that the mechanical behavior transition may constrain the evolution of asperity mechanism in nucleating rupture instability along heterogeneous shear surfaces owing to breakage of grain interfaces.

Keywords: granular materials, mechanical behavior, shear surface, acoustic emission, ring shear apparatus

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On the Pre-failure Shear Behavior of Clayey Soil

*Chengrui Chang[1], Gonghui Wang[1]

1. Disaster Prevention Research Institute, Kyoto University

Introduction

Landslides are significant natural hazard that cause substantial economic loss and extensive loss of life. Triggering in landslides occurs as a result of highly dynamic processes and the hydrological state has a profound influence on the stability of the slopes. For rainfall-induced landslides, the increase of pore water pressure as a result of rainfall infiltration progressively reduces the normal effective stress of the slope materials acting on a potential shear surface and the shear resistance decreases as the inter-particle friction is reduced by the buoyancy force. Saito (1965) first proposed a linear trend when the inverse velocity before failure is plotted against time which has made a significant contribution to the understanding and monitoring of landslides (Voight, 1988, 1989; Fukozono, 1990). Many studies focusing on the deformation and pore water pressure noted that the rate of strain was initially small but showed a very rapid increase towards failure (Anderson & Sitar, 1995; Zhu & Anderson, 1998; Dai et al, 1999; Ng & Petley,

Methods

The aim of this study is to investigate experimentally the nature of the interactions between the pore pressure variation and the development of the displacement in the pre-failure stage. All the soil samples were taken from the Nishiwaki landslide, which was induced by the heavy rainfall accompanying the No. 21 Typhoon on Oct. 22rd, 2017 in Wakayama Prefecture. Subsequently, two different series of tests were undertaken under the combined condition of predefined normal stress and shear stress simulating consolidated nature slope in the ring shear apparatus. One series of test is the pore-pressure-controlled test, which uses a serially connected air tank and water tank to increase the pore water pressure (PWP) in the shear box of ring shear apparatus. This series of tests aims at simulating the effect of decreasing the effective stress state whilst holding constant shear stress to reproduce a slope undergoing heavy rainfall. The pore water pressure was increased deliberately and then hold or decrease the pore water pressure as a short-term movement was detected. Such a procedure has been repeated until the shear resistance dropped, which indicates the shear failure. The shear-stress-controlled series is aiming to investigate the shear displacement pattern with a gently cumulative increase in shear stress under undrained condition, which involves an increase of the shear stress in a flattened gradient after consolidation. Both series of tests are conducted in three kinds of consolidated conditions to examine the correlation between velocity and acceleration.

Results and discussions

In pore-pressure-controlled tests, the displacement shows a creep-like pattern before failure. During the whole test, several periods of constant velocity had been identified. We also found that shear swelling occurred in the drained shear test, therefore, we inferred that the possible infiltration of water into the shear zone may enable the continuous increase of pore water pressure so that the shear resistance will be lowered to initiate the accelerating movement. We also found that “stick-slip” behavior (short-term movements) occurred in the shear tests. We inferred that the increment of the PWP initiates the shear displacement rather than the amount of the PWP.

The results indicate that the increment of PWP can initiate larger and more rapid shear displacement when the level of the PWP is higher. A series of creep-like movements leads to final failure. The role of increasing pore water pressure in the initiation of the tertiary acceleration will be key for us to understand the creep behavior, and further tests and detailed examination on this issue will be continued.

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GeoGuard: low-cost GNSS sensors for the continuous monitoring of landslides and structures

*Andrea Gatti[1], Giulio Tagliaferro[1], Eugenio Realini[1], Stefano Caldera[1]

1. Geomatics Research & Development srl

The United Nation Office for Disaster Risk Reduction warned that economic losses from landslides, floods, earthquakes, and drought will continue to escalate unless businesses take action to reduce their exposure to disaster risks. Structures can suffer structural deterioration due to aging, misuse or lack of proper maintenance. In addition, they are subject to exposure to natural hazards such as landslides, floods, and earthquakes. Traditional visual inspection techniques are both time consuming and expensive. They are also qualitative and can only assess outward appearance. Structures and natural hazard control and management are becoming one of the key issues in the approach to sustainable development of modern countries. In this framework, structural health monitoring is representing one of the most valuable approaches for the decision-making process. Global Navigation Satellite System (GNSS) technology can provide position information with accuracy to a few millimeters in near real-time. However, the widespread adoption of GNSS monitoring is hindered by the high cost of dual-/multi-frequency geodetic GNSS receivers.

In 2015, through a partnership with the Italian company Softeco, GReD started GeoGuard, an innovative end-to-end service for the continuous monitoring of landslides and structures by means of single-frequency GNSS low-cost receivers and antennas. GeoGuard provides accurate positioning with centimeter-level accuracy in near real-time, or millimeter-level accuracy for daily/sub-daily solutions. The GNSS network observations are processed by means of both Bernese software, and an ad-hoc evolution of goGPS, a free and open source positioning software package developed by the GReD team. A software platform was developed for the management of a GNSS positioning service, and for the visualization and delivery of results. Currently, GeoGuard uses GPS L1 observations for its operational activities; however, promising results are being obtained with the addition of Galileo E1 observations, especially for sites with limited sky visibility, and to improve the accuracy of sub-daily (e.g. hourly) solutions. Currently, the GeoGuard service is operational on two landslides, a highway bridge, a dam, and two penstocks.

Keywords: Monitoring, GNSS, GPS, Landslide, Structures, low-cost

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Landslide Susceptibility Analysis in the Chenyulan River Watershed, Taiwan

*Po-Tsun Yeh[1], Kuang-Tsung Chang[1]

1. National Chung Hsing University, Taiwan

Many rainfall-triggered landslides occurred in the Chenyulan river watershed of central Taiwan during typhoon Morakot. In order to prevent rainfall-triggered landslide disasters, it is important to understand the relation of the disasters and the factors of rainfall, geology, and topography. In this study, the landslide susceptibility model of the Chenyulan river watershed was built and evaluated under the multiple logistic regression analysis based on slope units. These units were delineated by topography and 249 units out of them were chosen because orientation data of weak planes were included. The detection of the binary dependent variables (landslide and non-landslide samples) were based on the geomorphic change using satellite imageries before and after typhoon Morakot. Then the independent variables include geological, topographic and rainfall factors. Especially, we considered the orientation of weak planes and the spatial and temporal variability of rainfall. The result showed that the p-value of Hosmer-Lemeshow test and the Area Under the Curve of ROC are over 0.1 and 0.75, respectively. As the result, the chosen factors in the model could predict landslides in the Chenyulan river watershed effectively. It could be reference for follow-up research.

Keywords: Landslide susceptibility, Spatial and temporal variability of rainfall, Multiple logistic regression, Orientation of weak plane, Slope unit

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Investigating the Relationship Between Tree Height and Landslide Occurrence in the Ikawa Catchment, Central Japan

*Jamie Rhys Evans[1], Fumitoshi Imaizumi [1]

1. Faculty of Agriculture, Shizuoka University

The occurrence of landslides in forested terrain can have large impacts on the future productivity of soil and the quality of water that drains from a catchment, as well as damaging a valuable asset in the forest itself. The relationship between tree height and landslide occurrence in the Ikawa catchment, Northern Shizuoka prefecture, is investigated to gain a better insight into the distribution of landslides. Root depth profile, measured for trees of various height via trenches, is used in conjunction with tree height when assessing the distribution of landslides. Root tensile strength for unit areas of soil is calculated from individual root diameters to better understand the effect of the root network on slope stability. Landslide ratios in the Ikawa catchment show that landslides occur more frequently in shorter forests, with occurrence decreasing as tree height increases. This is likely due to stabilizing features of trees being accentuated as they grow, which is supported by both total root area and total root tensile strength data showing a significant increase between that of the 6.5m Kumashide, 8m Momi, and 12m Kumashide. The random distribution of results when comparing landslide depth to tree height suggests that while tree height, and hence total root tensile strength, has an impact upon whether a landslide is to occur or not, the depth of the landslides that do occur are independent of the height of trees. This suggests that slope stability increases alongside tree height and that landslide depth is not controlled by tree height so is therefore controlled by other factors. While there is no relationship between tree height and landslide depth, both Kumashide trees surveyed show decreases in total root tensile strength around the average depth of landslides in the Ikawa catchment of 0.46m.

Keywords: Landslide depth, Tree height, Root tensile strength, LiDAR

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チベット高原南縁と東縁における遷急点遡及による地すべり
Landslides induced by the knickpoint migration in the southern and the eastern margins of the Tibetan Plateau.

*千木良 雅弘[1]、鄒 青穎[2]、チョウ シーユアン[4]、ウー シヨン[3]
*Masahiro Chigira[1], Ching-Ying Tsou[2], Siyuan Zhao[4], Xiong Wu[3]

1. 京都大学防災研究所、2. 弘前大学、3. 西南交通大学、4. 京都大学大学院理学研究科
1. Disaster Prevention Research Institute, Kyoto University, 2. Hirosaki University, 3. Souithwest Jiaotong University, 4. Graduate School of Science, Kyoto University

Because of the collision of Indian plate to Eurasian continent, Himalaya, which is the southern margin of the Tibetan Plateau, is uplifting very rapidly and also the eastern margin of the Tibetan Plateau is uplifting. Those mountains are the sites of uplift and also the sites of rapid erosion and mass movements. We made field survey, using PRISM image with a resolution of 5 m and 5-m ALOS AW3D in both areas. We studied gravitational slope deformation and landslide, which are the response of mountain slopes to river incision, along the Kaligandaki River in Nepal Himalaya and the Minjiang River in Sichuan and found that gigantic landslides have occurred due to the slope instability made by the upstream migration of knickpoints and undercutting of the nearby slopes.

Along the Kaligandaki River, there are two outstanding knickpoints at Kalopani and Talbagar, respectively. The knickpoint at Kalopani is located at the largest landslide dam, which is called Kalopani landslide or Lete landslide. This landslide is inferred to be preceded by buckling deformation of calc gneiss. It is located near the lower margin of the glaciated area, and the slope could have been eroded by a glacier at the foot of the slope. Downstream of the Lete landslide are aligned 4 gigantic landslides, of which the most upstream one is the Talbagar landslide. It occurred on the left bank just downstream of an outstanding knickpoint of the Kali Gandaki River. This knickpoint propagated from downstream forming a slope break 200-400 m high from the riverbed. Talbagar landslide is a rock compound slide and the other three gigantic landslides were of two mica gneiss and occurred on slopes that had been toppled above the slope break.

There are two significant knickpoints along the Minjian River upstream of the Longmenshan fault. The effects of the knickpoint propagation and inner gorge formation on slope stability are dependent on the geometrical relationships between the river and geological structures. When the geological trend is normal or highly oblique to the river axis, landslides generally do not occur, but gigantic catastrophic landslides have occurred on one side of the Minjiang valley, which can be attributed to a wedge structure consisting of bedding planes and joints with intersections dipping valleyward and tight folds with hinges plunging valleyward. Diexi landslide, the largest landslide along the Minjian River was a wedge failure induced by this knickpoint migration.

キーワード：地すべり、チベット高原、ヒマラヤ、眠江、遷急点
Keywords: Landslide, Tibetan Plateau, Himalaya, Minjan, Knickpoint

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[E] 口頭発表 | セッション記号 H (地球人間圏科学)：H-DS 防災地球科学

2019年5月28日(火) 10:45 ~ 12:15 | 304 3F

[H-DS09] 地すべりおよび関連現象

コンビーナ:千木良 雅弘(京都大学防災研究所)、王 功輝(京都大学防災研究所)、今泉 文寿(静岡大学農学部)、座長:王 功輝、土井 一生

Mass movements, such as landslides, rockfalls, and debris flows, have been occurring extensively in a large number of countries, causing heavy damage. In order to understand them and mitigate induced disasters, we invite contributions that report and discuss on mass movements and related phenomena, focusing on improved understanding of their characteristics; new insights into landslide mechanisms; the development of new approaches to monitoring; novel approaches to behavior forecasting and prediction; studies of successful landslide management; and the development of methods for hazard and risk evaluation. In particular, papers about recent landslide hazards, induced by 2017 northern Kyushu rainstorm, 2018 Osaka earthquake, 2018 western Japan rainstorm, and 2018 Hokkaido earthquake are welcome.

10:45 ~ 11:15

[HDS09-07] Landslides caused by the 2018 Hokkaido Eastern Iburi Earthquake

★Invited Papers

*林 真一郎[1]、小山内 信智[1]、山田 孝[1]、桂 真也[1]、古市 剛久[1]、柳井 清治[2]、村上 泰啓[3]、宮崎 知与[4]、谷岡 勇市郎[1]、瀧口 茂隆[5]、宮崎 真由美[6] (1.北海道大学、2.石川県立大学、3.国立研究開発法人土木研究所寒地土木研究所、4.株式会社シン技術コンサル、5.国土交通省、6.株式会社パスコ)

11:15 ~ 11:45

[HDS09-08] On the coseismic landslides occurring on tephra slopes during the 2018 Hokkaido Eastern Iburi Earthquake

★Invited Papers

*王 功輝[1]、古谷 元[2] (1.京都大学防災研究所、2.富山県立大学)

11:45 ~ 12:00

[HDS09-09] Seismological and geotechnical surveys on the landslides induced by the 2018 Hokkaido Eastern Iburi earthquake

*土井 一生[1]、大澤 光[2]、松浦 純生[1] (1.京都大学防災研究所、2.筑波大学山岳科学センター)

12:00 ~ 12:15

Discussion

Landslides caused by the 2018 Hokkaido Eastern Iburi Earthquake

*林 真一郎[1]、小山内 信智[1]、山田 孝[1]、桂 真也[1]、古市 剛久[1]、柳井 清治[2]、村上 泰啓[3]、宮崎 知与[4]、谷岡 勇市郎[1]、瀧口 茂隆[5]、宮崎 真由美[6]
*Shin-ichiro Hayashi[1], Nobutomo Osanai[1], Takashi Yamada[1], Shin'ya Katsura[1], Takahisa Furuichi[1], Seiji Yanai[2], Yasuharo Murakami[3], Tomoyoshi Miyazaki[4], Yuichiro Tanioka[1], Shigetaka Takiguchi[5], Mayumi Miyazaki[6]

1. 北海道大学、2. 石川県立大学、3. 国立研究開発法人土木研究所寒地土木研究所、4. 株式会社シン技術コンサル、5. 国土交通省、6. 株式会社パスコ
1. Hokkaido University, 2. Ishikawa Prefectural University, 3. Civil Engineering Research Institute for Cold Region, PWRI, 4. Shin Engineering Consultant, Co., Ltd., 5. Ministry of Land, Infrastructure, Transport and Tourism, 6. Pasco Corporation

The 2018 Hokkaido Eastern Iburi Earthquake struck the eastern Iburi region (epicenter: 42.691˚N, 142.007˚E, depth: 37.0km) of Hokkaido, Japan, at 3:07.59 JST, September 6, 2018 (18:07.59, September 5, 2018 UTC). Many shallow landslides and several large-scale deep-seated landslides, generating a landslide dam in the Hidaka-horonai River, were triggered by this magnitude 6.6 M_w (6.7 M_j) earthquake. The sedimentary rock in the affected area was covered by thick pyroclastic fall deposits derived from the Tarumae Volcano etc.. Landslides were densely distributed over hilly regions (elevation: 200–400 m) within an area of approximately 400 km^2 in Atsuma, causing 36 deaths, Abira and Mukawa, and representing the largest total area of earthquake-related landslides in Japan since the Meiji Era (1868–1912). The shallow landslides were characterized as follows: 1) pyroclastic fall deposits on sedimentary rock (basement complex) were moved by the strong seismic shock, 2) slip surface types included weathered tephra, weathered bedrock, and buried humus layers, 3) many occurred at relatively gentle slopes (< 30˚), 4) shallow landslides moving along valley type topography tended to travel longer than those moving along planar slope topography, and 5) concentrated shallow landslides occurred in tributary catchments of the Atsuma and Abira Rivers. Large-scale deep-seated landslides were characterized as follows: 1) rare occurrence and 2) slip surface within sedimentary rock.

キーワード：平成30年北海道胆振東部地震、降下火砕物、表層崩壊、河道閉塞
Keywords: 2018 Hokkaido Eastern Iburi Earthquake, pyroclastic fall deposits, shallow landslide, landslide dam

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On the coseismic landslides occurring on tephra slopes during the 2018 Hokkaido Eastern Iburi Earthquake

*王 功輝[1]、古谷 元[2]
*Gonghui Wang[1], Gen Furuya[2]

1. 京都大学防災研究所、2. 富山県立大学
1. Disaster Prevention Research Institute, Kyoto University, 2. Toyama Prefectural University

Numerous landslides were triggered by 2018 Hokkaido Eastern Iburi Earthquake on the tephra slopes, resulting in 36 casualties. Although one large landslide was initiated with its sliding surface being in the bedrock of sandstone and siltstone, most of them occurred on the tephra slope. To understand the initiation and movement mechanisms of these landslides occurring on tephra slopes, we performed field investigation (including geophysical survey, penetration test and field director shear box tests), and also conducted dynamic shear tests on the tephra samples taken from the sliding surface. The results will be presented in this report.

キーワード：地震時地すべり、2018年北海道胆振東部地震、テフラ斜面、発生機構、運動機構
Keywords: Coseismic landslide, 2018 Hokkaido Eastern Iburi Earthquake, Tephra slope, Initiation mechanism, Movement mechanism

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Seismological and geotechnical surveys on the landslides induced by the 2018 Hokkaido Eastern Iburi earthquake

*土井 一生[1]、大澤 光[2]、松浦 純生[1]
*Issei Doi[1], Hikaru Osawa[2], Sumio Matsuura[1]

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Atsuma Town, central part of Hokkaido, Japan, suffered from numerous landslides induced by the 2018 Hokkaido Eastern Iburi earthquake (Mw 6.7). We had a seismological and geotechnical surveys on some of the landslides. We selected a shallow landslide within tephra layers and a huge landslide of rockslide. Aftershock observation was conducted to grasp the vibration characteristics of the large landslide. Frequency components of ~2 Hz were dominant for S- and coda parts, with long durations of monochroic vibrations. Surface wave surveys, in both active and passive ways, were deployed to understand the vertical profile of the shallow landslide area. Very low (~ 50 m/s) Vs layers with the thickness ~ 1 m, which were consistent to the landslide depth, were detected along the survey line beside the landslide area, while such layers did not exist inside the landslide.

Acknowlegement: Hirokazu Fukui, a graduate student in Kyoto University, helped us for conducting the surveys.

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[E] 口頭発表 | セッション記号 H (地球人間圏科学)：H-DS 防災地球科学

2019年5月28日(火) 13:45 ~ 15:15 | 304 3F

[H-DS09] 地すべりおよび関連現象

コンビーナ:千木良 雅弘(京都大学防災研究所)、王 功輝(京都大学防災研究所)、今泉 文寿(静岡大学農学部)、座長:今泉 文寿、千木良 雅弘

Mass movements, such as landslides, rockfalls, and debris flows, have been occurring extensively in a large number of countries, causing heavy damage. In order to understand them and mitigate induced disasters, we invite contributions that report and discuss on mass movements and related phenomena, focusing on improved understanding of their characteristics; new insights into landslide mechanisms; the development of new approaches to monitoring; novel approaches to behavior forecasting and prediction; studies of successful landslide management; and the development of methods for hazard and risk evaluation. In particular, papers about recent landslide hazards, induced by 2017 northern Kyushu rainstorm, 2018 Osaka earthquake, 2018 western Japan rainstorm, and 2018 Hokkaido earthquake are welcome.

13:45 ~ 14:15

[HDS09-10] Initiation conditions of debris flows in Ohsawa landslide, Mt. Fuji

★Invited Papers

*今泉 文寿[1]、山本 一樹[1]、池田 敦[4]、逢坂 興宏[1]、杉本 宏之[2]、鈴木 聡[2]、佐藤 慎一[2]、柏原 佳明[3]、西村 直記[3] (1.静岡大学農学部、2.国土交通省富士砂防事務所、3.アジア航測、4.筑波大学生命環境系)

14:15 ~ 14:30

[HDS09-11] 四万十付加体中の重力斜面変形と深層崩壊の発生に対する断層粘土を含む衝上断層の役割

*荒井 紀之[1]、千木良 雅弘[1] (1.京都大学防災研究所)

14:30 ~ 14:45

[HDS09-12] Control effect of huge faults on the structure of surrounding regional rock mass in the whole mountain: implications for the distribution pattern of coseismic landslides

*Chao HUANG[1,2]、Yusheng LI[1]、Chunhao WU[3]、Shujian YI[1,3]、Kai LIU[1,4]、Gonghui WANG[2] (1.State Key Laboratory of Geohazard Prevention and Geoenvironment Protection, Chengdu University of Technology, China、2.Disaster Prevention Research Institute, Kyoto University, Japan、3.Institute of Mountain Hazards and Environment, Chinese Academy of Sciences, China、4.China Railway Eryuan Engineering Group CO. LTD, China)

14:45 ~ 15:15

Discussion

Initiation conditions of debris flows in Ohsawa landslide, Mt. Fuji

*今泉 文寿[1]、山本 一樹[1]、池田 敦[4]、逢坂 興宏[1]、杉本 宏之[2]、鈴木 聡[2]、佐藤 慎一[2]、柏原 佳明[3]、西村 直記[3]
*Fumitoshi Imaizumi[1], Kazuki Yamamoto[1], Atsushi Ikeda[4], Okihiro Ohsaka[1], Hiroyuki Sugimoto[2], Satoru Suzuki[2], Shinichi Sato[2], Yoshiaki Kashiwabara[3], Naoki Nishimura[3]

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1. Faculty of Agriculture, Shizuoka University, 2. Fuji Sabo Office, Ministry of Land, Infrastructure and Transport, 3. Asia Air Survey Co., Ltd., 4. Faculty of Life and Environmental Sciences, Tsukuba University

土石流の発生は一般に降雨条件のみによって説明されることが多い。しかしながら，地盤が凍結する時期においては地盤の浸透性の低下が考えられ，それに伴い土石流の発生条件が変化する可能性がある。加えて積雪の有無や不安定土砂の堆積量も，土石流の発生条件に影響を及ぼす要因である。そこで，土石流頻発渓流であり，かつ高標高域であるために地盤の凍結期間が長い富士山大沢崩れにおいて，地盤の凍結および不安定土砂の堆積量が土石流の発生条件に及ぼす影響を検討した。また，あわせて富士山大沢崩れにおいて特徴的な現象であり，積雪時に確認されるスラッシュ雪崩の発生条件についても検討した。本研究では，過去の土石流発生降雨，非発生降雨それぞれにおいて，積雪の有無と凍結の有無の推定を試みた。積雪の有無はdegree-day法を用いて推定し，凍結の進行を積算寒度により，融解の進行を積算暖度により推定した。そして，地盤の凍結の有無，積雪・降雪の有無，不安定土砂の堆積量の大小に応じて過去約50年間の降雨を整理し，土石流の発生条件を求めた。その結果，地盤が凍結すると少ない降雨で，土石流・スラッシュ雪崩が発生することがわかった。また，地盤の非凍結時には不安定土砂量が多いほど，土石流が発生しづらいことがわかった。一方，積雪・降雪の有無による土石流やスラッシュ雪崩の発生条件の違いは明確でなかった。

キーワード：土石流、崩壊、富士山、凍土
Keywords: Debris flow, Landslide, Mt. Fuji, Frozen soil

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四万十付加体中の重力斜面変形と深層崩壊の発生に対する断層粘土を含む衝上断層の役割

The role of thrust faults with incohesive clayey fault materials to generate deep-seated gravitational slope deformations and catastrophic landslides in the Shimanto accretionary complex

*荒井 紀之[1]、千木良 雅弘[1]
*Noriyuki Arai[1], Masahiro Chigira[1]

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1. Disaster Prevention Research Institute,Kyoto University

The purpose of this study is to clarify the geological and geomorphological background of deep-seated catastrophic landslides (DCLs) and related gravitational slope deformations (DGSDs) that occur in mountain areas of accretionary complexes. We performed the detailed geological survey for the area of 25 km^2 in the Shimanto accretionary complex in the middle of the Kii Mountains, Japan. In this area, six DCLs were induced by the heavy rain of Typhoon Talas in 2011. Using the 1-m DTMs made from LiDAR data taken before and after the landslides by the Kinki Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism, and Nara Prefecture, we investigated the distribution of the thrust faults with the incohesive clayey fault materials in the mountain slopes and the inner structures of these thrusts. Mineralogy, permeability and shear strength were measured for the fault gouge.
As a result, we obtained the following results and conclusions.
1. Low-angle thrust faults with incohesive fault rocks thicker than approximately 1 m were newly found to develop at intervals of a few km in the study area.
2. Many of these thrust faults were different from previously reported thrust faults. The thrust faults with incohesive fault rocks include clayey crush materials that form a weak and impermeable layer, which becomes the base of a DGSD and would accommodate a sliding surface of a DCL.
3. The DGSDs and rain-induced DCLs in the study area preferentially occur in the hanging walls of those thrust faults and their areal alignments are controlled by the thrust faults.
4. Thrust faults commonly extend for kilometers as planar features but are sometimes locally folded with their nearby rocks. When a syncline involving thrust faults plunges valleyward, this structure also facilitates DGSDs.

キーワード：深層崩壊、重力斜面変形、断層粘土、付加体
Keywords: deep-seated catastrophic landslide, gravitational slope deformation, incohesive clayey fault material, accretionary complex

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Control effect of huge faults on the structure of surrounding regional rock mass in the whole mountain: implications for the distribution pattern of coseismic landslides

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Introduction

Earthquakes and earthquake induced landslides are the most threatening geological disasters in nature. Coseismic landslide, as a surface catastrophic effect induced by earthquakes, has drawn much scientific attention. The fact that seismic faults play a control role in the occurrence of landslide has been generally recognized. Many relating researches focused on the relationship between landslide distribution patterns and the distance to the co-seismic fault, peak ground acceleration (PGA) of the earthquake, and types of faults based on remote sensing interpretation and GIS method. Many statistical methods including fuzzy analytic hierarchy process, principal component analysis, and logistic regression, were used to evaluate landslide susceptibility in an earthquake event considering the main role of faults. However, how the faults affect the distribution patterns of coseismic landslides has not been clearly understood.Therefore, in this study we examined this issue based on a case study on the landslides triggered by the 2008 Wenchuan earthquake, in China.

Method

We selected Qingping part of Longmenshan faults generating the Ms 8.0 earthquake as a target region. First, measurements of rock mass structure were conduceted. In-situ field rock mass structure investigations, 2m*2m measurement network was used, in laboratory, fractures that were visible to the naked eye in the field were sketched and counted using a square frame (0.3 *0.3 m) along profiles oriented across the faults. Then fracture density was calculated to determine the characteristics of fractured system of the crustal rock mass in the fault zone area. Finally, Wenchuan earthquake landslides distribution patterns was combined to deeply discuss the effects of faults on landslides.

Result

The results of spatial variations in fracture density with increasing distance from the Jiangyou-Dujiangyan fault were shown in Fig 1. As can be seen in Fig. 1, fracture density is much higher in the faults zone than other areas and sharply decreases with further increase after it exceeds a certain distance (CD) from the main fault. In Yingxiu-Beichuan fault, this CD is 3030 m in hanging wall and 1170 m in footwall, while in Jiangyou-Dujiangyan fault, this CD is 1350m in the hanging wall. Fracture density also increases when subsidiary faults across. The results showed that occurrences of fractures are strongly concentrated around the faults zone, such as Yingxiu-Beichuan fault and Jiangyou-Dujiangyan fault, presence of secondary faults also has a strong relation with fracture density distribution. Most co-seismic landslides for wenchuan earthquake in the research area distributed on the concentration part of rockmass factures.

Discussion

In this study, we found that there are control effects confined to a certain range of huge faults on the surrounding regional rock mass structure, showing a great impact on rock mass structure in a large scale. A concept named “fracture zone” was defined to express this phenomenon.

The results suggest the existence of remarkable hanging wall effect of rock mass structure, since the width of fracture zone in the hanging wall is greater than that in the foot wall. The fracture zone of Yingxiu-beichuan fault hanging wall is much wider than that of Jiangyou-dujaingyan fault, indicating that

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there is a stronger control effect on rockmass structure of Yingxiu-beichuan fault compared with Jiangyou-dujaingyan fault.

Most co-seismic landslides for wenchuan earthquake distributed on the concentration part of rockmass factures, namely fracture zone. Distinct “hanging wall” effect of rockmass structure is consistent with the distribution pattern of coseismic landslides in the research area. Results indicate that the control effect has directly impacts on the distribution pattern of Wenchuan coseismic landslides

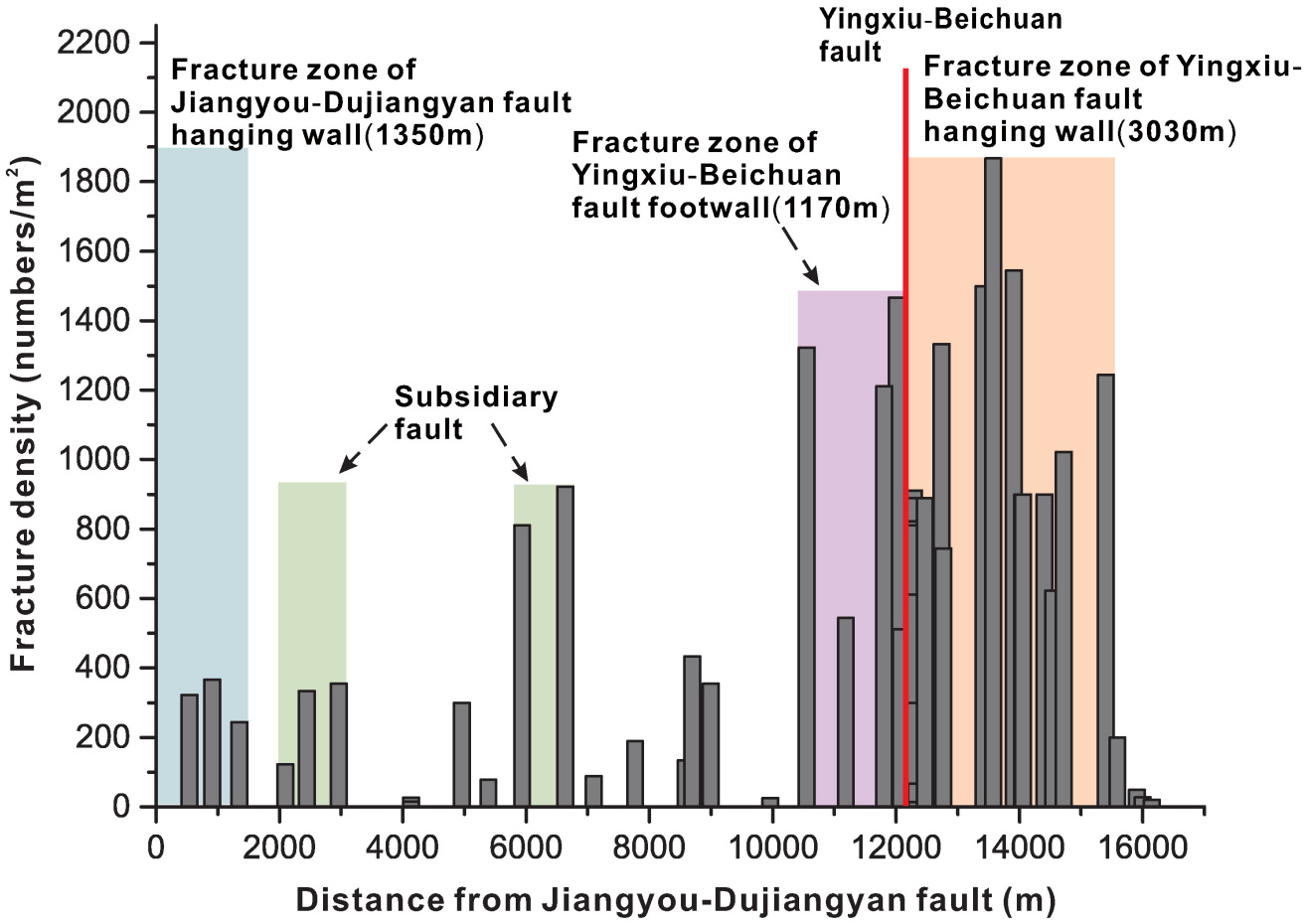
Conclusion

1. A control effect confined to a certain range of huge faults on the structure of surrounding regional rock mass in the whole mountain by using fracture density method, this effect was defined as “fracture zone” effect, which has directly impacts on the distribution pattern of Wenchuan earthquake induced landslides.
2. The control effect on surrounding regional rock mass structure were also founded in other huge faults, we argue that this effect is universal, which could be also suitable for other huge faults. The control effect marks long-term dangerous zones, since fragmented rock mass is vulnerable to subjected to failure, which has implications for disaster prevention in mountainous areas where faults are active.

Reference

Keefer, D. K. (1984). Landslides caused by earthquakes. GSA Bulletin 95(4): 406-42

Keywords: Huge fault, Rock mass structure, Coseismic landslide



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[E] 口頭発表 | セッション記号 H (地球人間圏科学)：H-TT 計測技術・研究手法

2019年5月28日(火) 9:00 ~ 10:30 | 302 3F

[H-TT18] 環境トレーサビリティー手法の開発と適用

コンビーナ:陀安 一郎(総合地球環境学研究所)、大手 信人(京都大学大学院情報学研究科社会情報学専攻)、Gabriel J Bowen(University of Utah)、座長:Nobuhito Ohte(Kyoto University)

現代社会は、自然界に存在するほとんどの元素を利用している。それをもたらす資源の持続的利用と環境に調和した社会の実現が叫ばれて久しいが、環境全体の質的改変に伴う人間圏の生存リスクは複合的に拡大している。そこで、自然環境の各要素や人間のつながりを診断・追跡する手法とその社会での広範な適用が必要になってきた。
　天然物や人工物を構成する各元素は、大気や水、生物などの地球の各圏および人間社会や人体の中に形を変えて移動している。多元素の濃度とその安定同位体比の情報は複雑な物質動態の追跡に有効であり、生態系サービスや大気水循環、生活や健康など人間を対象とする諸研究に利用されている。本セッションでは、その概念を環境トレーサビリティー手法と呼び、その開発とその適用例の情報交換を行う。
　本セッションでは「地球化学」「水文学」「生態学」「地質学」「鉱物学」「人類学」「食品科学（産地判別）」「科学捜査」など、専門的学問領域で活用されている同位体手法を、環境学の研究に利用する「同位体環境学」の視点での発表を歓迎する。特に、「Isoscapes」（面的同位体マップ）を用いた研究発表を期待する。

9:00 ~ 9:15

[HTT18-01] Environmental traceability methodology by multi-isoscapes

*陀安 一郎[1]、藤吉 麗[1]、藪崎 志穂[1]、SHIN Ki-Cheol[1]、中野 孝教[1]、谷口 真人[1] (1.総合地球環境学研究所)

9:15 ~ 9:45

[HTT18-02] Exploring physical and biological connections using isoscapes

★Invited Papers

*Gabriel J Bowen[1] (1.University of Utah)

9:45 ~ 10:00

[HTT18-03] Spatial and temporal variations in stable isotopes and soluble ions on high mountain snow surface of Mt. Tateyama, Toyama Prefecture, Japan

*竹内 望[1]、杉山 涼[1] (1.千葉大学)

10:00 ~ 10:15

[HTT18-04] Using Sr isotopes to determine the contribution of volcanic ash to Sr and Ca in stream waters in a chert watershed.

*越川 昌美[1]、渡邊 未来[1]、村田 智吉[1]、高松 武次郎[1]、三浦 真吾[1]、SHIN Ki-Cheol[2]、中野 孝教[2] (1.独立行政法人国立環境研究所、2.総合地球環境学研究所)

10:15 ~ 10:30

[HTT18-05] Influences of soil dust, sea salt and anthropogenic activities on ionic and Sr isotopic compositions of wet deposition in Iran

*横尾 頼子[1]、浅井 公輔[1]、堀井 彩衣[1]、安間 了[2]、Mehrabani Shiva[3]、申 基澈[4] (1.同志社大学理工学部、2.徳島大学、3.Kurdistan University、4.総合地球環境学研究所)

Environmental traceability methodology by multi-isoscapes

*陀安 一郎[1]、藤吉 麗[1]、藪崎 志穂[1]、SHIN Ki-Cheol[1]、中野 孝教[1]、谷口 真人[1]
*Ichiro Tayasu[1], Lei Fujiyoshi[1], Shiho Yabusaki[1], Ki-Cheol Shin[1], Takanori Nakano[1], Makoto Taniguchi[1]

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1. Research Institute for Humanity and Nature

Stable isotope ratios of elements, together with the concentrations of elements, can trace a matter flow, the environmental condition of sites, ecosystem structure and food products. Spatio-temporal variation of multiple isotope ratios can be used for studying the earth systems from local to global point of view. By using the traceability function of the multiple isotope ratios, we can conduct research that contributes to solving global environmental problems covering various regions and time scales. Spatio-temporal variation of multiple isotope ratios can be used for studying earth systems, ranging from local to global scales. The information may serve as a key decision- making factor for local people to consider water, food and environmental security, all of which are fundamental for the sustainability of human society.

We are conducting a research for establishing a methodology for how to use the concept of environmental traceability. A combination of quantitative and qualitative tools, including “Multi-Isoscapes” (use of multiple elements and multiple isotope ratios, together with GIS-based mapping technique), social surveys, and workshops, are deployed to investigate the role of environmental traceability in confronting environmental issues. We hypothesize that the role and perception of traceability methods in transdisciplinary processes will differ among stakeholders and that the co-production of “Multi-Isoscapes” can act as an effective “bridging tool” for understanding and explaining variation in local environments. The ultimate objective of this research is to demonstrate the effectiveness of multi-isotopic information in solving global environmental issues. Research is taking place at sites in Ono City, Fukui; Otsuchi Town, Iwate; Saijo City, Ehime; Oshino Village, Yamanashi; the Chikusa river watershed, Hyogo; Lake Biwa and Yasu river watershed in Shiga; and Silang-Santa Rosa sub-watershed in the Philippines.

キーワード：安定同位体、多元素同位体マップ、環境トレーサビリティー
Keywords: Stable isotopes, Milti-isoscapes, Environmental traceability

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Exploring physical and biological connections using isoscapes

*Gabriel J Bowen[1]

1. University of Utah

Environmental chemistry data provide a wealth of information on Earth system processes, but perhaps one of the most general and widely useful applications of such data is in to identify within- and between-system connectivity. Chemical signatures have been used to establish hydrological connectivity, identify the provenance of geological materials, artefacts and forensic evidence, and trace the migration of humans and other animals. Particularly useful are spatial and temporal patterns of environmental isotope variation, which are often predictable based on large-scale databases and/or fundamental physio-chemical theory. I will review case studies demonstrating how the resulting quantitative data products, called isoscapes, have led to new advances and applications in fields as diverse as forensic science, water resources research, and aquatic ecology. I will also discuss how community data and computational infrastructure, including the Waterisotopes Database (wiDB; http://waterisotopes.org) and Isoscape Modeling, Analysis and Prediction tool (http://isomap.org) are facilitating and promoting the use of geochemical data in connectivity research and related outreach and education.

Keywords: stable isotopes, traceability, connectivity, water resources, forensics, hydrology

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Spatial and temporal variations in stable isotopes and soluble ions on high mountain snow surface of Mt. Tateyama, Toyama Prefecture, Japan

*竹内 望[1]、杉山 涼[1]
*Nozomu Takeuchi[1], Ryo Sugiyama[1]

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A great amount of snow accumulates during winter in mountain regions in Japan due to strong westerly of the Asian monsoon. Snow can preserve various aerosols in the atmosphere, such as sea spay, anthropogenic pollutants, mineral dust, and volcanic substances. Thus, studies of snow chemistry provide a means to understand spatial and seasonal variabilities of aerosols. Furthermore, soluble chemists in snow affect alpine vegetations and also affect microbes growing on snow surface during snow melting season. In this study, we investigated spatial variations in water stable isotopes and major soluble ions on snow surface of high alpine area of Mt. Tateyama (2300 - 2700 m a.s.l.) from spring to summer to understand sources and transportation of aerosols affecting the surface snow chemistry. The soluble ion concentrations in the surface snow are generally higher in April, when the surface snow did not melt yet, than those in May to August, when the snow melted significantly. We found high anomaly in Cl and stable isotope in the area along a small valley, called Raicho-zawa throughout the seasons. They are likely to originate from an active volcanic fumarole, called Jigokudani, located in this area. Results shows that the chemical conditions of the snow surface in this mountain area are mostly influenced by sea spay and anthropogenic pollutants supplied by westerly before melting season, and are also partially influenced by the volcanic fumarole of the mountain throughout the melting seasons.

キーワード：積雪、安定同位体、溶存化学イオン
Keywords: snow, stable isotope, soluble ion

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Using Sr isotopes to determine the contribution of volcanic ash to Sr and Ca in stream waters in a chert watershed.

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The sources of Ca in forest ecosystems in Japan have been considered to be sea salt, weathering product of bedrock, and weak-acid soluble minerals in Kosa (Asian dust). However, we believe that volcanic ash in soil also plays an important contributor of Ca in areas with volcanic ash soil (e.g., Andosols), especially in the regions where the Ca supply from bedrock is anticipated to be low. We reported the significant contribution of volcanic ash in soil to Ca in stream waters and plants in a granite watershed of Tsukuba area, using stable isotope of Sr, a good proxy of Ca (Koshikawa et al. 2016). To evaluate the contribution of volcanic substances to soil-vegetation-stream systems, we conducted a similar study at the forest on Mount Amamaki where volcanic ash in soil would be more abundant than Tsukuba area and chert with high resistance to chemical weathering are widely distributed. In this presentation, we report the concentrations of Sr and Ca and the isotope ratio of Sr in the 42 stream waters, and those of precipitation, bedrock and volcanic ash which are considered to be the end component, and estimate the contribution of volcanic ash to Sr and Ca in stream waters.

キーワード：火山灰、Sr同位体比、渓流水、Ca供給源、チャート
Keywords: Volcanic ash, Sr isotopes, Stream water, Ca sources, Chert

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Influences of soil dust, sea salt and anthropogenic activities on ionic and Sr isotopic compositions of wet deposition in Iran

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We collected monthly wet deposition in four western cities (Hamedan, Ilam, Shiraz and Ahvaz) from January 2014 to May 2017 and in three eastern cities (Mashhad, Birjand and Zahedan) from January 2016 to May 2017 and in Rezvanshahr from May 2016 to May 2017 in Iran, and determined their pH values, electrical conductivity (EC), major ionic concentration (Na^+, Mg^{2+}, K^+, Ca^{2+}, Cl^-, NO_3^-, SO_4^{2-} and HCO_3^-) and Sr isotope ratios ($^{87}Sr/^{86}Sr$) in order to elucidate the influences of soil dust, sea salt and anthropogenic activities on wet deposition chemistry. In no-rainfall months, we rinsed the sampler with ultrapure water and collected it to understand the influence of aerosols. The climate in Iran is semiarid, and the dry and wet seasons are from June to September and from October to May, respectively.
The wet deposition and rinsed water samples in western and eastern Iran were neutral to slightly alkaline ranging from 6.26 to 9.04 and from 6.71 to 11.08 in pH, respectively. Those in Rezvanshahr were neutral to acidic ranging from 3.88 to 7.48 in pH. The ionic compositions of most precipitation samples were enriched in $Ca^{2+}$and HCO_3^-. Although the pH of natural rain in equilibrium state with atmospheric CO_2 is typically 5.6, precipitation in western Iran is not acidic because of neutralization by aeolian minerals such as calcite originating from arid areas. The $^{87}Sr/^{86}Sr$ of samples fell in a narrow range of 0.708±0.001. These values were most likely due to the dissolution of calcite. Small, but detectable seasonal variation was found in the $^{87}Sr/^{86}Sr$ ratio that suggests different provenances of calcite/gypsum controlled by changing wind direction.
The ionic compositions of several samples were abundant in NO_3^- and SO_4^{2-} in Hamedan, Ilam, Shiraz and Mashhad. These samples were collected during dry season and wet season immediately after the dry season. These results suggest that the samples dissolved NO_3^- and SO_4^{2-} derived from anthropogenic activities and/or soil dust such as sulfate minerals concentrated in atmosphere during the dry season. The ionic compositions of samples in Ahvaz, Rezvanshahr, Birjand and Zahedan were relatively enriched in Na^+ and Cl^-. Ahvaz and Rezvanshahr are closer to the Persian Gulf and the Caspian Sea, respectively. These indicate that the wet deposition samples in Ahvaz and Rezvanshahr are subject to salt from sea and salt lake.

キーワード：湿性降下物、イオン組成、Sr同位体比、西アジア
Keywords: wet deposition, ionic composition, Sr isotope ratio, West Asia

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[E] 口頭発表 | セッション記号 H (地球人間圏科学)：H-TT 計測技術・研究手法

2019年5月28日(火) 10:45 ~ 12:15 | 302 3F

[H-TT18] 環境トレーサビリティー手法の開発と適用

コンビーナ:陀安 一郎(総合地球環境学研究所)、大手 信人(京都大学大学院情報学研究科社会情報学専攻)、Gabriel J Bowen(University of Utah)、座長:Gabriel Bowen(The University of Utah)

現代社会は、自然界に存在するほとんどの元素を利用している。それをもたらす資源の持続的利用と環境に調和した社会の実現が叫ばれて久しいが、環境全体の質的改変に伴う人間圏の生存リスクは複合的に拡大している。そこで、自然環境の各要素や人間のつながりを診断・追跡する手法とその社会での広範な適用が必要になってきた。
　天然物や人工物を構成する各元素は、大気や水、生物などの地球の各圏および人間社会や人体の中に形を変えて移動している。多元素の濃度とその安定同位体比の情報は複雑な物質動態の追跡に有効であり、生態系サービスや大気水循環、生活や健康など人間を対象とする諸研究に利用されている。本セッションでは、その概念を環境トレーサビリティー手法と呼び、その開発とその適用例の情報交換を行う。
　本セッションでは「地球化学」「水文学」「生態学」「地質学」「鉱物学」「人類学」「食品科学（産地判別）」「科学捜査」など、専門的学問領域で活用されている同位体手法を、環境学の研究に利用する「同位体環境学」の視点での発表を歓迎する。特に、「Isoscapes」（面的同位体マップ）を用いた研究発表を期待する。

10:45 ~ 11:00

[HTT18-06] Long-term increasing trend of line-conditioned excess in groundwater

*勝山 正則[1] (1.京都大学農学研究科)

11:00 ~ 11:15

[HTT18-07] Geochemistry of river water in the Okayama and Tottori Prefectures, Japan

*山下 勝行[1]、亀井 隆博[1]、岸本 悠河[1]、森 雅彦[1]、大井 あや[2]、大西 彩月[2]、栗原 洋子[2]、千葉 仁[1]、中野 孝教[3]、SHIN Ki-Cheol[4] (1.岡山大学大学院自然科学研究科、2.岡山大学理学部、3.大野市、4.総合地球環境学研究所)

11:15 ~ 11:30

[HTT18-08] Study on groundwater flow system at Oshino Village in Yamanashi Prefecture – Report 5. Estimation of the residence time in spring water and groundwater at Oshino Village.

*藪崎 志穂[1]、谷口 真人[1]、陀安 一郎[1]、秋道 智彌[1]、大森 昇[2]、後藤 健[2]、渡邉 宗一郎[2]、渡辺 仁[2] (1.総合地球環境学研究所、2.忍野村役場)

11:30 ~ 11:45

[HTT18-09] The hydrogen and oxygen isotopic compositions of water in the Chikusa River

*大串 健一[1]、藪崎 志穂[2]、陀安 一郎[2]、藤吉 麗[2]、中野 孝教[2]、SHIN Ki-Cheol[2]、横山 正[3]、三橋 弘宗[4]、伊藤 真之[1]、八杉 和輝[1] (1.神戸大学、2.総合地球環境学研究所、3.兵庫県立赤穂特別支援学校、4.兵庫県立大学)

11:45 ~ 12:00

[HTT18-10] Dynamics of sulfate and nitrate inferred from stable isotope techniques in Chikusa river watershed, Hyogo Prefecture

*藤吉 麗[1]、陀安 一郎[1]、藪崎 志穂[1]、原口 岳[1]、由水 千景[1]、大串 健一[2]、古川 文美子[2]、伊藤 真之[2]、山本 雄大[3]、横山 正[4]、三橋 弘宗[5] (1.総合地球環境学研究所、2.神戸大学、3.名古屋大学、4.兵庫県立赤穂特別支援学校、5.兵庫県立大学)

12:00 ~ 12:15

[HTT18-11] Chemistry and sulfur and oxygen isotope ratios of sulfate ion of water soluble component of suspended particulate matter at Okayama city.

*千葉 仁[1]、山本 翼[1] (1.岡山大学自然科学研究科)

Long-term increasing trend of line-conditioned excess in groundwater

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The isotope composition in water is commonly used for the analysis of hydrological processes. According to the recently proposed two water world hypothesis, precipitation will separated into two water pools such as the stored portion in soil pore which is much evaporated and used by vegetation, and the rapidly infiltrated portion which is less affected by evaporation and recharge the stored ground- and stream water. The line-conditioned excess (or lc-excess) is an appropriate indicator to find these separation. This method defines the offset between a meteoric water line and each water samples, with a negative value indicate the effect of evaporation. The long-term observation of isotope composition is ongoing at the Kiryu Experimental Watershed (KEW). The isotope composition in the rain water does not have a clear increasing or decreasing trends for the observation period. The long-term trend of the lc-excess was also not found in soil water and shallow groundwater. On the other hand, the increasing trend of the lc-excess was found in deeper groundwater. This fact means that the effects of evaporation on the infiltrating water are decreasing. The d18O in the groundwater was slightly decreasing. If the global warming directly effects on the isotope composition in the groundwater, the d18O may increase. Thus, the decreasing d18O and the increasing lc-excess may be the results of the change of local hydrological processes. Recently, it is reported that the extreme rainfall events are increasing in Japan, including in KEW. Therefore, the trend of lc-excess in groundwater suggest that change of rainfall patterns cause the increase of rapid infiltration and recharge of groundwater body. Moreover, the long-term trend of groundwater isotope composition was observed at five locations, Hokkaido, Toyama, Yamanashi, Tottori, and Miyazaki prefectures in Japan and one location in California, USA using commercially available bottled waters. Within these locations, similar trend as KEW was found at Tottori and California. Although the depth and size of groundwater body and their residence time may effect on the patterns and trends of isotope composition, the results shown here suggest that the importance of the long-term monitoring of the groundwater. The effects of extreme rainfall events and vulnerability of each region should be evaluated based on the intensive observations at highly installed watersheds, as well as the utilization of easily available samples such as bottled waters.

キーワード：地下水、水の安定同位体、天水線、lc-excess、two water world仮説、極端豪雨現象
Keywords: Groundwater, Stable isotope in water, local meteoric water line, line-conditioned excess, two water world hypothesis, extreme events

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Geochemistry of river water in the Okayama and Tottori Prefectures, Japan

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In order to evaluate the effect of water-soil (rock) interaction, as well as human impact on the geochemical nature of river water, we have collected 695 river water samples from 454 locations in the Okayama and Tottori Prefectures, Japan. The area is ideal for such study because (1) the geology of the area is well studied, (2) there is a sharp contrast in the amount of precipitation between the southern Okayama and northern Okayama to Tottori, and (3) the population density is highly variable. We have measured the major dissolved components, trace element concentrations, and O-H isotope ratios for all of the samples, along with Sr and S isotope ratios of the selected samples. Using these data, the high-resolution geochemical maps of the two prefectures were constructed.
Both the oxygen and hydrogen isotope ratios display a clear altitude effect. The d-excess, on the other hand, is high in the northern Okayama and Tottori Prefectures (>20), and gradually decreases towards the southern Okayama (5~15). This pattern can be explained by considering the O-H isotopic signatures of the precipitation (e.g Mao 2017), as well as the difference in the amount of precipitation in the two areas. The concentration of some elements seems to correlate well with the type of rocks exposed in the area. For example, Ca and Sr concentrations are high in the areas where limestones are exposed, whereas Cr and Ni concentrations are generally high in the areas dominated by ultra-mafic rocks. In the Mt. Daisen area of the western Tottori Prefecture where dacitic volcanic rocks are common, the concentration of Si, V, Rb, Cs is high. These observations suggest that the concentration of some elements in the river water is strongly controlled by the geochemistry of rocks exposed in the area. The concentration of some dissolved constituents such as SO_4 and NO_3, on the other hand, seem to correlate well with the population density. This may imply that human activity (industrial and agricultural) is responsible for the elevation of SO_4 and NO_3 concentrations in the river water.

キーワード：河川水、岡山県、鳥取県
Keywords: River water, Okayama Prefecture, Tottori Prefecture

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Study on groundwater flow system at Oshino Village in Yamanashi Prefecture –Report 5. Estimation of the residence time in spring water and groundwater at Oshino Village.

Study on groundwater flow system at Oshino Village in Yamanashi Prefecture –Report 5. Estimation of the residence time in spring water and groundwater at Oshino Village.

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Oshino Village is located in southern part of Yamanashi Prefecture, Japan. The elevation is 936 m a.s.l. and the area of village is about 8 km from east to west and about 4 km from north to south. The Oshino Hakkai springs that is registered as World Cultural Heritage Site are located in Oshino Village. It is suggested that the Oshino Hakkai springs are recharged at Mt. Fuji as a result of field observation. The objective in this study to clarify the detailed groundwater flow and residence time of spring water and groundwater in Oshino Village. In this presentation, the authors will report about average residence time of groundwater and spring water.

The water samples for estimating the residence time by using the CFCs and SF_6 have been collected at 2 spring water sites, 1 shallow groundwater site and 11 deep groundwater sites. For ^{3}H analysis, water samples have been collected at 4 spring water sites and 4 deep groundwater sites. In this study, “shallow groundwater” is defined as several meters to some dozen meters depth, and “deep groundwater” is defined as about 100 m to 400 m depth.

As a result of analysis, the average residence time of spring water is about 10 to 26 years, shallow groundwater is about 30 to 40 years and deep groundwater is about 40 to 60 years. In addition, it is estimated that the average residence time of spring water which show the specific water quality ($Na\text{-}SO_4$ type, $\delta^{18}O$ and δD is relatively low) is more than 70 years. We will consider the relation between average residence time and water quality/ stable isotopes in future.

The continuous observation of water temperature and EC at 2 sites of Oshino Hakkai has been implemented since August, 2018. We will continue the field observation of Oshino village at 2019, and estimate the groundwater flow system and residence time more clearly.

キーワード：Oshino Village、groundwater、water quality、stable isotopes、groundwater flow、residence time
Keywords: Oshino Village, groundwater, water quality, stable isotopes, groundwater flow, residence time

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The hydrogen and oxygen isotopic compositions of water in the Chikusa River

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Chikusa River is the class B river facing the Seto Inland Sea in southwest Japan. Because of heavy rain, this river sometimes flows over and its basin is damaged, so Hyogo prefecture has carried out river reforming works to improve the capacity of flow until May, 2016. But the works changed the environment of this river, the impact on the quality of river water and the river ecosystem is concerned and we need the basic data of this river to measure this impact scientifically. In this study, we analyzed concentrations of dissolved ion and trace elements, stable isotopic ratio of water (δ2H, δ18O). In addition, we plotted the result of analysis on a basin map with a geographical information system so that the result could be seen easily and we aimed to offer the basic data which was easy to use. Furthermore, we estimated the formation factor of dissolved ion, trace elements and stable isotopic ratio of the river water through a comparison between the result of analysis and the land use, geological features and topography of the basin.
In Chikusa River, Chikusa River Conservation Committee has been holding “The simultaneous survey of water temperature all around Chikusa River” in every August since 2002. In this survey, the committee and many local residents measure water temperature at 94 sites, from headwaters to river-mouth and some tributaries. From 2015, Research Institute for Humanity and Nature, Kobe University and University of Hyogo has joined in this survey and started collecting water samples. In the survey of 2018 (held in August 5, 13:00~16:00), we received the water samples from local residents and we filtered them at once, with cellulose acetate filters whose diameters of holds are 0.2 μm. After filtering, we subdivided the samples into some polyethylene bottles and a glass vial and stored them at 20℃ or -30℃. We analyzed stable isotopic compositions of water. Stable isotopic composition of water was lower in the upstream and higher from the middle reaches to the downstream. From the upstream toward the middle reaches, the ratio became lower as the altitude became higher because of the precipitation affected by the altitude effects. On the other hand, the ratio was higher from the middle reaches to the downstream in spite of the altitude. These areas’ river became shallower and wider in the river reforming works, so the effects of sunlight on the river became big and the evaporation from the surface of river became more active.

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Dynamics of sulfate and nitrate inferred from stable isotope techniques in Chikusa river watershed, Hyogo Prefecture

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The Chikusa river watershed is located in the southwestern part of Hyogo prefecture. Recent river improvement in the watershed has posed concerns about changes in water quality and river ecosystem. This study aims to clarify the dynamics of dissolved ions especially sulfate and nitrate using stable isotope techniques, and to contribute to the evaluation of water environment in the watershed.

Water samples were collected from headwaters to the river mouth in August (2015, 2016, and 2017) and in February (2018), and measured ion concentrations, sulfur (δ^{34}S) and oxygen (δ^{18}O) stable isotope ratios of sulfate, and nitrogen (δ^{15}N) and oxygen (δ^{18}O) stable isotope ratios of nitrate.

Sulfate concentration was lower upstream and higher downstream in all periods, and the nearest point to the river mouth showed topically high concentration (1156 mgl^{-1}). The δ^{34}S and δ^{18}O values of sulfate suggested that the sulfate was mainly derived from soil sulfate, and the sulfate near the river mouth was derived from the seawater. In contrast, nitrate concentration was higher upstream and lower downstream in August, however the trend reversed in February. The δ^{15}N and δ^{18}O values of nitrate imply that the contribution of primary production and/or denitrification in water caused the reversed trend of nitrate concentration. The spatial distribution of δ^{15}N of nitrate showed a significant correlation with the proportion of fertilized land use (paddy field, farmland, and golf course) in all periods, suggesting an influence of fertilization.

キーワード：硫酸イオン、硝酸イオン、硫黄安定同位体、窒素同位体、酸素安定同位体、兵庫県千種川流域
Keywords: sulfate, nitrate, sulfur stable isotope, nitrogen isotope, oxygen stable isotope, Chikusa River watershed in Hyogo

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Chemistry and sulfur and oxygen isotope ratios of sulfate ion of water soluble component of suspended particulate matter at Okayama city.

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Suspended particulate matters (SPM and PM2.5) have been collected at Okayama University, Okayama city in order to elucidate their chemical nature, origin and relationship with sulfate ion in precipitation. SPM and PM2.5 were sampled once a month and duration of the sampling is 96 hours. Water soluble components of SPM and PM2.5 were extracted ultrasonically. Their chemical compositions were analyzed by ion chromatography and sulfur and oxygen isotope ratios were analyzed by EA-IRMS and TC/EA-IRMS, respectively.

Soluble components of PM and PM2.5 are overwhelmingly composed NH_4^+ and SO_4^{2-}, thus seems to be mainly $(NH_4)_2SO_4$. There is no significant compositional difference in SPM and PM2.5.

Sulfur isotopic ratio of sulfate in water soluble components in SPM and PM2.5 at Okayama city is high in winter and low in other seasons, similar to nss-sulfate in precipitation. However, their sulfur isotope ratios in autumn and winter are 1 to 2‰ higher than those of nss-sulfate in precipitation. High sulfur isotope ratios in winter seem to be affected by sulfur compounds originated from coal combustion in China. However, they are clearly lower than those of sulfate in total suspended particulate matter in Beijing (Han et al., 2016) and indicate that, even in winter, contribution of sulfur originated from coal-combustion in China seems to be small at Okayama city and local source may mainly contribute to sulfate of suspended particulate matter. Furthermore, sulfur isotope ratios of nss-sulfate in PM2.5 at Niigata city (Inomata et al., 2016) agree generally with our data at Okayama city.

Oxygen isotope ratios of soluble components in SPM and PM2.5 seem to be high in winter. Oxygen isotope ratios of nss-sulfate of precipitation is also high in spring. However, the cause of this phenomena is not clear now.

Present data suggests that the direct contribution of trans-border transport of SPM and PM2.5 from China is limited at Okayama city and/or that sulfur and oxygen isotope signatures of sulfate in water soluble components of SPM and PM2.5 are greatly altered during transport from China to Okayama.

キーワード：浮遊性粒子状物質の水溶性成分、岡山、硫酸の硫黄同位体比、硫酸の酸素同位体比
Keywords: Water soluble components of suspended particulate matter, Okayama, Sulfur isotope ratio of sulfate, Oxygen isotope ratio of sulfate

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[E] 口頭発表 | セッション記号 H (地球人間圏科学)：H-TT 計測技術・研究手法

2019年5月28日(火) 13:45 ~ 15:15 | 302 3F

[H-TT18] 環境トレーサビリティー手法の開発と適用

コンビーナ:陀安 一郎(総合地球環境学研究所)、大手 信人(京都大学大学院情報学研究科社会情報学専攻)、Gabriel J Bowen(University of Utah)、座長:陀安 一郎(総合地球環境学研究所)

現代社会は、自然界に存在するほとんどの元素を利用している。それをもたらす資源の持続的利用と環境に調和した社会の実現が叫ばれて久しいが、環境全体の質的改変に伴う人間圏の生存リスクは複合的に拡大している。そこで、自然環境の各要素や人間のつながりを診断・追跡する手法とその社会での広範な適用が必要になってきた。
　天然物や人工物を構成する各元素は、大気や水、生物などの地球の各圏および人間社会や人体の中に形を変えて移動している。多元素の濃度とその安定同位体比の情報は複雑な物質動態の追跡に有効であり、生態系サービスや大気水循環、生活や健康など人間を対象とする諸研究に利用されている。本セッションでは、その概念を環境トレーサビリティー手法と呼び、その開発とその適用例の情報交換を行う。
　本セッションでは「地球化学」「水文学」「生態学」「地質学」「鉱物学」「人類学」「食品科学（産地判別）」「科学捜査」など、専門的学問領域で活用されている同位体手法を、環境学の研究に利用する「同位体環境学」の視点での発表を歓迎する。特に、「Isoscapes」（面的同位体マップ）を用いた研究発表を期待する。

13:45 ~ 14:00

[HTT18-12] 登山家動物たちの種子散布は植物が温暖から逃れるのに有効か？

*直江 将司[1]、陀安 一郎[2] (1.国立研究開発法人　森林研究・整備機構　森林総合研究所、2.大学共同利用機関法人　人間文化研究機構 総合地球環境学研究所)

14:00 ~ 14:15

[HTT18-13] Spatial distribution of nitrogen stable isotope ratio in deer feces in an agro-environment, Osaka

*原口 岳[1]、幸田 良介[2]、陀安 一郎[1] (1.大学共同利用機関法人　人間文化研究機構　総合地球環境学研究所、2.大阪府立環境農林水産総合研究所)

14:15 ~ 14:30

[HTT18-14] 付着藻類の炭素窒素同位体比からみる富山県東部森林域から河川への栄養塩供給

*張 勁[1]、増田 亮介[1]、片境 紗希[1]、太田 民久[1]、稲村 修[2]、中川 書子[3] (1.富山大学、2.魚津水族館、3.名古屋大学)

14:30 ~ 14:45

[HTT18-15] Investigation on the possibility of the identification of air pollutant sources using stable isotope ratios of lead and strontium

*櫻井 伸治[1]、中桐 貴生[1]、田中 滉介[1]、堀野 治彦[1]、SHIN Ki-Cheol[2]、陀安 一郎[2]、藪崎 志穂[2] (1.大阪府立大学、2.総合地球環境学研究所)

14:45 ~ 15:00

[HTT18-16] Magnesium and zinc stable isotopes in stream ecology

*Kai Nils Nitzsche[1]、Yoshikazu Kato[1]、Ki-Cheol Shin[1]、Hiromitsu Kamauchi[1]、Ichiro Tayasu[1] (1.Research Institute for Humanity and Nature)

15:00 ~ 15:15

[HTT18-17] A mechanitic metabolic model of nitrogen stable isotope dynamics in trophic processes

*石井 励一郎[1]、相田 真希[2]、和田 英太郎 (1.総合地球環境学研究所、2.海洋研究開発機構)

登山家動物たちの種子散布は植物が温暖から逃れるのに有効か？
Do mountain-climbing mammals protect plants from global warming by their vertical seed dispersal?

*直江 将司[1]、陀安 一郎[2]
*Shoji NAOE[1], Ichiro Tayasu[2]

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1. Forestry and Forest Products Research Institute, Forest Research and Management Organization, 2. Research Institute for Humanity and Nature

Today, global warming is progressing rapidly, and attention is focused on how trees that make up the forest respond. The easiest and most powerful means for trees to escape from global warming is to move to colder areas, that is, higher altitude or latitude, by seed dispersal. Considering that the temperature drop with increasing altitude is one hundred to a thousand times larger than that of the equivalent latitudinal distance, vertical seed dispersal seems a key process for plant escape from warming temperatures. However, no study has evaluated vertical seed dispersal itself due to technical difficulty or high cost. By using negative correlation between altitudes and oxygen isotope ratio of seeds, we evaluated the vertical seed dispersal of summer-fruiting wild cherry and autumn-fruiting wild kiwi by mammals in central Japan. The results were contrasting: while seeds of cherry were dispersed toward mountain tops (by bear; mean +307.2, marten; +193.0 m), seeds of kiwifruit were dispersed toward the foot of mountains (by bear; -393.1, monkey; -98.5, raccoon dog; +4.5, marten; -226.9 m). These were probably because mammals followed plant phenology in temperate zone which proceeds from the foot to the top of mountains in spring to summer and from the top to the foot in autumn to winter. Downhill seed dispersal will likely lead to a serious population decrease of plants under global warming, because their performance is strongly reduced by novel competitive plants in the lower altitude environment. Considering that many of trees depend on animals and fruit in autumn to winter, forest composition in temperate zone might dramatically change under global warming due to biased vertical seed dispersal by animal.

キーワード：種子散布、温暖化、温帯林、哺乳類、サクラ、サルナシ
Keywords: seed dispersal, global warming, temperate forest, mammal, cherry, kiwi

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Spatial distribution of nitrogen stable isotope ratio in deer feces in an agro-environment, Osaka

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A rapid increase in the number of sika deer (*Cervus nippon*) in the last decades aroused needs for quantitatively estimating crop herbivory by them, in order to evaluate how much damage they cause to agriculture. Analysis of ingredients in deer feces using observation under microscopes or molecular techniques is useful to reveal whether they consumed crops. Nevertheless, these techniques in common tend to underestimate crop herbivory, because crops are usually digested more easily than wild plants and less likely to remain in the feces. Measurement of fecal nitrogen stable isotope ratio (fecal δ^{15}N) can be a complement to the molecular technique, considering that application of fertilizer leads to distinctively higher δ^{15}N values of crops than the adjacent wild plants. In our previous study using captive deer individuals, we estimated the fecal δ^{15}N values are 2.0 to 3.5‰ lower than those of deer diets. Based on the test using captive individuals, the uncertainties of the fecal δ^{15}N values associated with the variations in isotopic fractionation were far less than the difference of δ^{15}N values between fertilized crops and wild plants. In this study, for a field validation of the fecal δ^{15}N measurements as an indicator of crop consumption, we examined the spatial distribution of the fecal δ^{15}N, assuming the crop consumption should occur in the individuals of sika deer inhabiting close to cropland.

Deer feces were collected in 80 forested sites in the northern part of Osaka prefecture in the 2014 to 2015 winter period. The fecal samples, which were dried at 60℃, ground, and homogenized for each of the fecal mass, were used for δ^{15}N measurements. Based on GPS telemetry of sika deer in the region (Ishizuka et al., 2007), we assumed that short-time moving range of sika deer is around 500 m in radius and the accessibility of crops for the deer is reflected by surrounding land use within the distance from sampling points. Land use surrounding sampling points were categorized into four components; forest, crop field, herbal vegetation, residential area and area of each component were calculated. Land use data are obtained from MoE National Surveys on the Natural Environment and area (m^2) of the surrounding sampling points. We conducted Spatial AutoRegressive model (SAR) and PCNM-RDA analyses to analyze the effects of surrounding areas of these landscape components on the fecal δ^{15}N values and concentrations of nitrogen in the feces.

The surrounding area of crop field was selected as a single variable to explain the fecal δ^{15}N values, and the positive correlation between the fecal δ^{15}N values and crop field area indicated the availability of crop to deer was a factor of the increase in the fecal δ^{15}N values. Based on the result, this study supported our hypothesis that fecal δ^{15}N values are an effective indicator of crop consumption by sika deer. In our presentation, we will further discuss about the relationships among concentration of nitrogen in the feces, which is known as an indicator of nutritional status of the defecated individual, estimated deer population density, and land use to elucidate factors inducing crop consuming behavior of sika deer.

キーワード：鳥獣管理、空間解析、バイオロギング
Keywords: wildlife control, spatial analysis, biologging

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付着藻類の炭素窒素同位体比からみる富山県東部森林域から河川への栄養塩供給

Nutrient supply from forest to river in eastern Toyama: carbon and nitrogen isotopic composition of Epilithic Organic Matter

*張 勁[1]、増田 亮介[1]、片境 紗希[1]、太田 民久[1]、稲村 修[2]、中川 書子[3]
*JING ZHANG[1], Ryosuke Masuda[1], SAKI KATAZAKAI[1], Tamihisa Ohta[1], OSAMU INAMURA[2], Fumiko Nakagawa[3]

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1. University of Toyama, 2. Uozu Aquarium, 3. Nagoya University

森林域から河川への栄養塩供給を明らかにするため、人為的影響が少ない富山県東部の河川上流部に着目して研究を行った。試料は河川水と付着藻類を用い、水の主要化学成分濃度、水素・酸素安定同位体比、付着藻類の炭素・窒素安定同位体比を測定し、その結果とGISで得られた地形データや植生図等を合わせて解析した。結果は下記のとおりである。

1）河川水の酸素・水素安定同位体比から、河川水は夏季と冬季の降水標高300～2000mの山間の涵養域で、良く混合して形成されていた。
2）10月の付着藻類のδ13CとCa、HCO3濃度の間に相関関係があり、Caは炭酸塩鉱物（CaCO3）の風化によって河川へ供給されることと分かった。また、Ca、Na、K、Mg濃度は針葉樹割合と有意な正の相関関係を示し、降水が森林域を通過して付加され、河川水ではCaで200倍、Naで6倍、Kで8倍、Mgで10倍程度になった。
3）河川水の硝酸濃度と常緑樹割合に負の相関関係があり、硝酸態の酸素安定同位体比（Δ17O）から河川水中の硝酸の9割以上が森林由来であることから、降水中の硝酸の多くは森林内でトラップされ、再利用されたのちに河川へ流出していると考えられた。
4）河川水中の硝酸を利用して数日～数週間の窒素供給情報を”記録する”可能性がある付着藻類のδ15Nは、標高1500mを境に異なる傾向を示し、集水域内の植生による影響を受けている可能性が考えられた。また、そのδ15Nは涵養域内の常緑樹割合と正の相関関係が認められ、植生は河川への硝酸流出に影響があると示唆された。

キーワード：付着藻類、炭素窒素同位体比、栄養塩供給、森林域、富山県東部
Keywords: Epilithic Organic Matter, carbon and nitrogen isotopic composition, nutrient supply, forest area, eastern Toyama

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Investigation on the possibility of the identification of air pollutant sources using stable isotope ratios of lead and strontium

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*Shinji Sakurai[1], Takao Nakagiri[1], Kosuke Tanaka[1], Haruhiko Horino[1], Ki-Cheol Shin[2], Ichiro Tayasu[2], Shiho Yabusaki[2]

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In Japan, transboundary air pollution coming from neighboring countries is concerned as one of the serious threads on the health. However, it is not easy to assess the actual impact because of difficulty to identifying the detailed transport path and the source of pollutants. Although it is expected that stable isotope ratios (hereafter, isotope ratios) of lead (Pb) and strontium (Sr) can be used as environment tracers to identify the pollutant source, even the basic information on their characteristics such as chronological and/or seasonal variations at resolution of rainfall event as well as the relationship between the ratios and other water quality parameters is still not enough to consider the possibility.
In our study, rainwater was collected in a polyethylene bottle, on the top of which a polypropylene funnel was set, separately in every rainfall event from June 2016 to August 2018 at the campus of Osaka Prefecture University in Sakai, Osaka, Japan. The isotope ratios of Pb and Sr ($^{207}Pb/^{206}Pb$, $^{208}Pb/^{206}Pb$, and $^{87}Sr/^{86}Sr$) in the rainwater samples were measured using a multi-collector inductively coupled plasma mass spectrometer. Concentrations of heavy metals (Fe, Mn, Cd, Cu, Ni, and Pb), inorganic ions, pH, EC, TOC, COD, T-N, and T-P were measured as water quality parameters. Rainfall amount was measured with a rain gauge set near the rainwater sampling point. Other meteorological data needed to investigate and estimate the pollutant sources, such as air temperature, wind direction, and duration of drought, were obtained from the Japan Meteorological Agency.
There was no obvious trend either chronologically or seasonally for $^{207}Pb/^{206}Pb$ or $^{87}Sr/^{86}Sr$. The values of the $^{207}Pb/^{206}Pb$ ratio declined slightly during the observation period, but the $^{87}Sr/^{86}Sr$ ratio did not show this chronological variation.
There was no obvious correspondence between most of water quality parameters and each isotope ratio. The $^{207}Pb/^{206}Pb$ varied widely during events in which Cr and Fe concentrations were low, but was close to 0.871 as the concentrations of these metals were getting higher. There is similar tendency in $^{87}Sr/^{86}Sr$ for Fe and Cr. It was suggested that these metals might be derived from the same source.
For correspondence with meteorological factors, the monthly rainfall amount weighted average of $^{207}Pb/^{206}Pb$ fluctuated when the wind from the west or the west-southwest was dominant, while it took almost a unique value for the south-southwest. It was suggested that Pb was originated from various sources with the west wind.
Plots of the obtained data on the $^{207}Pb/^{206}Pb$ vs. $^{208}Pb/^{206}Pb$ were distributed upside and parallel to the lead isotope growth curve. When comparing our plots with the previous global studies, we found that ours were distributed in a manner similar to those from China and Russia. It was indicated that it is difficult to identify pollutant sources from these countries, which are thought to cause transboundary pollution in Japan.
Further research, including the collection of data on isotope ratios as environmental tracers, is necessary to identify pollutant sources using isotope ratio of Pb and/or Sr.

キーワード：安定同位体比、大気汚染、重金属、鉛、ストロンチウム、雨水

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Keywords: stable isotope ratio, air pollution, heavy metal, lead, strontium, rainwater

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Magnesium and zinc stable isotopes in stream ecology

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1. Research Institute for Humanity and Nature

Magnesium (Mg) and zinc (Zn) play important roles in biological production in stream ecosystems. Aquatic organisms take up metals from the diet and the water; however, relative contributions are largely unknown, which is assumed to depend on feeding habits. We determined Mg and Zn stable isotope ratios (δ^{26}Mg, δ^{66}Zn) of aquatic macroinvertebrates and of small goby, and their potential Mg and Zn sources (periphyton, plant litter, stream water) from upper and lower reaches of two temperate streams in the Lake Biwa catchment. Our goal was to understand Mg and Zn sources to aquatic organisms, and to explore δ^{26}Mg and δ^{66}Zn variations across feeding habits. δ^{26}Mg and δ^{66}Zn did not correlate with each other indicating that Mg and Zn sources differ across functional feeding groups and/or different degrees of isotopic fractionation during Mg and Zn uptake. Grazers, shredders and predators showed offsets to higher δ^{26}Mg values compared to metal sources indicating isotope fractionation during Mg accumulation, while stream water was the main Mg source to filter-feeders. In contrast, δ^{66}Zn of grazers and filter-feeders indicated Zn was often a mixture between periphyton and stream water, while δ^{66}Zn of shredders and predators gave evidence for Zn isotopic fractionation. Our results demonstrate the usefulness of applying non-traditional isotopes to understand metal sources to aquatic organisms, which could be used to trace the ultimate origin of metals from the catchment.

Keywords: Aquatic animals, Stream food web, Magnesium, Zinc, Non-traditional isotopes

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A mechanitic metabolic model of nitrogen stable isotope dynamics in trophic processes

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1. Research Institute for Humanity and Nature, 2. Japan Agency for Marine-Earth Science and Technology

Stable isotope analysis of nitrogen and carbon have been a powerful tool used for identifying trophic structure of ecosystems. Our previous studies suggested that the ratios of trophic fractionation of carbon and nitrogen isotopes ($Dd^{15}N/Dd^{13}C$) throughout food chain are similar in various ecosystems (Aita et al. 2011, Wada et al. 2013), although the general mechanisms determining isotopic incorporation rates and discrimination factors are not understood mechanistically yet. On the other hand, recent studies revealed the 15N enrichment factor for trophic processes varies among amino acids from which new method of estimation of the trophic level of animal samples (e.g., Chikaraishi et al. 2009).
Based on these observations, we developed a simple dynamic model of the isotopic fractionation in nitrogen metabolic processes that are common to animals composing most grazing food chains. Particularly, we focused on and incorporated the transamination and deamination processes of two classes of amino acid, essential and non-essential, respectively into the model. With this model we investigated how d15N signatures of the two amino acid classes and whole-body change. Preliminary result suggests that the instant isotopic composition of animals are sensitive to the change of their diet composition and growth rate, but on the other hand, the isotopic composition converges as the integrating period becomes long. Based on this model we will discuss possible negative feedback processes in isotopic enrichment for nitrogen to explain the commonly observed trophic-step 15N-enrichment factor through many food chains.

キーワード：代謝モデル、窒素安定同位体、生態学的条件
Keywords: metabolic model, nitrogen stable isotope, ecological conditions

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[E] 口頭発表 | セッション記号 H (地球人間圏科学)：H-CG 地球人間圏科学複合領域・一般

2019年5月28日(火) 15:30 ~ 17:00 | 302 3F

[H-CG28] Implementing Integrated Research for Sustainable Future

コンビーナ:氷見山 幸夫(北海道教育大学名誉教授)、近藤 昭彦(千葉大学環境リモートセンシング研究センター)、櫻井 武司(国立大学法人東京大学大学院農学生命科学研究科)、阿部 健一(総合地球環境学研究所)、座長:Ernan Rustiadi(Bogor Agricultural University)、王 勤学(国立環境研究所)、takeshi sakurai

The world global environmental studies are being re-organized in the framework of Future Earth, which is considered to be an important driver to achieve the Sustainable Development Goals (SDGs) set by UN in 2015. Geoscience, which has traditionally been concerned about the dynamic nature and phenomena of the Earth, including lithosphere, hydrosphere, atmosphere and biosphere, is now increasingly committed to human sphere and human dimensions of global change, assuming unique roles in Future Earth and the SDGs. The session is intended to discuss the crucial issues related with them, particularly in reference to such SDGs as good health and well-being, quality education, clean water and sanitation, sustainable cities and communities, climate action, life below water and life on land. Those interested in Future Earth, SDGs, and ESD (Education for Sustainable Development) particularly those who have already started or are about to start related projects, or are interested in Future Earth Knowledge-Action Networks (KANs), such as Ocean, Food-Water-Energy Nexus, Health, Disasters, Cities, Natural Assets, will find this Session an ideal place to present his/her research results, to exchange information and ideas, and to seek new collaborative relations with other research groups and even with partners in the society.

15:30 ~ 15:45

[HCG28-01] Implementing Integrated Research for Sustainable Future - a human geoscience perspective

*氷見山 幸夫[1] (1.北海道教育大学名誉教授)

15:45 ~ 16:00

[HCG28-02] **Application of environmental carrying capacity analysis and land cover change scenarios in collaborative spatial planning process: The Jakarta Megacity Case**

★Invited Papers

*ERNAN RUSTIADI[1]、Andrea Emma Pravitasari[2]、Diar Shiddiq[1]、Laode Syamsul Iman[1]、Setyardi Pratika Mulya[2]、Mia Ermyanila[1]、Nur Etika Karyati[1] (1.Center for Regional System Analysis, Planning and Development, Bogor Agricultural University 、2.Department of Soil Science and Land Resource, Faculty of Agriculture, Bogor Agricultural University)

16:00 ~ 16:15

[HCG28-03] Does the Market Economy Save the Local Natural Resources While Improving Human Welfare? The Case of 101 Natural Forests in the Middle Hills of Nepal

*櫻井 武司[1]、橘 永久[2]、Rayamajhi Santosh[3] (1.東京大学、2.千葉大学、3.Tribhuvan University)

16:15 ~ 16:30

[HCG28-04] Academic-public-private partnerships for sustainable herding under increasing frequency of climate hazards

*篠田 雅人[1] (1.名古屋大学大学院環境学研究科)

16:30 ~ 16:45

[HCG28-05] 現代北京市における公墓を主体とする死後の土地利用と市民の葬送

*土居 晴洋[1]、柴 彦威[2]、徐 培瑋[3] (1.大分大学教育学部、2.北京大学、3.北京師範大学)

16:45 ~ 17:00

[HCG28-06] Restoration and sustainable land management of degraded landscapes in Asia and Africa

★Invited Papers

*大黒 俊哉[1] (1.東京大学大学院農学生命科学研究科)

Implementing Integrated Research for Sustainable Future - a human geoscience perspective

Implementing Integrated Research for Sustainable Future - a human geoscience perspective

*氷見山 幸夫[1]
*Yukio Himiyama[1]

1. 北海道教育大学名誉教授
1. Emeritus Professor, Hokkaido University of Education

Global environmental programmes are re-organized under the framework of Future Earth, which is intend to play a leading role in guiding or coordinating world research communities for sustainability. Human geoscience, which has been built on geoscience which studies dynamic nature and phenomena of the Earth including its resources, geo-hazards and environmental changes, is uniquely committed to human sphere, where human, the environment, environmental problems and disasters are, and to the world sustainability. It hence has strong human/social scientific, as well as physical scientific, viewpoint, and assumes important roles in Future Earth, SDGs (Sustainable Development Goals), and other programmes for global sustainability or disaster risk reduction. This session is intended to discuss crucial issues related with them, and to seek right ways to implement needed integrated research for sustainable future in human geoscience perspective.

キーワード：フューチャーアース、持続可能な開発目標、持続可能性、地球人間圏科学、災害、環境問題
Keywords: Future Earth, SDGs, sustainability, human geoscience, disaster, environmental problem

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Application of environmental carrying capacity analysis and land cover change scenarios in collaborative spatial planning process: The Jakarta Megacity Case

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In the National Spatial Plan, the Jabodetabekpunjur area (Jakarta Megacity) is designated as a national strategic area. Due to the increasing environmental problems, the Indonesian government carried out a revision process of spatial plan based on an environmental carrying capacity assessment. This research is intended to explain how the study of land-based carrying capacity assessment was applied to the spatial planning process. First, this research is carried out by developing scenarios for land cover changes. Projections of land use change are carried out by extrapolating 20-year time series data on land cover change backward to forecast 20 years of future land use. The study of environmental carrying capacity against current and future conditions is based on the concept of land capability, land suitability, and multi-criteria analysis. The results of the study of carrying capacity were then used to revise existing spatial plans. The decision-making process on revising spatial plan was carried out by a collaborative process involving relevant stakeholders in serial workshop processes by considering the results of the carrying capacity study.

Keywords: urban sprawl, land capability, land use cover changes, regional planning

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Does the Market Economy Save the Local Natural Resources While Improving Human Welfare? The Case of 101 Natural Forests in the Middle Hills of Nepal

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To pursue a sustainable human development, while expanding human frontiers into space, we need to conserve the natural environment of our mother planet. In low-income countries, deterioration of local natural resources such as forests for firewood, inshore fishery for home and local consumption has been the most urgent environment issue. Various measures have been taken to stem excessive harvesting of local natural resources in the course of the population increase: e.g., community management. Little attention has been paid, however, to the seemingly most powerful lifesaver for the overuse of local natural resources: the market economy. Out-migration from the marginally productive rural areas along with the investments in urban areas would attain both the conservation of natural resources and improvements in human welfare. With 101 randomly-sampled natural forests in the Middle Hills of Nepal, we compare the impacts of community management and those of out-migration on forest conditions. Forest condition was evaluated by forest inventory conducted in 1997-1999 and 2014-2016.

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Academic-public-private partnerships for sustainable herding under increasing frequency of climate hazards

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Socio-ecological damage from climate-related disasters has increased worldwide, including a slow-onset cold-season disaster that is unique to Mongolia, known as *dzud*. *Dzuds* are defined, bio-geophysically, as anomalous climatic and/or land-surface (i.e. snow) conditions that lead to reduced accessibility and/or availability of pastures, and ultimately to significant livestock mortality during winter–spring. Our studies showed that recent *dzuds* were caused by a half-to-half combination of multi-climate hazards and man-made vulnerability, including inadequate pasture management, poverty, and insufficient winter preparedness. With this background, for the first time, our academia produced a new *dzud* risk map to predict risky areas at the national level for the 2015/2016 winter. Subsequently, the early warning system developed together with the risk map has been implemented and successfully applied for sustainable herding under the framework of partnerships among universities/research institutes, Mongolian government, international aid organizations, and herders. This action was supported by the Grant-in-Aid for Scientific Research from the Japan Society for the Promotion of Science ‘Integrating Dryland Disaster Science’ and nominated as a top case study of early warning early action at the Asian Ministerial Conference on Disaster Risk Reduction in July 2018.

キーワード：Transdisciplinary approach、Disaster risk map、Climate disaster、Livestock mortality、Mongolia
Keywords: Transdisciplinary approach, Disaster risk map, Climate disaster, Livestock mortality, Mongolia

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現代北京市における公墓を主体とする死後の土地利用と市民の葬送
Land use after death and funeral of citizen mainly based on public cemeteries in modern Beijing city

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人はその死後，残された親族などによって，一定の土地を占有することによって墓地を築く。したがって，経済成長と人口増加が続く中国の都市地域では，死者のために利用される土地への需要が大きいため，土地資源の管理の一環として墓地面積の拡大をコントロールすることが重要な政策課題である。

現代の北京市では，増加する死後の土地利用への需要に対応するため，ここ数十年の間に市内各地に大規模な公墓が整備されてきた。これらの公墓は市街地に比較的隣接する農村地域や郊外地域の風水上の適地などに立地している（土居・柴，2017）。

本報告は，現代の北京市において，これら公墓の整備の経緯や周辺農村コミュニティとの関係について考察する。また，漢民族以外の少数民族の葬送と公墓の関係についても考察する。

キーワード：都市政策、郊外農村、民族
Keywords: Urban policy, suburban rural areas, ethnic group

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Restoration and sustainable land management of degraded landscapes in Asia and Africa

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Land degradation causes reduction or loss of the biological or economic productivity and complexity, resulting from land uses or from processes arising from human activities and habitation patterns. As land degradation is also defined as “the processes of landscape changes caused by miss-match between natural land conditions and land use by human”, it is necessary to reconstruct new land use systems based on new human-environment relations which can realize sustainable use of ecosystem services. This paper introduces case studies on the sustainable land management (SLM) approaches, focusing on human-environment relations, or social-ecological systems in rangelands of Asia and Africa. Firstly, I show a modelling of trade-offs in ecosystem services and assessment of effectiveness of countermeasures on land restoration. Secondly, I show a concept and methodology of grassland management systems in consideration of biodiversity-ecosystem functioning relationships. Finally I propose future perspectives, possible research topics which should be further developed, and implication to SDGs.

キーワード：social-ecological system、threshold、biodiversity、ecosystem functioning、sustainable land management、non-equilibrium
Keywords: social-ecological system, threshold, biodiversity, ecosystem functioning, sustainable land management, non-equilibrium

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[E] 口頭発表 | セッション記号 S (固体地球科学)：S-SS 地震学

2019年5月28日(火) 13:45 ~ 15:15 | コンベンションホールB 2F

[S-SS06] Nankai Trough Seismogenic Zone Experiment: Logging and sampling the seismogenic megathrust

コンビーナ:金川 久一(千葉大学大学院理学研究科)、Demian M Saffer(Pennsylvania State University)、木下 正高(東京大学地震研究所)、座長:金川 久一(千葉大学大学院理学研究科)、Saffer Demian(Department of Geosciences, Pennsylvania State University)、木下 正高(東京大学地震研究所)

The Nankai Trough Seismogenic Zone Experiment (NanTroSEIZE) is a multidisciplinary investigation of fault mechanics and seismogenesis along the megathrust at the Nankai Trough subduction zone, and includes reflection and refraction seismic imaging, direct sampling by drilling, in situ measurements, and long-term monitoring in conjunction with laboratory and numerical modeling studies. During the past 12 IODP expeditions off Kii Peninsula since 2007, 15 sites have been drilled by D/V "Chikyu" down to depths from 100s of meters to more than 3000 meters below seafloor, where the inner and outer wedge of the Nankai margin has been logged and sampled extensively, and three state-of-the-art real-time downhole observatories are now in operation. The final NanTroSEIZE expedition aiming to log and sample the seismogenic megathrust at ~5200 meters below seafloor is now ongoing from October, 2018 to March, 2019.
In this session, we expect presentations not only on scientific outcomes from the past NanTroSEIZE expeditions, but also on the exciting preliminary results of the final NanTroSEIZE expedition. We welcome presentations on, but are not limited to, seismic imaging, borehole logging and monitoring, chemical analyses of pore water and mud gas, lithology, structures, physical properties and laboratory experiments of cuttings and core samples, and theoretical and numerical modeling.

13:45 ~ 14:00

[SSS06-01] Geoscientific information about plate boundary along the Nankai Trough provided by the GNSS-A

★Invited Papers

*横田 裕輔[1]、石川 直史[2] (1.東京大学生産技術研究所、2.海上保安庁海洋情報部)

14:00 ~ 14:15

[SSS06-02] Deep Drilling at the Nankai Trough: IODP NanTroSEIZE Expedition 358 Summary and First Results

★Invited Papers

*Harold Tobin[1]、Takehiro Hirose[7]、Matt Ikari[5]、Kyuichi Kanagawa[10]、Gaku Kimura[3]、Masataka Kinoshita[8]、Hiroko Kitajima[6]、Demian M Saffer[4]、Asuka Yamaguchi[9]、Lena Maeda[2]、Nobu Eguchi[2]、Sean Toczko[2] (1.Department of Earth and Space Sciences, University of Washington、2.JAMSTEC-CDEX、3.Tokyo Un. of Marine Science-Technology、4.Penn State University、5.MARUM Un. of Bremen、6.Texas A&M University、7.JAMSTEC-KCC、8.Un. of Tokyo Earthquake Research Institute、9.Un. of Tokyo AORI、10.Chiba University)

14:15 ~ 14:30

[SSS06-03] Coexistence of soft and hard sediments at deep Nankai accretionary prism, NanTro SEIZE Project, IODP Exp.358

*坂口 有人[1,2]、Michael Strasser[3]、浜橋 真理[4,5]、廣瀬 丈洋[2]、北島 弘子[6]、Expedition 358 Scientists IODP (1.山口大学、2.海洋研究開発機構、3.University of Innsbruck、4.東京大学、5.Nanyang Technological University、6.Texas A&M University)

14:30 ~ 14:45

[SSS06-04] Active and passive seismic experiment during the IODP Exp. 358 deep riser drilling in the Nankai Trough, Japan

*木村 俊則[1]、利根川 貴志[1]、白石 和也[1]、荒木 英一郎[1]、中村 恭之[1]、海宝 由佳[1]、藤江 剛[1]、三浦 誠一[1]、小平 秀一[1]、櫻井 紀旭[1]、真田 佳典[1]、木戸 ゆかり[1]、木下 正高[2]、高橋 成実[3,1]、町田 祐弥[1]、西田 周平[1] (1.国立研究開発法人海洋研究開発機構、2.東京大学地震研究所、3.国立研究開発法人防災科学技術研究所)

14:45 ~ 15:00

[SSS06-05] Microfabric analysis of damaged zone of principal shear zone in the frontal megathrust in the Nankai Trough

*木村 学[1]、山口 飛鳥[2]、濱田 洋平[3]、矢部 優[4] (1.東京海洋大学 海洋資源環境学部、2.東京大学 大気海洋研究所、3.海洋研究開発機構 高知コア研究所、4.海洋研究開発機構)

15:00 ~ 15:15

[SSS06-06] Seismic Imaging of Mud Diapirs in Northern Kumano Basin, Nankai Trough

*Gregory F Moore[1]、Miho Asada[2]、Shuichi Kodaira[2]、Achim Kopf[3] (1.University of Hawaii at Manoa、2.JAMSTEC、3.MARUM)

Geoscientific information about plate boundary along the Nankai Trough provided by the GNSS-A

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In the last decade, many geophysical implications were provided by the GNSS-A seafloor geodetic network. Along the Japan Trench, coseismic and postseismic deformations following the 2011 Tohoku-oki earthquake were detected [Sato et al., 2011, Science; Watanabe et al., 2014, GRL; Tomita et al., 2017, Sci. Adv.]. Coseismic monitoring result was applied for many seismological research [e.g., Ozawa et al., 2012, JGR] and geological research and monitoring plan. Postseismic viscoelastic behavior and afterslip event [Sun et al., 2016, Nature; Iinuma et al., 2016, Nature Comm.] could not be identified without our monitoring results.

After 2015, more important geoscientific suggestions were obtained from monitoring in the Nankai Trough. Yokota et al. [2016, Nature] showed undersea interseismic coupling condition. This observation result has been broadly applied to various geophysical studies while being modified [e.g., Nishimura et al., 2018, Gesphere; Noda et al., 2018, JGR] and constrains earthquake prediction research including numerical simulation and submarine drilling research.

In addition, recently, we improved the GNSS-A technology and upgraded observation frequency and precision [Yokota et al., 2017, Rep. Hydro. Ocean. Res; Yokota et al., 2018, MGR]. With the present observation ability, yearly time change of the amount of undersea crustal deformation was newly unclosed. This new version data suggests that there were longer-term sequences of slow slip events (SSEs) around strong coupling regions [Yokota and Ishikawa, this JpGU meeting].

These results provide several suggestions about property and condition on the plate boundary. The simple and biggest question is what is the reason for separating strong coupling and SSE conditions. Since the difference between the generation patterns of SSE and other slow earthquakes is also considered to be due to physical properties, some dominant factor can be assumed. Differences and similarities between deep and shallow SSEs are also important. What physical properties control the behaviors of deep and shallow SSEs?

For answering these questions, additional experiments and observations from many different viewpoints will be necessary. At the same time, continuous GNSS-A monitoring and upgrading its density and accuracy are required for understanding shallow coupling conditions and SSEs.

キーワード：GNSS-A、南海トラフ、SSE、プレート境界、固着状態
Keywords: GNSS-A, Nankai Trough, SSE, plate boundary, coupling condition

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Deep Drilling at the Nankai Trough: IODP NanTroSEIZE Expedition 358 Summary and First Results

*Harold Tobin[1], Takehiro Hirose[7], Matt Ikari[5], Kyuichi Kanagawa[10], Gaku Kimura[3], Masataka Kinoshita[8], Hiroko Kitajima[6], Demian M Saffer[4], Asuka Yamaguchi[9], Lena Maeda[2], Nobu Eguchi[2], Sean Toczko[2]

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IODP Expedition 358 was carried out beginning October 10, 2018 and scheduled to continue until March 31, 2019. The primary objective was to sample and make geophysical measurements in and around the megasplay fault/plate boundary fault at Site C0002, by extending the riser borehole (Hole C0002P) established during previous Integrated Ocean Drilling Program NanTroSEIZE expeditions. After Expedition 348 in 2014, Hole C0002P was left suspended, with steel casing in pace holding the borehole open to 2922 meters below the sea floor (mbsf). The primary seismic reflector target interpreted as the main plate boundary fault zone was estimated to lie at a little more than 5000 mbsf, necessitating a plan to re-enter that hole and then add about 2000 meters of new depth drilling to reach and cross it.

Drilling commenced with a sidetracking operation to establish Hole C0002Q, which was advanced to 3263 mbsf, but operational difficulties precluded going any deeper. Two more attempts were made to advance the riser hole over many weeks, but ultimately did not result in further progress toward the objective. At the time of this writing, coring operations are ongoing at the site at a depth of about 2900 mbsf, in deformed and steeply-dipping mid-Miocene age inner accretionary wedge rocks. There are plans to end riser operations at Site C0002 at the end of February 2019 despite not reaching the primary target, and instead commence drilling at a new site to target the frontal thrust portion of the plate boundary near previous IODP Site C0006. First results from the expedition will be reviewed in this presentation, and a preliminary assessment of the scientific outcomes will be made.

Keywords: Nankai Trough, IODP , megathrust

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Coexistence of soft and hard sediments at deep Nankai accretionary prism, NanTro SEIZE Project, IODP Exp.358

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It was believed that sediment strengthened irreversibly with depth, and same lithology has same strength in same depth. It was found that quite soft portions were developed within hard sedimentary rock at deep Nankai accretionary prism, southwest Japan, during the NanTro Seize Project, IODP Expedition 348 and 358.

The site C0002 is located at the Tonankai Earthquake (1944 M=8.0) area and penetrates 3262 m below sea floor (mbsf) through the Kumano basin and Nankai accretionary prism. The porosity decreases, and hardness increases with depth gradually. Deeper than approximately 2000 mbsf, the Silty claystone of dark gray lithified hard rock with low porosity less than 20% is occurred for main lithology. Interleaved between this hard rock, the Fine silty claystone with high porosity upper than 30% was observed deeper than 2360 mbsf (Tobin et al., 2015). This soft sediment is similar with the Silty claystone in grain size and mineral assemblages, but strength is totally difference. Such soft stuffs are commonly generated during drilling. In this site, various types of drill tools of bit and reamers were operated due to unstable hole condition. However, no relationship was found between drilling tool and occurrence of the Fine silty claystone. Optical microscope and micro X-CT observations revealed that some sedimentary laminations and burrows of benthos were preserved within the Fine silty claystone. These show that the fine silty claystone is natural sediment, but not drilling induced artifact.

The reason for coexistence of soft and hard sediments in same depth can be explained by conceptual idea as below. In initial state of diagenesis, some crystals will grow larger having smaller surface energy than the other. This surface energy difference in same solution causes that smaller crystal dissolution and larger crystal grow further. Resulting of this process, well crystalline and less crystalline parts probably have marked contrast in strength. This implies that present of heterogeneous strength distribution around the initiation depth of diagenesis.

キーワード：南海トラフ、IODP Exp.358、ちきゅう、続成作用
Keywords: Nankai trough, IODP Exp.358, CHIKYU, Diagenesis

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Active and passive seismic experiment during the IODP Exp. 358 deep riser drilling in the Nankai Trough, Japan

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Stress and strain should be crucial parameter to understand preparation/generation cycle of mega-thrust earthquakes which repeatedly occur along subduction zone. Recent studies suggest that seismic approach (c.f. seismic anisotropy analysis and seismic velocity monitoring) could be alternative tool to monitor stress/strain field in the seismogenic zone. The IODP Exp. 358, which includes deep riser drilling by D/V Chikyu around the IODP C0002 hole in the Nankai Trough region, is a great opportunity to observe the seismic dataset, which would be used to discuss the relationship between seismic parameters and stress field before, after and while the deep borehole drilling.

We performed a series of seismic experiments including passive and active surveys. The experiments include: 1) Seismic velocity monitoring near the C0002 hole by seismic interferometry using drilling/vessel noise. 2) Seismic anisotropy survey around the C0002 hole by air-gun circular shooting. 3) Microearthquakes and tremors monitoring to identify stress condition around the borehole. In this region, real-time borehole seismic observatory and seafloor seismic observatory, named LTBMS (Long-Term Borehole Monitoring System) and DONET (Dense Oceanfloor Network system for Earthqukae and Tsunamis), have been already installed and operated. These observatories can be used as seismic receivers for this experiment. 10 OBSs (Ocean Bottom Seismicmeter) were additionally deployed near the C0002 hole for dense seismic observation within 10 km from the C0002 hole. 6 OBSs were deployed by R/V Yokosuka during the YK18-14 cruise. Another 4 OBSs were deployed by Chikyu’ s ROV (Remotely Operated Vehicle) with distances of 90 m to 300 m from the C0002 hole. These OBSs will be recovered from May to Oct. 2019. As active seismic survey, R/V Kaimei fired circular shooting line around the C0002 hole during the KM18-10 cruise. The air-gun signals were clearly observed by LTBMS seismometer and seafloor DONET seismometers. The observed data show clear seismic events which should be caused by seismic anisotropy. Since 2013 to 2016, we have performed the same survey around the C0002 hole by R/V Kairei in every year. Therefore, time-lapse discussion on seismic anisotropy should be possible by using the newly and existing dataset.

Phase analysis and beam-forming processing would be possible by using the OBS array dataset to discuss distributions of microearthquake and tremors. OBS array data can be also used for seismic interferometry analysis to discuss velocity structure monitoring during the drilling. In this presentation, we will show initial data observed by OBS if the data were available after the recovery. Also, we will show initial results of active seismic survey observed by LTBMS and DONET seismometers including time-lapse discussion on seismic anisotropy.

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キーワード：南海トラフ、地震波探査、深部掘削、モニタリング
Keywords: Nankai Trough, Seismic experiment, Deep drilling, Monitoring

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Microfabric analysis of damaged zone of principal shear zone in the frontal megathrust in the Nankai Trough

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The outer wedge of the Nankai forearc is located to the south of the splay fault, which is the traditional southern margin of the seismogenic rupture zone. The evidence for seismo-tsunamigenic slip was, however, recognized on the basis of a thermal anomaly along ~2 mm thick fault gouge indicative of frictional heating at the frontal thrust. This fact suggested a rupture propagation to the Nankai Trough in the past. Recently, slow slips along the megathrust beneath the outer wedge were observed and an intimate relationship between the coseismo-tsunamigenic large and fast slip and interseismic slow slips is a matter of great concern.

The underlying micro-mechanical processes responsible for the fast or slow slips are, however, poorly known.

We revisited the recovered core sample of the frontal thrust and added further micro-textural observations for damaged zone to already reported principal shear zone. The detailed mineralogical, chemical and micro fabric analysis for a principal shear zone presents the nearly complete transformation from smectite to illite, which is consistent with frictional heating. The observed micro-texture of the gouge and its surroundings of damaged zone is characteristic of experimentally-produced brittle textures for slow slip. This suggests an overprint of slow slip on the previous seismo-tsunamigenic fast slip. This micro-tectonic based interpretation is consistent with the recent observation of inter-sesimic slow slip beneath the outer wedge and around the frontal megathrust. We suggest that the illite-smectite lithology of gouge and surrounding is conditionally stable, allowing it to transition from co-seismic rapid slip to inter-seismic slow slip at different times.

キーワード：Nankai trough、frontal thrust、principal shear zone、slow slip、fault fabric、tsunamigenic fault
Keywords: Nankai trough, frontal thrust, principal shear zone, slow slip, fault fabric, tsunamigenic fault

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Seismic Imaging of Mud Diapirs in Northern Kumano Basin, Nankai Trough

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Mud volcanoes (MV), the surface expression of deeper-seated diapirs are now well known in Kumano Basin. Fifteen years ago, Morita et al. (2004) published a seismic line across the basin showing mud diapirs sourcing the MVs, but the extent of these diapirs has remained underappreciated. We present JAMSTEC 2D seismic lines across and along the basin axis showing that significant deformation of the shallow sedimentary section in the northern part of the basin is caused by mud diapirs. The diapirs feed at least 11 MVs in the northern part of the basin, all of which have been surveyed with multibeam bathymetry, high-resolution sonar and sampling. The diapirs range in diameter from 4-6 km and have seismic expression to at least 2-3 km below the seafloor. Older sedimentary layers are tilted upward adjacent to the diapirs and have internal onlap features that indicate several stages of uplift. Bottom simulating reflections (BSRs) that cross-cut the sediment and diapirs are locally disrupted under the MVs, indicating upward migration of fluids through the methane hydrate layers to the surface. Morita et al. (2004) report that mudstone fragments carried to the surface by the MVs range in age from 18.2-13.6 Ma (late Early Miocene –early Middle Miocene), indicating that the mud diapirs, which probably originate within the underlying accretionary prism, passed through the older layers of the forearc basin.

Reference: Morita, S., Ashi, J., Aoike, K., and Kuramoto, S. (2004), Evolution of Kumano basin and sources of clastic ejecta and pore fluid in Kumano mud volcanoes, Eastern Nanaki Trough, In: Proceedings of the International Symposium on Methane Hydrates and Fluid Flow in Upper Accretionary Prisms, Engineering Geology Laboratory, Department of Civil & Earth Resources Engineering, Kyoto University, Kyoto, pp. 92–99.

Keywords: Nankai Trough, Mud diapir, Accretionary prism

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[E] 口頭発表 | セッション記号 S (固体地球科学)：S-IT 地球内部科学・地球惑星テクトニクス

2019年5月28日(火) 9:00 ~ 10:30 | A10 東京ベイ幕張ホール

[S-IT21] 核-マントルの相互作用と共進化

コンビーナ:河合 研志(東京大学大学院理学系研究科地球惑星科学専攻)、飯塚 毅(東京大学)、太田 健二(東京工業大学大学院理工学研究科地球惑星科学専攻)、土屋 卓久(愛媛大学地球深部ダイナミクス研究センター)、座長:河合 研志、Sebastian Ritterbex

近年の高圧実験の進歩で、地球中心部に至る温度圧力条件での鉱物の物性測定が可能となってきた。一方、高精度な古地磁気測定、地球物理学観測、精密地球物理学分析、地球ニュートリノによる地球深部放射性物質の直接観測などの発展と共に、マントル対流や地磁気ダイナモの数値シミュレーション技術も大きく発展して、地球内部の状態の理解が進んできた。本セッションでは、地球及び惑星における核ーマントル相互作用と進化に焦点をあてた、様々な研究分野の成果を一堂に会する機会を提供し、情報交換を進めることを目的とする。異なる分野間の連携を発展させるための日本版地球・惑星深部研究グループ(J-SEDI）の形成に関わる講演も歓迎する。

9:00 ~ 9:15

[SIT21-19] Seismological Explorations of Earth's Outer Core: Normal Mode and Body Wave Analyses

★Invited Papers

*Jessica C E Irving[1]、Sanne Cottaar[2]、Vedran Lekic[3]、Wenbo Wu[4] (1.Princeton University、2.University of Cambridge、3.University of Maryland, College Park、4.California Institute of Technology)

9:15 ~ 9:30

[SIT21-20] ディスカッション

*河合 研志[1] (1.東京大学)

9:30 ~ 9:45

[SIT21-21] On the 1-D radial convective structure of the Earth’s core inferred from a coupled core-mantle evolution model

*中川 貴司[1] (1.香港大学地球科学専攻)

9:45 ~ 10:00

[SIT21-22] Structural and transport properties of liquid iron-light-element mixtures under outer core conditions

*大村 訓史[1]、土屋 卓久[2] (1.広島工業大学、2.愛媛大学)

10:00 ~ 10:15

[SIT21-23] Development of New Technology for Geoneutrino Directional Measurement

*渡辺 寛子[1] (1.東北大学ニュートリノ科学研究センター)

10:15 ~ 10:30

[SIT21-24] Investigation of multi light elements in iron-silicate-water system using high pressure and temperature neutron experiments: Implications for the Earth's evolution

★Invited Papers

*飯塚 理子[1]、後藤 弘匡[2]、福山 鴻[1]、鍵 裕之[1] (1.東京大学大学院理学系研究科地殻化学実験施設、2.東京大学物性研究所)

Seismological Explorations of Earth's Outer Core: Normal Mode and Body Wave Analyses

*Jessica C E Irving[1], Sanne Cottaar[2], Vedran Lekic[3], Wenbo Wu[4]

1. Princeton University, 2. University of Cambridge, 3. University of Maryland, College Park, 4. California Institute of Technology

Earth's outer core is a source of both the geodynamo and heat for mantle convection. However, we still do not fully understand its chemical composition, and there is debate about whether the uppermost outer core may contain a stratified layer enriched in light elements. We present low frequency normal mode and high frequency body wave investigations of the outer core's properties.

Normal mode oscillations of the whole Earth, excited by large earthquakes, are sensitive to the large-scale variations in velocity and density. We use reported centre frequencies of hundreds of normal mode oscillations to investigate the bulk properties of the outer core. We carry out a Bayesian inversion using a mineralogical Equation-of-State framework to infer the outer core's velocity, density and mineralogical properties, under the assumption that the outer core is well mixed and adiabatic. The model we produce, EPOC, describes the Elastic Parameters of the Outer Core. EPOC predicts seismic velocities at the top of the outer core which are closer to some existing body-wave models than to PREM, resolving a long-standing discrepancy. EPOC also fits normal-mode data better than the Preliminary Reference Earth Model. We also consider the effects of relaxing our assumptions that (i) there is no stratified layer at the top of the outer core, and (ii) that PREM is correct outside the outer core.

To better assess the uppermost outer core, often referred to as the E' layer, we use a novel, iterative technique to measure SmKS differential travel times. SmKS waves are particularly sensitive to the E' layer, and reflect (m-1) times from the underside of the core-mantle boundary. We find that the SmKS differential travel times are better described by models with seismic velocities in the E' layer slower than PREM, such as EPOC or body-wave derived KHOMC (Kaneshima and Helffrich, 2013).

Keywords: Outer Core, Normal Modes, Body waves

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ディスカッション
Discussion

*河合 研志[1]
*Kenji Kawai[1]

1. 東京大学
1. University of Tokyo

ディスカッション

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On the 1-D radial convective structure of the Earth’s core inferred from a coupled core-mantle evolution model

*中川 貴司[1]
*Takashi Nakagawa[1]

1. 香港大学地球科学専攻
1. Department of Earth Sciences, The University of Hong Kong

A coupled core-mantle evolution model in the global heat and mass balance of the Earth’s mantle and core is to reveal the 1-D radial convective structure of the Earth’s core over the geologic time-scale. Since tracking the convective structure of the Earth’s core over the geologic time-scale is not still available for numerical geodynamo simulations, the assessment with the global heat and mass balance model of Earth’s core and mantle is quite powerful. Regarding the global heat balance of the Earth’s mantle, the global heat balance approach incorporating with the heat transport by the partial melting is assumed, which is the parameterized mantle convection based on the modified version of Driscoll and Bercovici (2014). The heat flow across the core-mantle boundary computed from this parameterized convection model is used to compute the thermal and chemical structure of the Earth’s core based on the global heat balance of the Earth’s core with the realistic material properties of the Earth’s core provided from Labrosse (2003; 2015) However, on the assessment of convective structure, the effects of compositional convection caused by releasing the light elements associated with inner core growth and/or the metal-silicate partitioning are included (e.g. Takehiro and Sasaki, 2018). As indicated in Takehiro and Sasaki (2018), the effects of compositional convection are essential for understanding the convective structure of the Earth’s core even if the realistic density structure of the Earth’s core is included in the energy flux computations. On the magnetic field generation caused by geodynamo actions, again, the compositional convection plays a significant role under the high thermal conductivity expected from the high-pressure physics. In the presentation, I will indicate the evolution of the convective structure described as the entropy flux of the Earth’s outer core over 4 billion years as a function of the evolution of the heat flows across the core-mantle boundary and oceanic lithosphere.

キーワード：地球中心核、進化、対流構造
Keywords: Earth's core, Evolution, Convective structure

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Structural and transport properties of liquid iron-light-element mixtures under outer core conditions

*大村 訓史[1]、土屋 卓久[2]
*Satoshi Ohmura[1], Taku Tsuchiya[2]

1. 広島工業大学、2. 愛媛大学
1. Hiroshima Inst. of Tech., 2. Ehime Univ.

It is widely believed that Earth’ s outer core consists of liquid iron (or liquid-nickel alloy) with light element (LE) impurities. For understanding magnetic and thermal behaviors of the Earth, it is required to explore electrical and thermal conductivities of liquid iron and influence of the light elements on these properties.

For this reason, we have investigated influences of light elements on transport properties of liquid iron under high pressure by using ab initio molecular dynamics simulations. We reported the structural and transport properties of liquid Fe-LE binary systems in connection with a microscopic structural properties. This times, in addition to binary systems, we have investigated transport properties of Fe-LE ternary systems. To provide further details of the effects of light-element, we discuss structural and transport properties of liquid Fe alloys in terms of the type and amount of light elements.

キーワード：液体鉄合金、第一原理分子動力学シミュレーション、輸送特性、高圧物性
Keywords: liquid iron alloy, ab initio molecular dynamics simulation, transport properties, high pressure properties

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Development of New Technology for Geoneutrino Directional Measurement

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1. 東北大学ニュートリノ科学研究センター
1. Research Center for Neutrino Science, Tohoku University

Neutrino is an elusive particle and it can penetrate even astronomical objects. While neutrino experiments continue to explore the neutrino propertied, e.g. oscillation nature of neutrino flavor transformation, mass-square differences and mixing angles, we have began to utilize neutrino as a tool to look into the Earth. Anti-neutrinos emitted from radioactive isotopes, geo-neutrinos, bring unique and direct information of the Earth’s interior and thermal dynamics.

KamLAND, Kamioka Liquid-scintillator Anti-neutrino Detector, has 1 kton ultra pure liquid scintillator. They reported the first experimental study of geo-neutrino in 2005. Later the geo-neutrino signals were used to estimate the Earth’s radiogenic heat production and constrain the composition models of the bulk silicate Earth. Following the Fukusima reactor accident in March 2011, the entire Japanese nuclear reactor industry has been subjected to a protected shutdown. This unexpected situation allows us to improve the sensitivity for geo-neutrinos.

The liquid scintillator detectors have the sensitivity for measuring total amount of geo-neutrinos from the Earth’s crust and mantle. However, we do not have the technology to track the direction of incoming geo-neutrinos at present due to the high miss-identification in a neutrino’s track reconstruction. The direction-sensitive detector can map out the U and Th distribution inside the Earth and this technic is also applicable to resolving crust versus mantle contributions. Recent progress in studying this this new technology confirmed that a signify improvement is possible in neutrino tracking identification with a combination of ^{6}Li-loaded liquid scintillator and imaging detector. We developed prototype detector to measure 3D image of scintillation light and study the methodology for the image reconstruction. We will present recent status of our prototype detector and achievement of dark noise reduction of pixelated detector.

キーワード：地球ニュートリノ、放射性熱源
Keywords: geoneutrino, radiogenic power

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Investigation of multi light elements in iron-silicate-water system using high pressure and temperature neutron experiments: Implications for the Earth's evolution

*飯塚 理子[1]、後藤 弘匡[2]、福山 鴻[1]、鍵 裕之[1]
*Riko Iizuka-Oku[1], Hirotada Gotou[2], Ko Fukuyama[1], Hiroyuki Kagi[1]

1. 東京大学大学院理学系研究科地殻化学実験施設、2. 東京大学物性研究所
1. Geochemical Research Center, Graduate School of Science, The University of Tokyo, 2. The Institute for Solid State Physics, The University of Tokyo

Introduction:
The Earth’s core is considered to consist of Fe alloy and some light elements (O, S, Si, H, C). Hydrogen (H) is the most abundant element in the universe and one of the promising candidates existing in the Earth’s core. However, its amount dissolved in the core and its process are still unknown because H cannot be detected by X-ray diffraction (XRD) and it easily escapes from iron by the release of pressure. Recently, H content in *fcc*-Fe at high pressure and high temperature (high-PT) has been determined using in-situ neutron diffraction measurements at J-PARC [1], suggesting that H had preferentially dissolved into iron before any other light elements have dissolved in the very early stage of Earth’s evolution. It is important to further study the partitioning of the other light elements between iron hydride (not pure iron) and silicates. To clarify the effects of multi light elements on the core-mantle segregation in the Earth’s formation, we have focused on sulfur (S) and investigated its effect on hydrogenation of iron.

Experimental:
Iron fine powder was pelletized with/without S powder and placed at the center of the graphite sample capsule. Powder mixture of quartz (SiO_2), brucite $Mg(OD)_2$ (or MgO for comparison of the water existence) surrounds the Fe pellet. Sample composition of Fe:$Mg(OD)_2$:SiO_2=2:1:1 of molar ratio with 5wt.% of S simulates an ideal condition of the primitive Earth.
In-situ high-PT neutron experiments were carried out using a six-axis multi-anvil press “Atsuhime” installed at MLF, PLANET (BL11), J-PARC. An originally improved multi-anvil 6-6 type assembly was applied. Three samples were pressurized up to 6–7 GPa and then heated up to 700 ˚C step by step. The reaction processes (dehydration of $Mg(OD)_2$, phase transformations of Fe (*bcc*-*fcc*) and FeS, formation of silicates) were carefully checked in real time. The diffraction patterns of *fcc*-Fe were measured at 550 ˚C and 700 ˚C for long time and analyzed using the Rietveld refinement method to determine structural and atomic parameters of *fcc*-Fe and sub-products. The recovered samples were examined by XRD and SEM-EDS to more precisely identify the products, their compositions, and the elements partition.

Results and Discussion:
The cell volume changes in *fcc*-Fe and sub-phase of FeS-V were investigated for every hour during the long-time measurements at 700 ˚C. For the sample including water, the volume of *fcc*-Fe was significantly increased with time, while the sample without water showed no change regardless of temperatures. The cell volume of FeS-V did not increase, suggesting that the formation of FeS was promoted in the existence of water, but its hydrogenation was negligible. Fe gradually incorporated D in the existence of water and FeD_x formed (x~0.10 at a maximum). From the results of SEM, the inhibition of deuterization might be due to the formation of FeS layer surrounding Fe pellet, whereas such a thick layer was not observed when using the Fe+S pellet. The sample without water did not include FeS layer nor Fe-bearing silicates.
It is suggested that both S and Fe were not mobile and could not react with each other without the existence of water. H and S can be preferentially incorporated into solid Fe at lower-T (~700 ˚C) before

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melting. The other light elements (C, O, Si) could have dissolved into molten iron hydride and/or FeS in the later process of Earth’s core-mantle differentiation at much higher-PT condition.

Reference:
[1] R. Iizuka-Oku, T. Yagi, H. Gotou, T. Okuchi, T. Hattori, A. Sano-Furukawa, Nature Commun. 8, 14096 (2017).

キーワード：水素、硫黄、高温高圧下その場観察、コアーマントル形成、軽元素
Keywords: Hydrogen, Sulfur, In situ high pressure and high temperature observation, Core-mantle formation, light elements

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[E] 口頭発表 | セッション記号 S (固体地球科学)：S-IT 地球内部科学・地球惑星テクトニクス

2019年5月28日(火) 10:45 ~ 12:15 | A10 東京ベイ幕張ホール

[S-IT21] 核-マントルの相互作用と共進化

コンビーナ:河合 研志(東京大学大学院理学系研究科地球惑星科学専攻)、飯塚 毅(東京大学)、太田 健二(東京工業大学大学院理工学研究科地球惑星科学専攻)、土屋 卓久(愛媛大学地球深部ダイナミクス研究センター)、座長:辻野 典秀、上木 賢太

近年の高圧実験の進歩で、地球中心部に至る温度圧力条件での鉱物の物性測定が可能となってきた。一方、高精度な古地磁気測定、地球物理学観測、精密地球物理学分析、地球ニュートリノによる地球深部放射性物質の直接観測などの発展と共に、マントル対流や地磁気ダイナモの数値シミュレーション技術も大きく発展して、地球内部の状態の理解が進んできた。本セッションでは、地球及び惑星における核ーマントル相互作用と進化に焦点をあてた、様々な研究分野の成果を一堂に会する機会を提供し、情報交換を進めることを目的とする。異なる分野間の連携を発展させるための日本版地球・惑星深部研究グループ(J-SEDI）の形成に関わる講演も歓迎する。

10:45 ~ 11:00

[SIT21-25] Low hydrogen contents in the cores of terrestrial planets

★Invited Papers

*Vincent Clesi[1]、Mohamed Ali Bouhifd[2]、Nathalie Bolfan-Casanova[2]、Geeth Manthilake[2]、Federica Schiavi[2]、Caroline Raepsaet[3]、Hélène Bureau[4]、Hicham Khodja[3]、Denis Andrault[2] (1.Laboratoire de Geologie de Lyon - Terre, Planètes, Environnement, Université Claude Bernard Lyon 1, CNRS, ENS-Lyon, 69622 Villeurbanne, France.、2.Laboratoire Magmas et Volcans, Université Clermont Auvergne, CNRS UMR 6524, OPGC–IRD, Campus Universitaire des Cézeaux, 6 Avenue Blaise Pascal, 63178 Aubière Cedex, France.、3.Laboratoire d'Etude des Eléments Légers, NIMBE, CEA, CNRS, Université Paris-Saclay, CEA Saclay, 91191 Gif sur Yvette Cedex, France.、4.Institut de Minéralogie et de Physique de la Matière et de Cosmochimie, Sorbonne Universités, UMR CNRS-UPMC 7590, 4 place Jussieu, 75252 Paris, France.)

11:00 ~ 11:15

[SIT21-26] Discussion

*土屋 卓久[1] (1.愛媛大学地球深部ダイナミクス研究センター)

11:15 ~ 11:30

[SIT21-27] Fe_2S: the most iron-rich Fe-S compound at pressures of the inner core

*舘野 繁彦[1,2]、小澤 春香[2,3]、廣瀬 敬[1,4]、鈴木 敏弘[5] (1.東京工業大学地球生命研究所、2.岡山大学惑星物質研究所、3.日本原子力研究開発機構原子力基礎工学研究センター 、4.東京大学地球惑星科学専攻、5.東京大学地殻化学実験施設)

11:30 ~ 11:45

[SIT21-28] First-principles Investigation of Iron Diffusion Properties with Implications to Inner Core Plasticity

★Invited Papers

*Sebastian Ritterbex[1]、Taku Tsuchiya[1] (1.GRC Ehime University)

11:45 ~ 12:00

[SIT21-29] Dependence of the dipole component dominancy on the Rayleigh number and inner core size in geodynamo simulations

*西田 有輝[1]、加藤 雄人[1]、松井 宏晃[2]、松島 政貴[3]、熊本 篤志[1] (1.東北大学大学院理学研究科地球物理学専攻、2.Dept. of Earth and Planetary Sciences, University of California, Davis、3.東京工業大学理学院地球惑星科学系)

12:00 ~ 12:15

[SIT21-30] Elasticity of Fe-Si Alloy

*土屋 卓久[1]、福永 優[1] (1.愛媛大学地球深部ダイナミクス研究センター)

Low hydrogen contents in the cores of terrestrial planets

*Vincent Clesi[1], Mohamed Ali Bouhifd[2], Nathalie Bolfan-Casanova[2], Geeth Manthilake[2], Federica Schiavi[2], Caroline Raepsaet[3], Hélène Bureau[4], Hicham Khodja[3], Denis Andrault[2]

1. Laboratoire de Geologie de Lyon - Terre, Planètes, Environnement, Université Claude Bernard Lyon 1, CNRS, ENS-Lyon, 69622 Villeurbanne, France., 2. Laboratoire Magmas et Volcans, Université Clermont Auvergne, CNRS UMR 6524, OPGC–IRD, Campus Universitaire des Cézeaux, 6 Avenue Blaise Pascal, 63178 Aubière Cedex, France., 3. Laboratoire d’ Etude des Eléments Légers, NIMBE, CEA, CNRS, Université Paris-Saclay, CEA Saclay, 91191 Gif sur Yvette Cedex, France., 4. Institut de Minéralogie et de Physique de la Matière et de Cosmochimie, Sorbonne Universités, UMR CNRS-UPMC 7590, 4 place Jussieu, 75252 Paris, France.

The accretion of planets from primordial materials and their subsequent differentiation to form a core and a mantle are fundamental questions in terrestrial and solar system. Many of the questions about the processes are still open and much debated. For example, could the presenceof water during the metallic phase segregation affect the planet-accretion models? The existing studies on the elemental metal-silicate partitioning under hydrous conditions were extended recently to a range of P, T, f_{O2} and water content (5 - 20 GPa, 2000 - 2500 K, from 1 to 5 log units below the iron-wüstite buffer, and for X_{H2O} varying from 500 ppm to 1.5 wt%) [1]. These experimental results show that except for Fe, there is no effect of water on the partitioning of moderately siderophile elements. It allowed us to build consistent models of planetary accretion from reducing to oxidized conditions. Furthermore, for the range of water concentrations studied, there is no evidence of important hydrogen incorporation into planetary cores, thus making unlikely for hydrogen to be a major light element of the core as previsously assumed [2]. We report H metal-silicate partition coefficients of about 0.2, up to two orders of magnitude lower than reported previously, and indicative of lithophile behavior. Our results imply H content of ~60 ppm in the Earth and Martian cores [3].

[1] Clesi et al. (2016) Geochim. Cosmochim. Acta 192, 97-121.

[2] Okuchi, T. (1997) Science 278, 1781-1784.

[3] Clesi et al. (2018) Science Advances 4: e1701876

Keywords: Hydrogen, Core formation, Primitive Earth, Experimental Petrology

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Discussion

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1. Geodynamics Research Center, Ehime University

Discussion

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Fe_2S: the most iron-rich Fe-S compound at pressures of the inner core

*舘野 繁彦[1,2]、小澤 春香[2,3]、廣瀬 敬[1,4]、鈴木 敏弘[5]
*Shigehiko Tateno[1,2], Haruka Ozawa[2,3], Kei Hirose[1,4], Toshihiro Suzuki[5]

1. 東京工業大学地球生命研究所、2. 岡山大学惑星物質研究所、3. 日本原子力研究開発機構原子力基礎工学研究センター、4. 東京大学地球惑星科学専攻、5. 東京大学地殻化学実験施設
1. Earth-Life Science Institute, Tokyo Institute of Technology, 2. Institute for Planetary Materials, Okayama University, 3. Nuclear Science and Engineering Center, Japan Atomic Energy Agency, 4. Department of Earth and Planetart Science, The University of Tokyo, 5. Geochemical Research Center, The University of Tokyo

Sulfur is considered to be one of the light elements in the Earth’s core as iron sulfides are universally found in iron meteorites. The phase diagram of the Fe–FeS system at the high-pressure and high-temperature (P-T) conditions of the core has particular importance to understand the composition and state of the Earth’s core. Because Fe3S is known as the most iron-rich Fe–S compound at > 20 GPa, the iron–sulfur core model has been discussed considering Fe and Fe_3S in the solid core. However, our previous experiment reveals that Fe_3S decomposes into S-bearing hcp-Fe and CsCl (B2)-type phase above ~250 GPa from X-ray diffraction measurements (XRD) (Ozawa et al., 2013 GRL). Furthermore, TEM analysis on the recovered sample exhibits that S-poor phase, likely to be a former hcp-Fe, coexisted with S-rich phase with >33.5 atm% S. Hence, the S-rich end-member compound has not been constrained under pressure more than 250 GPa. In order to re-investigated the phase relations in Fe-FeS system, we studied phase relations in Fe_2S at multi-megabar pressure range.

High P-T conditions were generated in a laser-heated diamond-anvil cell (DAC) using double-beveled diamond anvils with 40 or 60 μm culets. We used the Fe_2S phase as the starting material, which was synthesized beforehand at high pressures in a multianvil apparatus and confirmed by microprobe analysis. SiO_2 glass and MgO were used for thermal insulation and pressure calibration. We loaded such sample assembly as MgO/SiO_2-glass/Fe_2S/SiO_2-glass so that MgO was detached from an iron sample, in order to avoid possible chemical reaction at high temperature. Angle-dispersive XRD measurements were conducted at BL10XU, SPring-8. Heating was performed from both sides of the sample by employing a pair of 100 W Yb fiber lasers.

We performed three separate sets of experiments at pressures between from 120-310 GPa and temperature up to 3000 K. When we heated the Fe_2S sample being mostly amorphous by compression to 300 GPa at 300 K, the 20 new peaks appeared in a few minutes and became spotty with further heating. All peaks are assigned to the orthorhombic structure, which agrees well with Pnma symmetry phase proposed by the theoretical prediction (Bazhanova et al., 2017). This observation indicates that Fe_2S composition crystallizes as a single phase. In the following decompression and re-heating the sample, its stability was confirmed to be 150-310 GPa.

Our previous study (Mori et al., 2017 EPSL) reported that hcp-Fe and B2 phase crystallizes in Fe-6wt% S bulk composition at 270 GPa and 2400 K. Then, the peaks from the B2 phase become weak at further hearting. We re-analyzed the series of XRD datum, and found that such apparent weakening was caused due to the appearance of Fe_2S phase. Indeed, in the XRD patten collected at 3500 K, we confirmed that additional weak peaks from Pnma-Fe_2S were clearly visible and the reflection from the coexisting hcp-Fe phase became intense simultaneously. This indicates that stable phase assemblage in Fe-6wt% S bulk composition changes from hcp-Fe + B2-FeS into hcp-Fe + Pnma-Fe_2S. Hence, Fe_2S is the sulfur-rich end-member compound after the decomposition of Fe_3S at 250 GPa. The slope of eutectic melting curve

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should have kink at the decomposition of Fe_3S. Also, pressure evolution of the eutectic composition should change as well. Since the extrapolation from lower pressure data <250 GPa is not available, higher P-T experiments are necessary to establish the phase diagram at the pressure of inner core boundary.

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First-principles Investigation of Iron Diffusion Properties with Implications to Inner Core Plasticity

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The mechanical properties of Earth’ s inner core are key for understanding the evolution and dynamics of the core. However, little is known about the mechanical properties of iron (alloys) at inner core conditions. Therefore, long-standing questions remain open about the viscous strength of the inner core (Yoshida et al., 1996; Karato, 1999), about the origin of its seismic anisotropy (Deuss, 2014) and about its rotational dynamics (Buffett, 1997). All these issues rely on plastic deformation of the inner core, which is barely constrained.

Under extreme conditions of the Earth’ s deep interior, plasticity is expected to be rate limited by atomic diffusion. Experimental studies of diffusion in iron-nickel alloys at elevated P,T conditions finally rely on extrapolation to inner core conditions (Yunker and Van Orman, 2007; Reaman et al., 2012). Here, we investigate vacancy diffusion in iron at the appropriate inner core conditions. We use a density functional approach to calculate all quantities entering the diffusion coefficient, including the role of pressure and temperature, and quantify the self-diffusion coefficient of hcp iron according to transition state theory (TST).

Vacancy diffusion controls many deformation mechanisms such as dislocation creep, an effective strain producing mechanism in metals. We derived a creep model (based on Weertman, 1955 and Nabarro, 1967) to quantify the rate limiting bounds of climb-controlled dislocation creep in hcp iron to provide the first theoretical estimates of the inner core viscosity. Our results suggest an inner core viscosity that is significantly lower than that of Earth’ s mantle.

Keywords: Inner Core, Self-diffusion, Plasticity

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Dependence of the dipole component dominancy on the Rayleigh number and inner core size in geodynamo simulations

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Geomagnetic field is generated by a dynamo action in the fluid outer core. Studies of the thermochemical evolutions of the Earth's core suggest that the solid inner core has been growing up for approximately one billion years [e.g., O'Rourke and Stevenson, 2016]. Results of numerical dynamo simulations with various aspect ratios (ratios of inner to outer core radii) indicates that the sustained magnetic field is categorized into dipolar-dominated or non-dipolar-dominated regime [e.g., Hori et al., 2010; Driscoll, 2016]. However, any dominant factors controlling the regime have not been fully understood. In the present study, we perform dynamo simulations with various inner core radii using a geodynamo code Calypso to investigate the characteristics of the generated magnetic field. We fix the Ekman, Prandtl, and magnetic Prandtl numbers to be $E = 10^{-3}$, $Pr = 1$, and $Pm = 5$, respectively, and change the Rayleigh number and the aspect ratio to be $r_i/r_o = 0.15$, 0.25, and 0.35. Then we examine the dominancy of the dipole component in two approaches; one is calculating the dipolarity, f_{dip}, which is the ratio of the amplitude of the axial dipole magnetic field to the total amplitude, and the other is comparing magnetic energy for the dipole component with extrapolated magnetic energy for $l = 1$ using an exponential function for odd degree components from $l = 3$ to $l = 19$. The magnetic energy for the dipole component is compared with that extrapolated from the fitting curve.

In $r_i/r_o = 0.25$ and 0.35 cases, f_{dip} is approximately 0.8 at $Ra/Ra_{crit} \fallingdotseq 2.0$ and gradually decreases to approximately 0.45 with increase of Ra/Ra_{crit} up to around 6.0, where Ra_{crit} is the critical Rayleigh number. By referring to the obtained fitting curve, we find that the magnetic energy for the dipole component is more than 5 times larger than the extrapolated value for $l = 1$ at $Ra/Ra_{crit} \fallingdotseq 2.0$ and decreases with increase of Ra/Ra_{crit} in both aspect ratios. The dependency of the dipole component dominancy on the Rayleigh number is similar in both aspect ratio cases. However, in the $r_i/r_o = 0.15$ case, f_{dip} is approximately 0.4 at $Ra/Ra_{crit} \fallingdotseq 8.0$ and decreases to approximately 0.1 with increase of Ra/Ra_{crit} up to around 15.6. At $Ra/Ra_{crit} = 8.1$ and 9.0, the amplitude of the dipole component is comparable to extrapolated value from the fitting curves. At $Ra/Ra_{crit} > 10.1$, the magnetic energy for $l = 1$ component is smaller than that for the $l = 2$ component. Consequently, the magnetic field obtained in the simulation results is non-dipolar. To summarize above, we categorize the present dynamo simulations as shown in Figure 1. Here we define strong/weak dipolar dynamo by a condition that the magnetic energy is larger/smaller than the kinetic energy. The axial dipolar component becomes small in all three ratio cases for larger Rayleigh numbers. Non-dipolar components become larger for the smaller inner core. In other words, for $r_i/r_o < 0.35$, it is likely that the dipolar magnetic field is dominant for larger inner core.

キーワード：地球ダイナモ、内核サイズ、レイリー数、双極子成分
Keywords: Geodynamo, Inner core size, Rayleigh number, Dipole component dominancy

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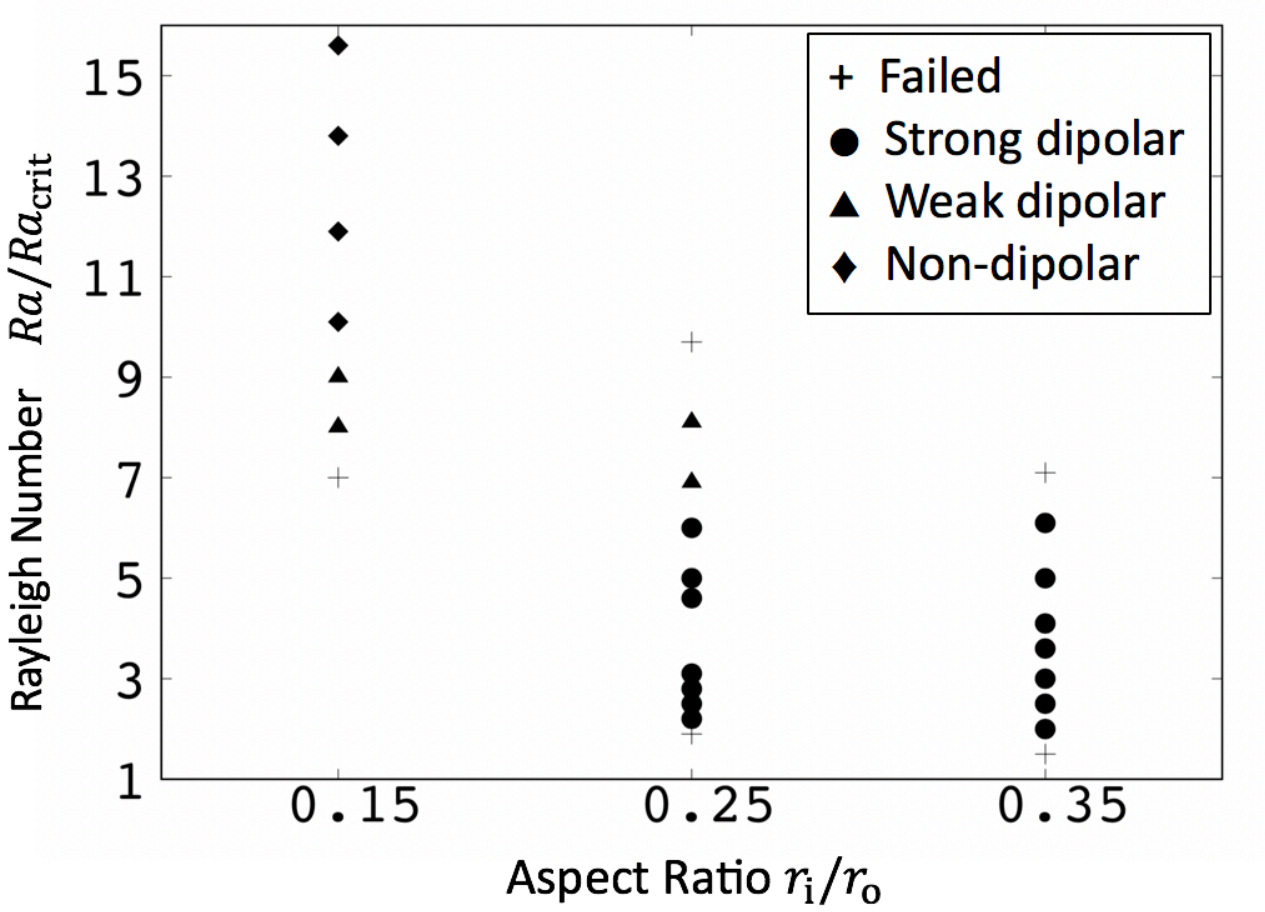


Figure 1 Dynamo regime in various aspect ratios. Cross, circle, triangle, and diamond symbols represent failed, strong dipolar, weak dipolar, and non-dipolar dynamo cases, respectively.

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Elasticity of Fe-Si Alloy

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Earth’ s inner core (329~364 GPa and 5000~6000 K) is thought to be composed of solid Fe-Ni alloy with some unknown light elements (e.g., Mao et al., 1998). Thermoelasticity of iron alloys is therefore a key to interpreting seismological information of the inner core: density, seismic wave velocities, and their anisotropy. So far, several studies reported that pure hcp iron has a shear modulus distinctly larger than that of the inner core and a small P-wave anisotropy (e.g., Mao et al., 1998; Vocadlo et al., 2009). This large V_P/V_S ratio of the inner core is one of the remaining inexplicable features of the deep Earth, and it suggests the presence of mechanisms to lower the S-wave velocity in the inner core, such as a low-velocity component (Prescher et al., 2015), pre-melting effect (Martorell et al., 2013), anelasticity, and so on.

In this study, we perform ab initio molecular dynamics simulations on the thermoelasticity of alloy compositions including potential light element candidate of Si. Computations are conducted at the inner core P,T conditions. The obtained velocities, density and aggregate anisotropies are compared against seismological constraints, and we show the first evidential result on the suitable compositions to the inner core constituents, which can reproduce all of V_P, V_S, V_Φ, and ρ of the inner core simultaneously. We also report why Fe-Si alloy can have a large V_P/V_S ratio.

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キーワード：第一原理計算、高温高圧弾性特性、内核
Keywords: Ab initio density functional computation, High-P,T elasticity, Inner core

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[E] 口頭発表 | セッション記号 S (固体地球科学)：S-MP 岩石学・鉱物学

2019年5月28日(火) 13:45 ~ 15:15 | A08 東京ベイ幕張ホール

[S-MP29] Oceanic and Continental Subduction Processes

コンビーナ:Hafiz Ur　REHMAN(Department of Earth and Environmental Sciences, Graduate School of Science and Engineering, Kagoshima University)、辻森 樹(東北大学)、Chin-Ho Tsai(Department of Natural Resources and Environmental Studies, National Dong Hwa University)、岡本 和明(埼玉大学教育学部地学)、座長:Hafiz REHMAN(Kagoshima University)、Tatsuki Tsujimori

This JpGU-AGU joint session aims at bringing earth scientists from Japan and overseas to present their research related to the processes of oceanic and continent subduction, continent-continent collisions, metamorphism of crustal rocks, formation of the oceanic/continental arcs, and accretion/ tectonic erosion of material along subduction boundaries.

Topics such as role of the fore- and back-arcs in the subduction zones, process of accretion of volcaniclastic and terrigenous sediments along the subduction/collision boundaries, deformation and metamorphism of subducted crust, and exhumation will be the main focus of the session.

In addition to the above mentioned topics, our focus for the10th anniversary of this international session will be towards our understanding and progress on the ultrahigh-pressure/temperature metamorphic terranes in the world.

Exchange of ideas among geoscientists applying different approaches on problems related to the theme of the session are most welcome.

13:45 ~ 14:00

[SMP29-01] Pb-isotope of Fe-Ni alloy associated with serpentinite: Geochemical constraints on the fluid-mediated hyper-reducing environment in mantle wedge

★Invited Papers

*掛札 真由[1]、辻森 樹[1]、山下 勝行[2]、飯塚 義之[3] (1.東北大学、2.岡山大学大学院自然科学研究科、3.中央研究院地球科学研究所)

14:00 ~ 14:15

[SMP29-02] PETROCHEMISTRY AND AGE DETERMINATION OF THE NEWLY DISCOVERED ECLOGITE IN THE WESTERN MONGOLIA

*苗村 康輔[1]、チョイドンジャムツ エルデンジャルガル[4]、加藤 丈典[5]、ジャフハラン オトゴンクゥ[3]、道林 克禎[2] (1.名古屋大学博物館、2.名古屋大学環境学研究科、3.中国地質科学院、4.モンゴル科学アカデミー、5.名古屋大学宇宙地球環境研究所)

14:15 ~ 14:45

[SMP29-03] **Continental subduction, "*Intraslab UHP Metasomatism*", and the formation of metamorphic diamond**

★招待講演

*小笠原 義秀[1] (1.Department of Earth Sciences, Waseda University)

14:45 ~ 15:00

[SMP29-04] Ultrahigh-pressure pseudotachylyte in a marble

★Invited Papers

*西山 忠男[1]、藤本 智也[1] (1.熊本大学先端科学研究部理学系地球環境科学講座)

15:00 ~ 15:15

[SMP29-05] Dehydration and Deformation process of subducted large Oceanic Pleateau -case study of the Mikabu blueschist-

*岡本 和明[1] (1.埼玉大学教育学部地学)

Pb-isotope of Fe-Ni alloy associated with serpentinite: Geochemical constraints on the fluid-mediated hyper-reducing environment in mantle wedge

*掛札 真由[1]、辻森 樹[1]、山下 勝行[2]、飯塚 義之[3]
*Mayu Kakefuda[1], Tatsuki Tsujimori[1], Katsuyuki Yamashita[2], Yoshiyuki Iizuka[3]

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1. Tohoku University, 2. Graduate School of Natural Science and Technology, Okayama University, 3. Institute of Earth Sciences, Academia Sinica

Although the occurrence of Fe-Ni alloy is very limited in the vicinity of modern Earth’s surface due to the highly oxidized state, serpentinization in the forearc mantle wedge can rarely provide extraordinary reducing environments that stabilizes the Fe-Ni alloy.

In order to understand those fluid-mediated hyper-reducing environments in serpentinizing mantle wedge of an active convergent plate margin, we revisited so-called ‘josephinite' —an unusual ‘metallic rock' composed mainly of Fe-Ni alloy (awaruite)— found in the Josephine Ophiolite, by engaging in microtextural and geochemical analyses.

Microtextural analyses using high-resolution FE-SEM and FE-EPMA found the presence of Ni-As mineral within aggregates of Fe-Ni alloy; the Ni-As mineral also occurs as discrete grains in ‘josephinite'-hosting serpentinite, suggesting that Ni-As mineral acted as a precursor seed before the crystallization of Fe-Ni alloy.

Since each leachate obtained by stepwise leaching of a ‘josephinite' pebble confirmed compositional homogeneity, this allows to calculate weighted mean values that give much precise Pb isotope compositions of aliquots of seventeen leaching steps determined by ID-TIMS; the values yielded $^{207}Pb/^{204}Pb$ = 18.3378 ±0.0016, $^{206}Pb/^{204}Pb$ = 15.5693 ±0.0015, and $^{208}Pb/^{204}Pb$ = 38.0879 ± 0.0044. These newly obtained high precision Pb isotope compositions revealed that the ‘josephinite'-forming fluids have a minor GLOSS-like sedimentary component. The presence of Ni arsenide also supports the infiltration of arsenic-bearing external fluids derived from sedimentary rocks.

Considering the geological context of the Josephine Ophiolite, the ‘josephinite’-forming fluids might have been derived from the top layer of subducting sediments. The lack of high-pressure metamorphic rocks such as blueschist in ‘josephinite'-hosted serpentinite implies that the ‘josephinite' formation might have occurred at a relatively shallow level of serpentinizing mantle wedge.
The absence of carbonate minerals further postulates that redox agent of the ‘josephinite' forming hyper-reducing environment was H_2 evolved by the serpentinization rather than CH_4 that is commonly preserved in blueschist and eclogites. This fact would speculate a widespread hyper-reducing environment caused by H_2 fluids in a shallow level of serpentinizing mantle wedge.

キーワード：鉄ニッケル合金、蛇紋岩化、Pb同位体組成、還元流体、マントルウェッジ
Keywords: Fe-Ni alloy, serpentinization, Pb isotope composition, reducing fluid, mantle wedge

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PETROCHEMISTRY AND AGE DETERMINATION OF THE NEWLY DISCOVERED ECLOGITE IN THE WESTERN MONGOLIA

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1. Nagoya University Museum, 2. Nagoya University Graduate school of environmental studies, 3. Chinese Academy of Geological Sciences, 4. Mongolian Academy of Sciences, 5. Nagoya University Space-Earth Environmental Research

This study report on newly discovered eclogite from the Western Mongolia in the Central Asian Orogenic Belt. Lenticular eclogite bodies with several meters in length are enclosed in quartzite of the Shubun/Urgamal formation in the southernmost part of the Zavkhan block which forms a part of the Neoproterozoic Tuva-Mongolian arc. Trace element patterns of eclogites are like those of OIB. We used relatively fresh eclogite sample and amphibolite sample to reconstruct the pressure-temperature history. Fresh eclogite preserves omphacite (with jadeite 38 mole%) coexisting with garnet ($Alm_{56}Gros_{35}Pyr_{8}$), barroisite, phengite (Si=3.36 apfu, O=11), quartz, epidote, rutile with accessory apatite, calcite, and hematite (assemblage 1). Garnet-core includes paragonite and kyanite coexisting with titanite, quartz, barroisite, which represents prograde stage mineral assemblage (Stage 0). The eclogite assemblages are variably retrogressed into amphibolite assemblage of hornblende, plagioclase, quartz, biotite, Mg-rich garnet-rim ($Alm_{61}Gros_{29}Pyr_{9}$), epidote and titanite (assemblage-2). In amphibolite sample, atoll-shaped garnet is ubiquitously observed. The atoll-shaped garnet consists of the eclogite facies core, Ca-rich mantle ($Alm_{53}Gros_{44}Pyr_{3}$) probably formed during the amphibolite facies stage 2, and a Ca-poor Mg-rich rim (or shell) ($Alm_{64}Gros_{25}Pyr_{10}$). The last Ca-poor garnet rim coexists with plagioclase, hornblende, epidote, quartz, titanite (assemblage-3). The earliest stage of metamorphism might happen in the "lawsonite stability field" if we interpret kyanite formed from paragonite. Subsequent Stage 1 P-T condition was determined at about 2 GPa and 480 ºC by garnet-clinopyroxene-phengite geothermobarometry. The eclogite once experienced decompression to the epidote-amphibolite assembalge equilibrated at ca. 0.8 GPa and 400 ºC during the Stage 2, determined by garnet-hornblende-plagioclase geothermobarometry. After the initial exhumation, the eclogite experienced heating to the high-pressure amphibolite stage 3 formed at ca. 600 ºC and 1.2 GPa. Such multiple P-T paths have been reported from eclogites from collision zones such as Sesia Alps and W.Tianshan. Additionally, we determined U-Pb age of zircon by CHIME method. Zircon typically exhibit oscillatory zoning and are sometimes included at the garnet core. Most zircons are severely altered, with rare fresh core only in large zircon grains (>0.1 mm). We obtained three populations of age at 1170 Ma, 680 Ma and 340 Ma for such zircon fresh cores. If we interpret these ages as igeneous protolith ages, the eclogite-facies metamorphism should have taken place after 340 Ma. Combining the metamorphic history and U-Pb zircon ages, we speculated that the eclogite primarily formed at the ocean island on the Mongol-Okhotsk (MO) ocean. If so, eclogite-facies metamorphism (assemblage 0→1) should have taken place when the MO plate subducted beneath the Siberian craton. Subsequently the eclogite probably separated from the subducting plate and come up to the crustal depth through the subduction channel, and was transformed into epidote-amphibolite assemblage (assemblage 2). Finally, continental collision took place when the N. China craton collide with the Siberian craton to close the MO ocean at 140 Ma, which transformed the rock to high-pressure amphibolite (assemblage 3).

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キーワード：エクロジャイト、中央アジア造山帯、モンゴル・オホーツク海
Keywords: Eclogite, Central Asian Orogenic Belt, Mongol-Okhotsk Ocean

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Continental subduction, “*Intraslab UHP Metasomatism*”, and the formation of metamorphic diamond

Continental subduction, “*Intraslab UHP Metasomatism*”, and the formation of metamorphic diamond

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Deep continental subduction is the process carrying supracrustal materials into deep mantle, and UHP metamorphic rocks are the direct evidence for this process as the materials having the information of P-T and the chemical environments during subduction, escaped from the homogenization with mantle rocks. Usually, UHPM silicate rocks have been strongly retrograded during exhumation, and the preservation of UHPM information is limited excepting inclusions in refractory minerals; decoding the chemical processes in subducted materials is difficult. In carbonate and calc-silicate rocks, UHPM information has been well preserved and can be decoded even in the matrix because the chemical reactions in these rocks make distinct changes from the protolith chemistries, not erased during exhumation.

Carbonate-bearing assemblages have large P-T stabilities at HP/UHP and low H_2O activity, and this indicates high possibility of survival of carbonates and transportation of carbon into deep mantle. H_2O-fluid supply is necessary for metamorphic reactions in these rocks because H_2O-fluid lowers temperatures of decarbonations. As a model showing the processes in deeply subducting continental materials, *Intraslab UHP Metasomatism* (metasomatism within subducting continental materials at UHP mantle depths) will be introduced on the basis of our last 20 years research on the Kokchetav UHPM rocks. In this model, key materials are H_2O and CO_2 in the subducting continental slab, and a key process is H_2O-fluid infiltration within the slab. The outline of this model is as follows. 1) In the subducting slab, silicate rocks (gneisses and eclogite) were a H_2O reservoir, and carbonate and calc-silicate rocks were a CO_2 reservoir. 2) During subduction, H_2O-fluid with several components (e.g. C, K, Ti) occurred by dehydrations of silicate rocks. 3) Dehydrations in silicate rocks preceded decarbonation reactions in carbonate and calc-silicate rocks. 4) Infiltration of H_2O-fluid into carbonate and calc-silicate rocks was a trigger for decarbonations. 5) H_2O-fluid infiltration was controlled by the timing of dehydrations in silicate rocks and vaired in mm to cm scales to form or to characterize the mineral assemblages in carbonate and calc-silicate rocks. 6) H_2O-fluid (with C-bearing species) contributed to the formation of diamond in some carbonate calc-silicate rocks. 7) Modal compositions of carbonates in the protoliths controlled the survival of carbonate depending on the intensity of fluid infiltration.

The following subjects from the Kokchetav UHPM rocks support this model. A) Dolomite marble contains abundant diamond formed at two stages; 2nd stage diamond ($\delta^{13}C$: -17 to -27 ‰) from H_2O-fluid. Dol + Di is not the highest-T assemblage and was controlled by fluid composition, XCO_2 as 0.1, which was suitable for diamond formation. B) Dolomitic marble has the highest-T assemblages, Arg-Fo, Arg-Ti-Chum, but diamond was unstable because of low XCO_2 as 0.01. C) Calcite (after Arg) marble with Coe exsolution in Ttn contains diamond only in Di layer, and other parts do not; this indicates short-term stability of diamond in this rock depending on changing XCO_2. The later fluid was low XCO_2 as 0.02; too low for diamond formation. D) Two types of Grt-Cpx rocks occur; diamond-bearing and diamond-free. Their

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protoliths are a mixture of silicates and carbonates. Minor diamond occurs as two modes in diamond-bearing Grt-Cpx rock; one is fine-grained (several μm) and the other is cubic (max. 200 μm). A cubic diamond has fine core and crystallized slowly from H_2O-fluid on a fine grain as a seed crystal. E) In gneisses, diamond occurrence is diverse; several morphologies with different colors were observed. Two-stage growth was not confirmed. Dissolution of carbon from diamond in gneisses could be possible, and carbon was carried into dolomite marble by H_2O-fluid to crystallize 2^{nd} stage diamond.

Many of the subjects being still unclear will be mentioned as the targets of future research.

キーワード：intraslab UHP metasomatism、UHP metamorphism、diamond、carbonate、fluid、Kokchetav Massif
Keywords: intraslab UHP metasomatism, UHP metamorphism, diamond, carbonate, fluid, Kokchetav Massif

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Ultrahigh-pressure pseudotachylyte in a marble

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A black vein in a marble from the Higo metamorphic rock in central Kyushu, Japan, represents a signature of dolomite growth from a carbonate melt and also evidence of liquid immiscibility between carbonate and silicate melts. The formation condition is estimated to be 3.5 GPa and 1280 C by the dolomite composition based on the phase diagram in the system CaCO3– MgCO3. This is a peculiar example of pseudotachylyte formed under ultrahigh-pressure condition.

The Higo metamorphic rock is Cretaceous low P/T metamorphic rock, however, some authors have suggested the existence of high to ultrahigh-pressure metamorphism prior to the low P/T metamorphism. In the south of Mt. Kousadake, Tomochi Town, Kumamoto Prefecture, marble occurs as several layers intercalated with pelitic and siliceous gneisses. The thickness of the marble layer is variable from several meters to several tens of meters. In one of the marble layers, near the contact with the surrounding pelitic gneiss, we found a black vein 10 cm thick and 1 m long, of which strike crosscuts that of the boundary between the marble and gneiss. It shows a branching texture, extending perpendicular to the vein strike from the vein towards the country rock (marble). The branching is a signature typical to the pseudotachylyte.
The marble consists of pure calcite, whereas the black vein consists of dolomite domain and silicate domain. The dolomite domain is composed of aggregates of anhedral to subhedral dolomite grains of 10 micrometers in size with oscillatory or complex zoning in terms of Ca, Mg and Fe. The dolomite grains do not show any deformation texture. The dolomite domain occasionally includes fractured quartz clasts, of which fractures are filled with dolomite. The silicate domain occurs as rounded or irregular-shaped aggregates of several hundred micrometres in size. It consists of rounded quartz grains, fibrous aggregates of hydrous alumino-silicate (unknown clay mineral) and minor dolomite grains. The silicate domains occur sporadically in the dolomite domains, and some silicate domains are connected with each other by network veins of silicates of the same material as the silicate domain. Rounded zircon rarely occurs in the silicate domain. In some parts of the vein, thin marble layers several millimeters thick occur, showing a flow folding.
Subhedral shape, oscillatory zoning and non-deformed texture of dolomite in the dolomite domain indicates the origin of dolomite either as precipitates from the fluid or as growth in the melt. If dolomite precipitated from the C-O-H fluid, the assemblage of dolomite + quartz, which occurs both in the dolomite and silicate domains, is stable at relatively low T, high P and high XCO2 region. Outside the stability field, it will react to form diopside. Diopside is common in calc-silicate gneisses in this region, therefore, the assemblage of dolomite + quartz + C-O-H fluid would imply temperature condition lower than that of the regional metamorphic condition. This observation leads to a conclusion that the dolomite grew from the melt, because fault rocks should show temperature condition higher than that of the country rock owing to frictional heating. The silicate domain may represent recrystallized silicate melt, and the coexistence of carbonate and silicate domains implies the liquid immiscibility between carbonate and silicate melts. In such a case, dolomite should represent a minimum melt composition in the system CaCO3 –MgCO3. The minimum melt composition and its temperature depends strongly on pressure

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(Irvine and Wyllie, 1975 and Buob et al., 2006), therefore, we can estimate the melting temperature and pressure from the dolomite composition. The effect of FeCO3 component is evaluated to be small based on the experiment of Shatsky et al. (2014). The estimated pressure and temperature conditions are 3.5 GPa and 1280 C. Thus, we interpret that the black vein is a pseudotachylyte formed under ultrahigh-pressure condition, indicating that the Higo metamorphic rock has experienced the ultrahigh-pressure.

References: Buob, A., et al. (2006) Amer. Mineral., 91, 435-440; Irvine, A.J. and Wyllie, P.J. (1975) GCA, 39, 35-53; Shatsky, A. et al. (2014) Amer. Mineral., 99, 773-785.

キーワード：超高圧変成作用、シュードタキライト、肥後変成岩
Keywords: Ultrahigh-pressure metamorphism, pseudotachylyte, Higo metamorphic rock

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Dehydration and Deformation process of subducted large Oceanic Pleateau -case study of the Mikabu blueschist-

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In order to know an origin of mega-earthquake related to subducted large seamount, observation of deformation process recorded in the blueschist (high P/T metamorphic rock) is the best method. Mikabu blueschist is considered as accreted large oceanic plateau and suffered blueschist facies metamorphism at Jurassic time. It extends approximately 1000 km in EW direction from the Kanto Mountain to Kyushu Island. In north-south direction, succession of ocean plateau stratigraphy can be reconstructed although accretion thrusts duplicate them. We have done detailed field observation along the N-S route and collected the rock sample systematically. In the outcrop, the Mikabu blueschist is well foliated with mineral lineation. However, we have identified massive, cataclastic samples in the structural middle in the NS section. Under the microscope, glassy parts suffered brittle and ductile deformation. Origin of the most glass part can be ascribed as igneous product. However, some glass layers along the deformation band in stilpnomelane aggregates might be formed as melt due to shear heating. If this zone is related to earthquake fault zone, it indicates that a huge earthquake has occurred. Metamorphic petrology based on mineral assemblage devides the Mikabu belt as three zones; the North, Mid, and the South zone, respectively. Psseudo-section analysis concludes that the North zone suffered relatively higher T metamorphism compated to the South zone. In the Mid zone, local temperature increase stabilized stilpnomelane after chlorite.

キーワード：沈み込んだ巨大海山、沈み込み帯変成作用、変成変形過程
Keywords: subducted large-ocean plateau, blue schist metamorphism, deformation and metamorphic process

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[E] 口頭発表 | セッション記号 S (固体地球科学)：S-MP 岩石学・鉱物学

2019年5月28日(火) 15:30 ~ 17:00 | A08 東京ベイ幕張ホール

[S-MP29] Oceanic and Continental Subduction Processes

コンビーナ:Hafiz Ur　REHMAN(Department of Earth and Environmental Sciences, Graduate School of Science and Engineering, Kagoshima University)、辻森 樹(東北大学)、Chin-Ho Tsai(Department of Natural Resources and Environmental Studies, National Dong Hwa University)、岡本 和明(埼玉大学教育学部地学)、座長:Tsai Chin-HO(National Dong Hwa University)、Hafiz REHMAN(Kagoshima University)

This JpGU-AGU joint session aims at bringing earth scientists from Japan and overseas to present their research related to the processes of oceanic and continent subduction, continent-continent collisions, metamorphism of crustal rocks, formation of the oceanic/continental arcs, and accretion/ tectonic erosion of material along subduction boundaries.

Topics such as role of the fore- and back-arcs in the subduction zones, process of accretion of volcaniclastic and terrigenous sediments along the subduction/collision boundaries, deformation and metamorphism of subducted crust, and exhumation will be the main focus of the session.

In addition to the above mentioned topics, our focus for the10th anniversary of this international session will be towards our understanding and progress on the ultrahigh-pressure/temperature metamorphic terranes in the world.

Exchange of ideas among geoscientists applying different approaches on problems related to the theme of the session are most welcome.

15:30 ~ 15:45

[SMP29-06] Unusually high Nb/Ta ratio of fluid-precipitated jadeites from New Idria serpentinite body, California: Implications for extreme fractionation in slab fluids

*高橋 菜緒子[1]、辻森 樹[2]、常 青[3]、木村 純一[3] (1.東北大学大学院理学研究科、2.東北大学東北アジア研究センター、3.海洋研究開発機構・地球内部物質循環研究分野)

15:45 ~ 16:00

[SMP29-07] The collision process interpreted using the systematic change of metamorphic pattern along theQinling–Dabie–Odesan collisional belt between the North and South Korea-China Cratons

★Invited Papers

*Chang Whan Oh[1,2] (1.Department of Earth and Environmental Sciences, Chonbuk National University, Jeonju, Republic of Korea、2.Environmental Science System Research Center, Chonbuk National University,Jeonju, Republic of Korea)

16:00 ~ 16:15

[SMP29-08] Contrasting collision processes between northwest and central Himalaya: examination from the "Lesser Himalayan granites” in Pakistan

*小笠原 正継[1]、福山 繭子[2]、Siddiqui Rehanul[3] (1.産業技術総合研究所地質調査総合センター地質情報研究部門、2.秋田大学理工学研究科、3.Balochistan University of Information Technology, Engineering and Management Sciences)

16:15 ~ 16:30

[SMP29-09] New petrologic indications of subduction metamorphism in the Yuli belt, eastern Taiwan

*Chin-Ho Tsai[1]、Chih-Ying Yeh[1]、Dominikus Deka Dewangga[1]、Yui Kouketsu[2]、Masaki Enami[3] (1.Department of Natural Resources & Environmental Studies, National Dong Hwa Univ.、2.Department of Earth & Planetary Sciences, Nagoya Univ.、3.Institute for Space-Earth Environmental Research, Nagoya Univ.)

16:30 ~ 16:45

[SMP29-10] **The importance of Mn-nodules on the sea floor during subduction for the formation of ophiolitic diamond**

*Richard Wirth[1] (1.Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences 3.5 Surface Geochemistry)

16:45 ~ 17:00

[SMP29-11] **Along-strike variability of primitive magmas inferred from olivine-hosted melt inclusions, southernmost Andean Southern Volcanic Zone, Chile**

*Derek Weller[1,2]、Charles R Stern[2] (1.Earthquake Research Institute、2.University of Colorado)

Unusually high Nb/Ta ratio of fluid-precipitated jadeites from New Idria serpentinite body, California: Implications for extreme fractionation in slab fluids

*高橋 菜緒子[1]、辻森 樹[2]、常 青[3]、木村 純一[3]
*Naoko Takahashi[1], Tatsuki Tsujimori[2], Qing Chang[3], Jun-Ichi Kimura[3]

1. 東北大学大学院理学研究科、2. 東北大学東北アジア研究センター、3. 海洋研究開発機構・地球内部物質循環研究分野
1. Graduate School of Science, Tohoku Univ., 2. CNEAS, Tohoku Univ., 3. Department of Solid Earth Geochemistry, JAMSTEC

Fractionation of Nb and Ta, which are conventionally thought as geochemical twins, is a key to understanding the evolution of the silicate Earth. The subchondritic Nb/Ta ratio of the continental crust (12-13; Barth et al., 2000), which is a long-standing problem, has been explained by Nb/Ta fractionation during subduction processes such as slab melting and/or dehydration. However, recent studies have revealed that extreme Nb/Ta fractionation of subduction-zone fluids from minerals in eclogite (up to 87; Xiao et al., 2006; Liang et al., 2009) and metagranite (up to 239; Chen and Zheng, 2015). In order to decipher Nb-Ta (and Zr-Hf) behavior of slab-derived fluids in shallower levels, we investigated a veined jadeitite from the New Idria serpentinite body, which is regarded as direct precipitates from slab-derived fluids at forearc depth. We applied *in-situ* measurements of trace element abundance of jadeites using a LA-ICP-QMS. The New Idria jadeites is characterized by remarkably high Nb concentration but depleted in Ta. Consequently Nb/Ta ratio varies from 10 to 115; Zr/Hf ratio also shows a wide range of 38–164. Nb–Ta and Zr–Hf correlations suggest coupling behaviors of those elemental pairs in fluids during the jadeitite vein formation. A simple Rayleigh fractional crystallization model for jadeite growth using partitioning coefficient D_{Nb} and D_{Ta} between clinopyroxene-aqueous fluid (Stalder et al., 1998) is also unlikely to explain the data. Although the extreme Nb/Ta and Zr/Hf fractionation can occur in seawater (Firdaus et al., 2011), oxygen isotope composition of New Idria jadeites ($\delta^{18}O$ = +8.4 to +9.9‰; Sorensen et al., 2006) eliminates a possibility that jadeitite-forming fluid source was originated from pore fluids derived from seawater. Alternatively, the Nb-Ta behavior might be explained by breakdown of hydrous minerals with high Nb/Ta ratio such as phengitic mica and/or consequences of high degree of fluid-rock interaction in a case of $D_{Nb}/D_{Ta} > \sim 10$ for fluid-rock system. New Idria jadeitite veins would provide an evidence for the presence of highly Nb/Ta fractionated fluids in serpentinized mantle wedge beneath forearc, supporting the idea that Nb and Ta are highly mobile and fractionate during the early stage of oceanic plate subduction before the appearance of rutile.

キーワード：Nb/Ta分別、沈み込み、流体、水-岩石相互作用、ひすい輝石
Keywords: Nb/Ta fractionation, subduction, fluid, water-rock interaction, jadeite

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The collision process interpreted using the systematic change of metamorphic pattern along theQinling–Dabie–Odesan collisional belt between the North and South Korea-China Cratons

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1. Department of Earth and Environmental Sciences, Chonbuk National University, Jeonju, Republic of Korea, 2. Environmental Science System Research Center, Chonbuk National University,Jeonju, Republic of Korea

Along the Qinling–Dabie–Odesan collisional belt between the North Korea-China and South Korea-China Cratons, the peak metamorphic conditions reflect systematically changing metamorphic regimes from east to west: ultra-high temperature (UHT) granulite-facies metamorphism in the Odesan area (905–1160˚C, 9-10.6 kbar) at 247-245 Ma; high pressure (HP) eclogite-facies metamorphism in the Hongseong area (819–835˚C, 23-25 kbar) at 250 Ma; ultra-high pressure (UHP) eclogite-facies metamorphism in the Sulu, Dabie and Hong’ an areas (620–880˚C, 26–43 kbar) at 220-240 Ma; HP eclogite facies metamorphism in the Tonbai area (530–610˚C, 17–20 kbar) at 216 Ma; epidote–amphibolite and blueschist facies metamorphism in the Wudang area (505–550˚C, 10–13 kbar) at 216 Ma ; and HP granulite-facies metamorphism in the western Qinling area (657–772˚C, 9.7–13.2 kbar) at 214 Ma. Additionally, the Triassic post-collisional igneous rocks regionally intruded at both ends of the collision belt, in the Hongseong–Odesan areas at 230 Ma and in the west Qinling at 210 Ma. These observations indicate that the following collisional processes occurred along the Qinling–Dabie–Odesan collisional belt. The collision between the North Korea-China Craton and South Korea-China Craton first occurred in the eastern margin of the collision belt (the Odesan area) with an angle of approximately 60˚ between their long axes of two Cratons and propagated towards west. The amount of oceanic slab subducted before the collision increased from the Odesan area to the Sulu area due to westwards increase in the width of the ocean between the North Korea-China and South Korea-China Cratons, resulting an increase in the depth of slab break-off. After slab break-off occurred in the Sulu area, the lateral tearing force strengthened, resulting a decrease in the depth of slab break-off from the Sulu area to the western Qinling area as collision propagated westward. At both ends of the collision belt, post collisional igneous activities occurred with metamorphism higher than granulite facies relating to high heat supply from upwelling mantle due to shallow depth of slab break-off.

Keywords: Qinling-Dabie-Odesan collision belt, The depth of slab break-off, Peak metamorphism, Post collisional igneous activity, Collisional process

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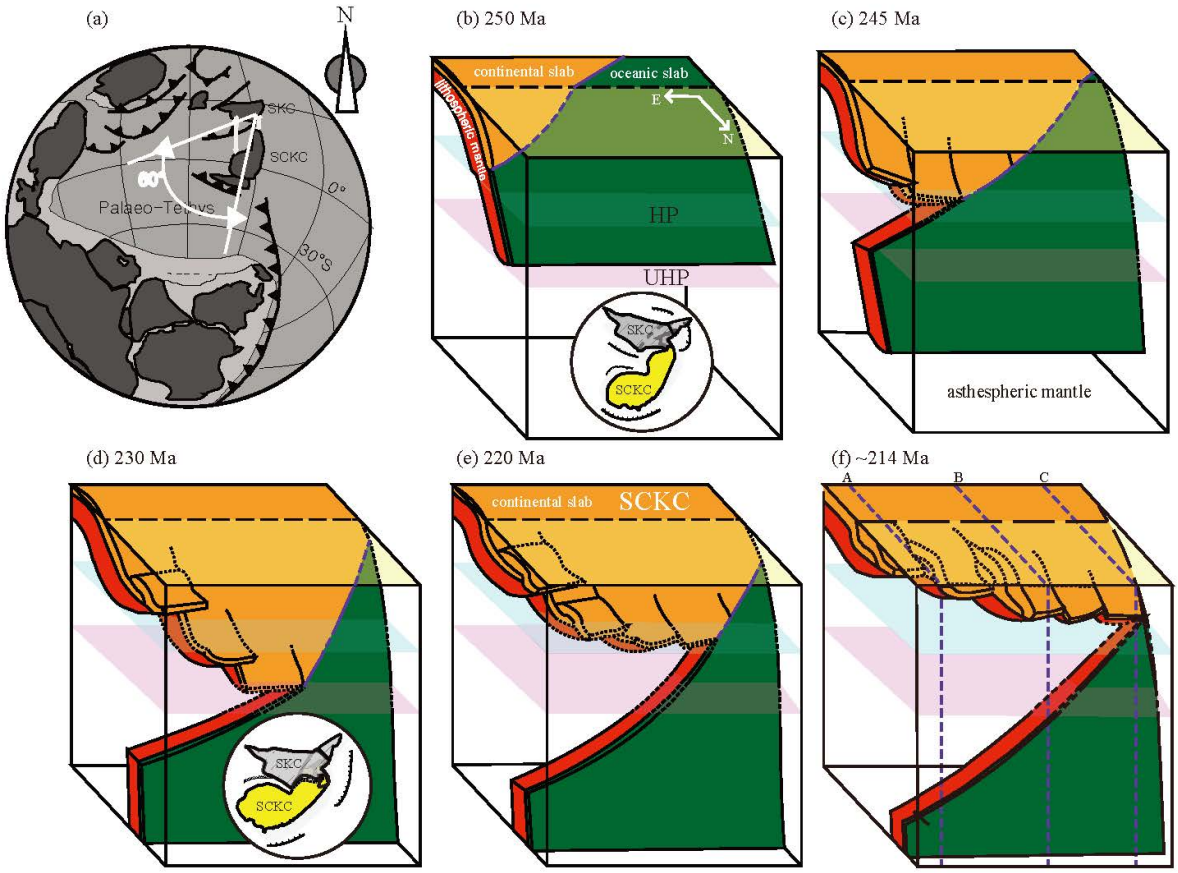


Fig. 16 Oh and Lee,

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Contrasting collision processes between northwest and central Himalaya: examination from the "Lesser Himalayan granites” in Pakistan

*小笠原 正継[1]、福山 繭子[2]、Siddiqui Rehanul[3]
*Masatsugu Ogasawara[1], Mayuko Fukuyama[2], Rehanul H Siddiqui[3]

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1. Institute of Geology and Geoinformation, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2. Graduate School of Engineering Science, Akita University, 3. Balochistan University of Information Technology, Engineering and Management Sciences

The Himalayan orogenic belt was formed by the Cenozoic collision of Indian and Eurasian plates. In the eastern and central part of the Himalaya, four main tectonostratigraphic zones have been recognized, such as from south to north, Sub-Himalaya, Lesser Himalaya, Greater Himalaya and Tethys Himalaya. However, the northwest Himalaya in Pakistan and northwest India shows some distinct features differ from the main part of the Himalaya, i.e., (1) Presence of the Cretaceous island arc blocks between the Indian and the Eurasian blocks: (2) Boundary between the Lesser Himalaya and Greater Himalaya is not well defined: (3) Presence of UHP eclogites: (4) Extensive exposure of “Lesser Himalayan granites” represented by the Mansehra granite in Pakistan. As granite and granitic gneiss are major components of the Himalayan orogenic belt, we have examined geochemical and isotopic characteristics of the Mansehra granite and compared those with “Lesser Himalaya granites” and granite gneisses of the Greater Himalaya in the central part of the Himalaya. Before the collision of the India to the Eurasian, granites similar to the Mansehra granite were present along the northern margin of the India continent. The collision of India continent with the Tibet of the Eurasia plate formed two separate zones of granites, the “Lesser Himalayan granites” and extensively deformed granite gneiss in the Greater Himalaya. In the collision of India to the Cretaceous island arc blocks in northwest Himalaya did not disturbed distribution of the granite, resulting large exposure of the Mansehra granite. The southern extension of the Karakoram Fault which is a dextral strike-slip fault separating the Tibet and the Karakoram/Pamir block, approximates a boundary between the northwest Himalaya and the eastern and central Himalaya.

キーワード：collision、Himalaya、granite
Keywords: collision, Himalaya, granite

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New petrologic indications of subduction metamorphism in the Yuli belt, eastern Taiwan

*Chin-Ho Tsai[1], Chih-Ying Yeh[1], Dominikus Deka Dewangga[1], Yui Kouketsu[2], Masaki Enami[3]

1. Department of Natural Resources & Environmental Studies, National Dong Hwa Univ., 2. Department of Earth & Planetary Sciences, Nagoya Univ., 3. Institute for Space-Earth Environmental Research, Nagoya Univ.

Previous reports of high-pressure (HP) metamorphism in the Yuli belt are mainly from meta-igneous and meta-volcaniclastic rocks, which are minor constituents within allochthonous metabasite-serpentinite blocks embedded in the dominant metasedimentary schists. By contrast, no HP minerals have yet been found in the metasedimentary rocks, whereas serpentinite is not suitable for pressure constraint. Thus skepticism on whether the Yuli belt is truly a HP metamorphic belt still exists. To solve this problem, we have investigated garnet-bearing pelitic schists using quartz-inclusion Raman spectroscopy barometry and surveyed the metasomatic zones around the Tsunkuanshan serpentinite body. Our Raman spectroscopic analyses on quartz inclusions in garnet from three metapelitic samples yielded residual (entrapment) pressures of 11-15 kbar at temperatures of 420-620˚C (constrained by Raman spectra of carbonaceous material thermometry). These results are essentially consistent with those of HP metabasites, glaucophane schists, and metaplagiogranites in the Yuli belt by recent pseudosection modeling. In the Tsunkuanshan area, meter-scale metasomatic zones crop out at the contact between serpentinite and surrounding pelitic schists. We discovered rare early-stage glaucophane (crossite) in an intermediate amphibole-albite rich rock in the metasomatic zones. This new occurrence indicates that serpentinite bodies might have been incorporated into a (paleo) subduction channel and subsequently recrystallized together with the host metasediments in HP conditions. Both the new pressure-temperature constraints from metasedimentary rocks and the finding of blue amphibole in metasomatic zones around serpentinite bodies indicate that the Yuli belt was subject to ‘warm’ subduction metamorphism.

Keywords: glaucophane, metasomatic zone, serpentinite, garnet, quartz-inclusion Raman barometry

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The importance of Mn-nodules on the sea floor during subduction for the formation of ophiolitic diamond

*Richard Wirth[1]

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Diamonds, native elements and unusual metal alloys from chromitites in ophiolites have been reported already almost 20 years ago (Bai et al., 2000). However, the genesis of these diamonds enclosed in chromite is still challenged. A major question is the origin of all the unusual elements and alloys recorded so far such as W, Co, Ta, CrFe, NiCu, AgAu, CoFeNi and most important Mn-Ni-Co alloys. Meanwhile, diamonds in chromite in ophiolites have been reported from several different locations on the planet (Tibet, Mongolia, Polar Urals, Turkey, Albania), which are separated from each other by long distances (Yang et al., 2014). There is one common feature observed in these diamonds, they usually contain small inclusions (from nanometre up to a few micrometre in size) of a Mn-Ni-Co alloy. The composition of the alloy is varying in diamond from different locations. These diamonds are natural diamonds that is demonstrated by the presence or coexistence of several additional nanoinclusions in diamond such as oxides, silicates and sulphides and selenides. Thinking about the genesis of these ophiolitic diamonds the question arises where all these strange elements and alloys come from? They are not typical Upper Mantle components. However, it is well known that Mn-nodules from the sea floor contain all these rare and unusual elements (Wegorzweski et al., 2015 and ref. therein). Subduction of the sea floor transports the nodules to a depth where melting of the nodules finally occurs. Depending on the Co-concentration melting of a Mn-Ni-Co ally will start at temperatures < 900˚C with increasing Co-concentration at much lower temperature. Under local reducing conditions such Mn-Ni-Co alloy melt pools might exist in the subducted slab. The sea floor also contains plenty of organic material that could potentially supply the carbon necessary for the formation of diamond. Carbon rich fluids might react with the Mn-Ni-Co alloy melt, the melt acting as a catalyst to reduce the C-rich fluid to C. Carbon is dissolved in the alloy melt to a high amount depending on pressure and temperature. A change in PT during uplift then will result in the precipitation of solid carbon from the melt. If that happens in the diamond stability field diamond will precipitate. That process would explain the presence of such kind of Mn-Ni-Co alloy inclusions in diamond. Mn-nodules with their content of a wide variety of elements from the periodic system cannot only explain the unusual occurrence of diamond in chromitite in ophiolites but also the presence of other unusual elements and compounds. The details of the processes involved are not fully understood and they are subject of future investigations.

Bai, W.J., Robinson, P.T., Fang, Q., Hu, X-F., Zhou, M., (2000) Origin of PGE and base metal allloysin podifoem chromitites of he Luobusa ophiolite, southern Tiet. Canadian Mineralogist, 38, 585-598.

Wegorzewski, A.V., Kuhn, T., Dohrmann, R., Wirth, R., Grangeon, S. (2015) Mineralogical characterization of individual growth structures of Mn-nodules with different Ni+Cu content from the central Pacific Ocean. Amer. Min., 100, 2497-2508.

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Yang, J., Meng, F., Xu.X, Robinson, P.T., Dilek, Y., Makeyev, A.B., Wirth, R., Wiedenbeck, M., Griffin, W.L., Cliff, J. (2014) Diamonds, native elements and metal alloys from chromitites of the Ray-Iz ophiolite of the Polar Urals. Gondwana Research, http://dx.doi.org/10.1016/j.gr.2014.07.004.

Keywords: Subduction, Mn-nodules, ophiolitic diamond

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Along-strike variability of primitive magmas inferred from olivine-hosted melt inclusions, southernmost Andean Southern Volcanic Zone, Chile

*Derek Weller[1,2], Charles R Stern[2]

1. Earthquake Research Institute, 2. University of Colorado

Glass compositions of melt inclusions in olivine phenocrysts found in tephras derived from explosive eruptions of the four volcanoes along the volcanic front of the southernmost Andean Southern Volcanic Zone (SSVZ) are used to constrain primitive magma compositions and melt generation parameters. Primitive magmas from Hudson, Macá, and Melimoyu have similar compositions and are formed by low degrees (8-18 %) of partial melting. Compared to these other three centers, primitive magmas from Mentolat have higher Al_2O_3 and lower MgO, TiO_2 and other incompatible minor elements, and are generated by somewhat higher degrees (12-20%) of partial melting. The differences in the estimated primitive parental magma compositions between Mentolat and the other three volcanic centers are consistent with difference in the more evolved magmas erupted from these centers, Mentolat magmas having higher Al_2O_3 and lower MgO, TiO_2 and other incompatible minor element contents, suggesting that these differences are controlled by melting processes in the mantle source region above the subducted oceanic plate. The observed along-arc changes in parental magma chemistry may be due to the close proximity below Mentolat of the subducted Guamblin Fracture Zone that could efficiently transport hydrous mineral phases, seawater, and sediment into the mantle, driving enhanced volatile fluxed melting beneath this center compared to the others.

Keywords: Andean volcanism, tephra, olivine melt inclusions, primitive magma

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[E] 口頭発表 | セッション記号 S (固体地球科学)：S-MP 岩石学・鉱物学

2019年5月28日(火) 13:45 ~ 15:15 | A07 東京ベイ幕張ホール

[S-MP30] 地殻-マントル・コネクション

コンビーナ:田村 芳彦(海洋研究開発機構　海域地震火山部門)、石塚 治(産業技術総合研究所活断層火山研究部門)、Chris Conway(Geological Survey of Japan)、座長:田村 芳彦(JAMSTEC)、Chris Conway、森下 知晃(金沢大学)

近年、地殻の薄い海洋島弧が大陸生成の場ではないのか、という考えや、中央海嶺における正断層に沿った海水のしみこみがマントル融解を引き起こして、モホ面を形成するのではないか、という考えが出されている。地表ー地殻ーマントルの関係やマントルから地殻を通して噴火に至るマグマの生成・挙動に関して、火山学、地球化学、岩石学、地質学、年代学、地球物理学などの広い分野からの投稿を期待する。

13:45 ~ 14:00

[SMP30-01] **Noble gas and carbon isotopic compositions of petit-spot lavas from southeast of Marcus Island**

★Invited Papers

*山本 順司[1]、河野 哲馬[2]、高畑 直人[3]、佐野 有司[3] (1.北海道大学総合博物館、2.北海道大学大学院理学院、3.東京大学大気海洋研究所)

14:00 ~ 14:15

[SMP30-02] A series of cummingtonite-bearing rhyolites in Niijima, Izu-Bonin arc, Japan: petrological and geochemical constraints

★Invited Papers

*荒川 洋二[1]、遠藤 大介[2]、大鹿 淳也[3]、新村 太郎[4]、池端 慶[1] (1.筑波大学　生命環境系 地球進化科学専攻、2.島根県立三瓶博物館サヒメル、3.中国地質大学（武漢）地球資源学部、4.熊本学園大学　経済学部)

14:15 ~ 14:30

[SMP30-03] **Generation of primary andesitic magma in oceanic arcs: Evidence from Kibblewhite Volcano, Kermadec Arc**

★Invited Papers

*平井 康裕[1,2]、田村 芳彦[2]、Kaj Hoernle[3]、Christian Timm[4]、Folkmar Hauff[3]、Reinhard Werner[3]、Bogdan Vaglarov[2]、常 青[2]、宮崎 隆[2]、木村 純一[2] (1.金沢大学大学院 自然科学研究科、2.海洋研究開発機構、3.ゲオマール海洋研究所、4.GNSサイエンス)

14:30 ~ 14:45

[SMP30-04] Petrogenesis of high-Mg# andesite lavas from Ruapehu volcano, New Zealand

*Chris Conway[1]、Katy Chamberlain[2]、Yumiko Harigane[1]、Daniel Morgan[3] (1.Geological Survey of Japan、2.Univ. Derby、3.Univ. Leeds)

14:45 ~ 15:00

[SMP30-05] Hydrous felsic magma generated by unmixing of slab-derived supercritical liquid: evidence from Rishiri Volcano, Kuril Arc

★Invited Papers

*谷内 元[1]、栗谷 豪[2,3]、横山 哲也[4,3]、中村 栄三[3]、中川 光弘[2] (1.北海道大学大学院理学院自然史科学専攻、2.北海道大学大学院理学研究院地球惑星科学部門、3.岡山大学惑星物質研究所、4.東京工業大学理学院地球惑星科学系)

15:00 ~ 15:15

[SMP30-06] Genesis of recent mafic volcanism in the Taupo Volcanic Zone, New Zealand: insights into the birth and death of cataclysmic caldera-forming systems?

*Georg F Zellmer[1]、Jun-Ichi Kimura[2]、Claudine Stirling[3]、Gert Lube[1]、Phil A Shane[4] (1.Volcanic Risk Solutions, Massey University, Tennent Drive, Palmerston North 4410, New Zealand、2.Department of Solid Earth Geochemistry, Japan Agency for Marine-Earth Science and Technology [JAMSTEC], Natsushima-cho 2-15, Yokosuka 237-0061, Japan、3.Department of Chemistry, University of Otago,

Dunedin 9054, New Zealand、4.School of Environment, University of Auckland, Auckland 1142, New Zealand)

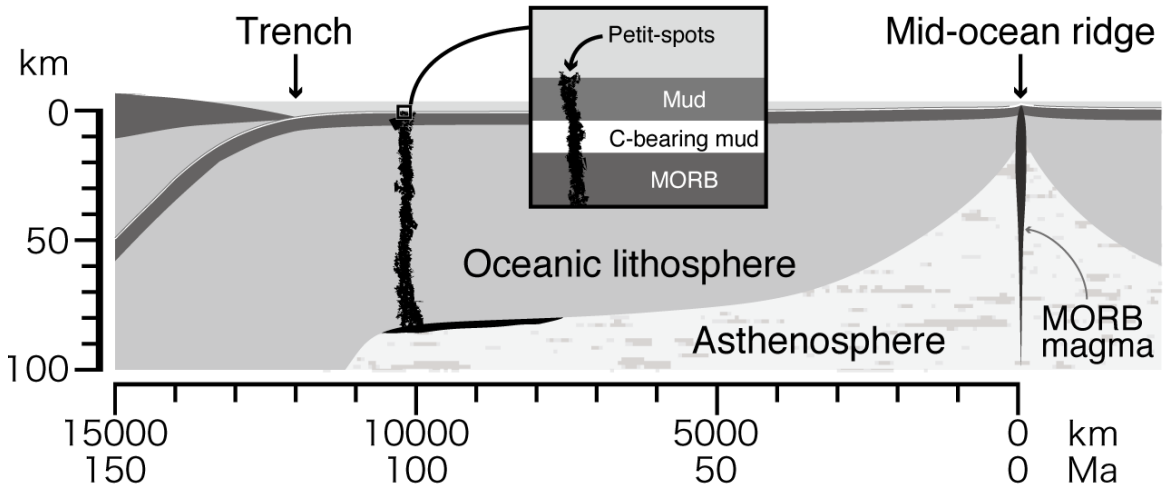
Noble gas and carbon isotopic compositions of petit-spot lavas from southeast of Marcus Island

*山本 順司[1]、河野 哲馬[2]、高畑 直人[3]、佐野 有司[3]
*Junji Yamamoto[1], Tetsuma Kawano[2], Naoto Takahata[3], Yuji Sano[3]

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1. Hokkaido University Museum, 2. Graduate School of Science, Hokkaido University, 3. Atmosphere and Ocean Research Institute

We measured noble gas isotopic compositions of quenched lavas sampled from seamounts, so-called petit-spot volcanoes, on the 160-million-year-old northwestern Pacific Plate. The samples $^{3}He/^{4}He$ and $^{40}Ar/^{36}Ar$ ratios were, respectively, 2.5–8.3 Ra and up to 1735, where Ra stands for atmospheric $^{3}He/^{4}He$, which are analogous to or lower than those of MORB. Considering narrow sampling regions, a secondary effect might be responsible for variation of the data.
During ascent and subsequent cooling of magma in the oceanic lithosphere, chemical components in the magma will be assimilated with those in the lithosphere. Correlation between $CO_2/^{3}He$ ratios and carbon isotopic ratios suggests that carbon was affected by the incorporation of seafloor carbonate. The same would be true of noble gases. The mixing of noble gases among a mantle source, an atmospheric component dissolved in seawater and a radiogenic component can explain the data distribution. There is no $^{3}He/^{4}He$ ratio exceeding MORB-like value. The mantle source of the petit-spot magma was likely to have had a MORB-like $^{3}He/^{4}He$ ratio originally. The eruption of petit-spot magma shows a close relation with the bending of subducting oceanic plates. The MORB-like $^{3}He/^{4}He$ ratio supports the hypothesis that the petit-spot magma is derived from the lithosphere–asthenosphere boundary.

キーワード：希ガス、炭素同位体、プチスポット、リソスフェアーアセノスフェア境界、地殻同化
Keywords: noble gases, carbon isotope, petit-spot, lithosphere-asthenosphere boundary, crustal assimilation



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A series of cummingtonite-bearing rhyolites in Niijima, Izu-Bonin arc, Japan: petrological and geochemical constraints

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1. Earth Evolution Sciences, Faculty of Life and Environmental Sciences, University of Tsukuba, 2. Shimane Prefectural Sanbe Nature Museum Sahimeru (Shimane) , 3. Earth Resoueces Faculty, China University of Geosciences, 4. Faculty of Economics, Kumanoto-Gakuen University

Niijima volcano in the northern part of the Quaternary Izu–Bonin volcanic arc, Japan, consists predominantly of rhyolitic volcanic units and minor basaltic and andesitic units. Most of the rhyolites are characterized by a phenocryst assemblage of orthopyroxene (Opx), cummingtonite (Cum), biotite (Bt), and hornblende, and a lack of clinopyroxene (Cpx). These rocks can be classified into four types: Opx–Cum, Cum, Cum–Bt, and Bt according to their eruption sequence (e.g., Isshiki, 1987; Endo et al., 2010). Cummingtonite is a common phenocryst phase and is present in most of the rhyolitic units. This sequence of cummingtonite-bearing rhyolites is a unique feature amongst the silicic volcanoes of the northern Izu–Bonin volcanic arc, most of which have an Opx–Cpx phenocryst assemblage (Shukono et al., 2006; Tamura et al., 2009; Haraguchi et al., 2017).

The decreasing anorthite contents (An mol.%) of plagioclase and Mg values (Mg#) of cummingtonite and biotite with time possibly indicate a gradual decrease in the temperature (and pressure) of the magmas. The rhyolites have high whole-rock SiO_2 (73–78 wt.%) and K_2O (1.5–3.3 wt.%) contents, and their trace element contents and patterns differ slightly amongst and within the four types. Highly differentiated rare earth element (REE) patterns characterize most of the rhyolites from Niijima volcano. All rock types from Niijima volcano have limited ranges of isotope values ($^{87}Sr/^{86}Sr$ = 0.70317–0.70339; $^{143}Nd/^{144}Nd$ = 0.51303–0.51308). The phenocryst assemblages and mineral chemistries of the rhyolitic volcanic rocks suggest that these magmas were produced under low temperatures (<800˚C) and low pressures (<3 kbar), and possibly water-saturated conditions, which is consistent with the experimental results for similar dacites and rhyolites from other volcanic arcs (Geschwind and Rutherford, 1992; Nicholls et al., 1992). Major and trace element variations indicate that fractionation of mostly plagioclase and amphibole was the dominant process during evolution of the rhyolitic magma, as supported by the presence of tonalite–granite xenoliths with cumulate textures and chemistries.

The coeval basaltic and andesitic volcanic units and mafic–intermediate inclusions (or enclaves) indicate that these magmas played an important role in the generation and evolution of the dominant rhyolitic magmas. The parental rhyolitic magmas are likely to have been generated by partial melting of lower to middle crust as a result of basaltic underplating, after which the magmas ascended and fractionated into more silicic magmas, producing more than 13 magma units at shallow crustal levels. At deeper crustal levels, basaltic and rhyolitic (or dacitic) parental magmas were mixed to produce andesitic to dacitic magmas, and these magmas ascended and mingled with the shallow rhyolitic magmas before eruption. The complex magmatic system beneath Niijima volcano was developed within a relatively thick crustal sequence on the rear-arc side of the Izu–Bonin volcanic arc.

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キーワード：新島火山、カミンゴトン閃石、高シリカ流紋岩、伊豆ー小笠原火山弧、玄武岩質ー安山岩質包有物
Keywords: Niijima volcano, Cummingtonite, High-silica rhyolite, Izu-Bonin arc, basaltic-andesitic inclusions

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Generation of primary andesitic magma in oceanic arcs: Evidence from Kibblewhite Volcano, Kermadec Arc

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Melting of hydrous subarc mantle at low pressure (<1 GPa) may produce primary andesitic melts, suggesting that primary andesitic lavas can be expected in oceanic arcs where the crust is thin (Tamura et al., 2016). Beneath thick crust, melting of hydrous mantle at higher pressures will occur at higher pressures below the thick crust, generating basaltic primary melts. Recently, Tamura et al. (2018) discovered olivine-bearing andesites derived from primary andesitic melts at the Nishinoshima volcano in the Ogasawara Arc, Japan, where the crustal thickness is 21 km. Here, we will present another example for generation of primary andesitic melts in the southern Kermadec arc.

During R/V SONNE expedition in 2017 (SO-255), phenocryst-poor andesites (57.5–57.6 wt.% SiO_2) were recovered from Kibblewhite volcanic complex, southern Kermadec Arc. These andesites contain skeletal olivine and clinopyroxene microphenocrysts with similar and restricted Mg-numbers (Mg/[Mg+Fe] = 0.84–0.85) and a few euhedral olivine xenocrysts with a magnesian cores (Mg/[Mg+Fe] = ~0.92). The magnesian andesites (5.5–5.6 wt.% MgO; Mg# = 56.8–57.3) have relatively high Ni (~50 ppm) and Cr (~180 ppm) contents. These lavas have depleted high-field strength element and enriched large-ion lithophile element compositions (e.g., Nb/Yb = 0.75–0.80; Ba/Nb = 148–175), similar to the coeval Kibblewhite basalts and typical for other southern Kermadec Arc lavas. Sr-Nd-Hf-Pb isotope compositions for the andesites and basalts of the Kibblewhite Volcano also cannot be distinguished from each other and are consistent with the range of published data for the southern Kermadec Arc (Todd et al., 2011; Timm et al., 2014).

Calculation of equilibrium olivine compositions and olivine fractionation trends (Tamura et al., 2000) indicate that olivine microphenocrysts in the andesites are in equilibrium with host rocks and that the andesites have experienced 10% olivine fractionation from mantle-derived primary melts. Primary melt compositions for the andesites (estimated by addition of 10 wt.% equilibrium olivines) are still andesitic (55.9–56.0 wt.% SiO_2; 9.58–9.68 wt.% MgO) in composition and similar to the estimated primary andesite melt of the Nishinoshima volcano. According to thermo-barometric modelling of Lee et al. (2009) the primary melts for the andesites are segregated from mantle peridotite at temperatures of 1190–1220℃ and pressures of 0.45–0.55 GPa assuming primary H_2O contents to be 1.0–3.0 wt.%. The low primary magma segregation pressures, corresponding to 15–18 km depths, are consistent with thin (9–12 km; Bassett et al., 2016) crust beneath the southern Kermadec Arc.

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キーワード：Subduction zone、Kermadec Arc、Kibblewhite Volcano、SO-255
Keywords: Subduction zone, Kermadec Arc, Kibblewhite Volcano, SO-255

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Petrogenesis of high-Mg# andesite lavas from Ruapehu volcano, New Zealand

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The eruption of high-magnesium andesites (HMA) with Mg# values >60 at continental arc volcanoes conflicts with the expectation that mantle-equilibrated primitive magmas produced at subduction zones are basaltic. Studies of the origins of HMA lavas provide details on how primitive magmas transit through arc lithosphere, which has implications for constraints on crust-mantle connections as well as volcanic hazards.

Here we report on the occurrence and origin of a sequence of HMA lavas erupted at ~45 ka from Ruapehu volcano, which is a frequently active andesite-dacite stratovolcano in the Taupo Volcanic Zone (TVZ). The suite of lavas forms linear trends on bivariate whole-rock major and trace element plots that are distinctly elevated for MgO, Ni and Cr compared with all other lavas of Ruapehu and most other calk-alkaline andesites of the TVZ. The relatively primitive whole-rock geochemical characteristics are attributed to the involvement of mafic sources during magma genesis, as revealed by the presence of sharply reverse-zoned pyroxene phenocrysts with rims of $Mg\#_{85\text{-}89}$ and olivine xenocrysts with cores of $Fo_{88\text{-}93}$ and Cr-spinel inclusions. The contribution of felsic end-members to the genesis of Ruapehu HMA magmas is recorded by the presence of rhyolitic glass within partially fused metasedimentary xenoliths and the low Mg# cores for pyroxenes within crystal clots that also preserve rhyolitic interstitial glass and melt inclusions.

The petrological and geochemical features of the samples indicate that the assembly of HMA magmas involved influxes of mafic magmas from the mantle that entrained olivine xenocrysts into mush zones of bulk (rhyo-) dacitic composition, which had evolved via preceding assimilation, fractionation and mixing processes in the crust. Timescale results from Fe-Mg interdiffusion modelling of orthopyroxene indicate that eruptions occurred within days to weeks of magma mixing events. Ruapehu HMA lavas are valuable samples of high-Mg# magmas collected from the global subduction zone system that were formed by crustal level magma hybridization processes (cf. Streck and Leeman, 2018) rather than directly by mantle melting processes (cf. Mitchell and Grove et al. 2016).

Keywords: andesite, magma mixing, active volcano

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Hydrous felsic magma generated by unmixing of slab-derived supercritical liquid: evidence from Rishiri Volcano, Kuril Arc

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*Hajime Taniuchi[1], Takeshi Kuritani[2,3], Tetsuya Yokoyama[4,3], Eizo Nakamura[3], Mitsuhiro Nakagawa[2]

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1. Department of Natural History Science, Graduate School of Science, Hokkaido University, 2. Department of Earth and Planetary Science, Faculty of Science, Hokkaido University, 3. Institute for Planetary Materials, Okayama University, 4. Department of Earth and Planetary Sciences, Tokyo Institute of Technology

Introduction

Water-rich components released from the subducting slab play important roles in the generation of subduction-zone magmas in the mantle wedge (e.g. Elliott, 2003). With increasing fluid releasing depths, the slab-derived water-rich materials would become supercritical liquid (e.g. Bureau and Keppler, 1999).Experimental studies have suggested that slab-derived supercritical liquid is separated into hydrous silicate melt and aqueous fluid during the ascent in the mantle wedge (e.g. Kawamoto et al., 2012). However, the occurrence of magmas corresponding to this hydrous melt has not been reported so far. In this context, we have carried out a detailed petrological, geochemical, and chronological study on calc-alkaline andesite and dacite at Rishiri Volcano.

Results

Rishiri Volcano is a Quaternary stratovolcano in southern Kuril arc, and is 300 km above the Wadati-Benioff Zone. The volcanic activity started at ~0.2 Ma, which is characterized by coexistence of alkali basalt, tholeiitic andesite to dacite, and calc-alkaline andesite to dacite. The calc-alkaline andesitic products and the following dacitic lavas, investigated in this study, comprise Middle stage of the volcanic activity (Ishizuka, 1999). Our new $^{40}Ar/^{39}Ar$ age data for the dacitic and andesitic lavas are 35.5 ±1.4 ka and 34.6 ±3.0 ka, respectively.

The phenocryst assemblage of the dacitic lavas is Cpx + Opx + Pl, and that of the andesitic lavas is Ol + Cpx + Opx + Pl. All phenocrysts in the dacite have homogeneous compositions or show normal zonation with limited variations. In contrast, those in the andesite occasionally show reverse zonation. Some olivine and plagioclase phenocrysts have core compositions with up to Mg#89 and An#88, respectively. The dacitic lavas are characterized by high Sr/Y and La/Yb ratios (adakitic signature), no Eu anomaly, homogeneous Sr, Nd, and Pb isotopic ratios, and ^{230}Th-excesses. On the other hand, the andesitic lavas are heterogeneous in whole-rock major, trace, and isotopic compositions.

Discussion

The petrological and geochemical features of the andesitic products suggest that they were produced by mixing between felsic magma and primitive mafic magma. On the other hand, the dacitic lavas do not show any evidence of magma mixing. The absence of Eu anomaly negates a primary role of fractional crystallization in the magma genesis. In addition, the adakitic signature cannot be produced by crustal

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melting, because the underlying crust is too thin (Niu et al., 2016) for garnet to be stable (e.g. Rapp and Watson, 1995). Therefore, it is suggested that the dacitic magma was derived from the upper mantle, most plausibly, from the subducting slab. The slab origin of the magma is consistent with the ^{230}Th-excess signature and the Pb isotopic compositions, which can be explained by mixing of a sediment component and an altered oceanic crust component of the slab.

One possible origin of the dacitic magma would be direct partial melting of the subducted slab (e.g. Defant and Drummont, 1990). However, extremely high temperatures with >1300ºC (Mibe et al., 2011) is required to melt the slab at ~300 km depth, which is highly unlikely. The andesitic and dacitic lavas erupted almost contemporaneously (~35 ka), with the former preceding the latter. The primitive mafic magma, involved in the generation of the andesitic magma, is considered to have been generated through fluid-fluxed melting of the mantle. These observations suggest that slab-derived aqueous fluid and slab-derived hydrous melt, corresponding to the dacitic magma, were almost simultaneously present in the upper mantle beneath the Rishiri Volcano at ~35 ka. Therefore, it is suggested that the dacitic magma may represent hydrous melt, which was separated from the ascending slab-derived supercritical liquid at the depth corresponding to the critical end point, leaving behind aqueous fluid (e.g. Kawamoto et al., 2012) that induced the generation of the primitive basaltic magma.

キーワード：超臨界流体、不混和現象、沈み込み帯火成活動
Keywords: Supercritical liquid, Unmixing, Subduction zone magmatism

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Genesis of recent mafic volcanism in the Taupo Volcanic Zone, New Zealand: insights into the birth and death of cataclysmic caldera-forming systems?

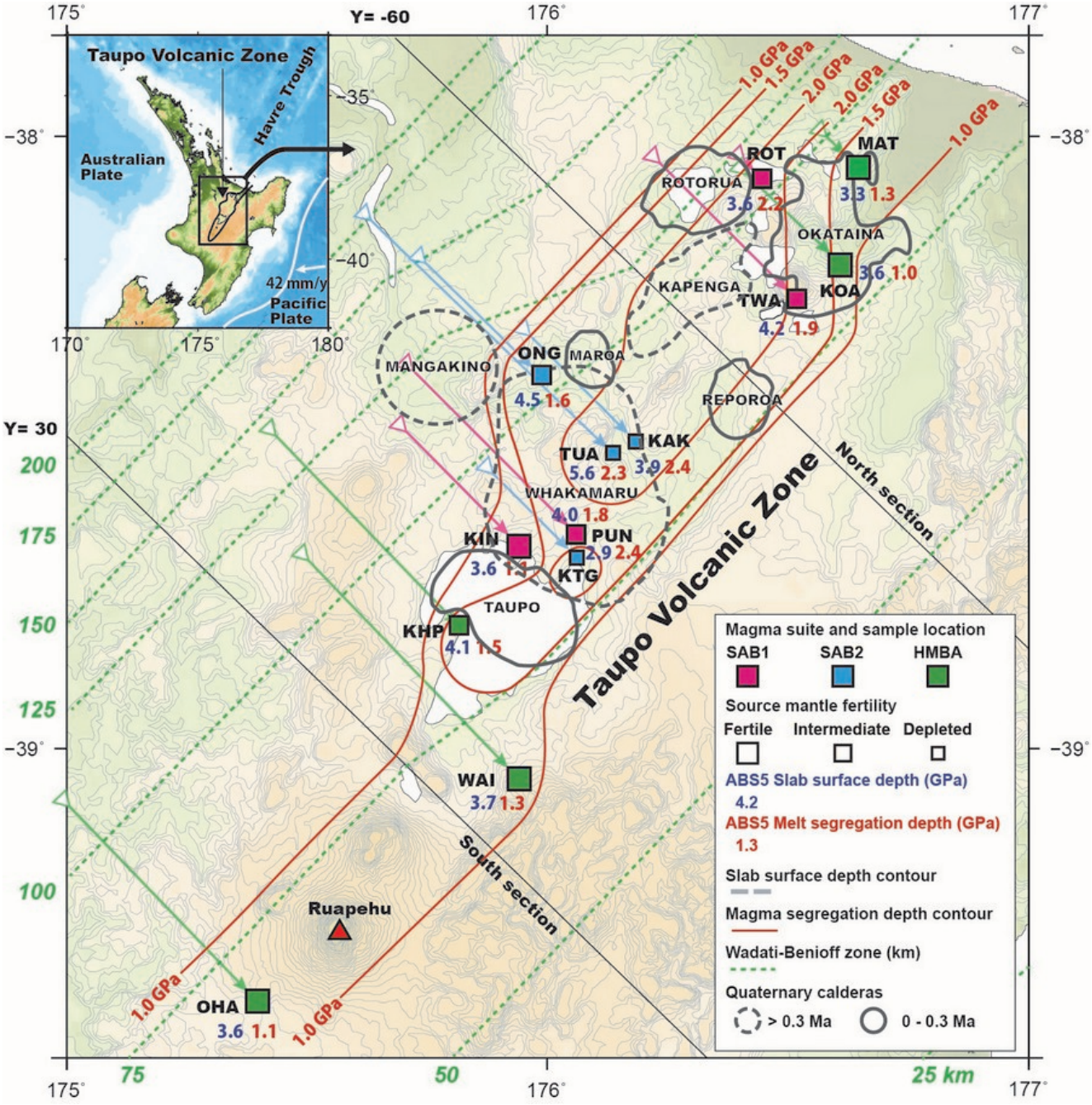
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Mafic magmatism of the actively extending Taupo Volcanic Zone (TVZ) of the North Island, New Zealand, is volumetrically minor, but thought to tap the material that provides the heat source for voluminous rhyolite production through partial melting of the crust, which ultimately results in cataclysmic caldera-forming eruptions. We have studied the major and trace element chemistry 14 mafic samples from across the entire TVZ, and the uranium isotopic composition of whole rocks, groundmasses and separates of mafic mineral phases from a selection of 9 samples (with the remaining 5 too sparsely phyric for mineral separation). Some minerals yield significant ^{234}U enrichments despite groundmass and whole rock close to ^{238}U-^{234}U secular equilibrium, pointing to uptake of variably hydrothermally altered antecrystic minerals prior to the eruption of originally sparsely pyric to aphyric mafic magmas. However, incompatible trace element pattern indicate that there are three chemically distinct groups of samples, and that all but one sample may be used to derive primary melt compositions. We employ the latest version of the Arc Basalt Simulator (ABS5) to forward model these compositions, deriving mantle source parameters including mantle fertility, slab liquid flux, mantle volatile content, degree of melting, and P-T conditions of melt segregation. We show that mafic rocks erupted in areas of old, now inactive calderas constitute low-degree, deep melts, while those in areas of active caldera-volcanism are high-degree partial melts segregated from a less depleted source at an intermediate depth. Finally high-Mg basaltic andesites erupted in the southwest and the northeast of the TVZ point to a fertile, shallow mantle source. Our data are consistent with a petrogenetic model where mantle melting is dominated by decompression, rather than fluid fluxing, and progresses from shallow to deeper levels with time. Melt volumes initially increase to a tipping point, at which large scale crustal melting and caldera volcanism become prominent, and then decrease due to progressive depletion of the mantle wedge by melting, resulting in the dearth of heat provided and eventual cessation of rhyolitic cataclysim. For the first time, a direct link becomes apparent between the chemistry of recently erupted mafic magmas and the long-term activity and evolution of caldera volcanism in the TVZ.

Keywords: Arc Basalt Simulator, uranium isotopes, basaltic magmatism, rhyolitic magmatism, subduction zone processes

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[E] 口頭発表 | セッション記号 S (固体地球科学)：S-MP 岩石学・鉱物学

2019年5月28日(火) 15:30 ~ 17:00 | A07 東京ベイ幕張ホール

[S-MP30] 地殻-マントル・コネクション

コンビーナ:田村 芳彦(海洋研究開発機構　海域地震火山部門)、石塚 治(産業技術総合研究所活断層火山研究部門)、Chris Conway(Geological Survey of Japan)、座長:Chris Conway、田村 芳彦(JAMSTEC)

近年、地殻の薄い海洋島弧が大陸生成の場ではないのか、という考えや、中央海嶺における正断層に沿った海水のしみこみがマントル融解を引き起こして、モホ面を形成するのではないか、という考えが出されている。地表ー地殻ーマントルの関係やマントルから地殻を通して噴火に至るマグマの生成・挙動に関して、火山学、地球化学、岩石学、地質学、年代学、地球物理学などの広い分野からの投稿を期待する。

15:30 ~ 15:45

[SMP30-07] **Introducing an oceanic core complex in the Shikoku Basin: Mado Megamullion**

★Invited Papers

*小原 泰彦[1,2]、沖野 郷子[3]、秋澤 紀克[3]、藤井 昌和[4]、針金 由美子[5]、平野 直人[6]、平内 健一[7]、石塚 治[5]、町田 嗣樹[8]、道林 克禎[9]、Sanfilippo Alessio[10]、Snow Jonathan[11]、山下 浩之[12] (1.海上保安庁海洋情報部、2.海洋研究開発機構、3.東京大学大気海洋研究所、4.国立極地研究所、5.産業技術総合研究所、6.東北大学、7.静岡大学、8.千葉工業大学、9.名古屋大学、10.パビア大学、11.ヒューストン大学、12.神奈川県立生命の星・地球博物館)

15:45 ~ 16:00

[SMP30-08] Spatial variation of petrological and geochemical characteristics of mantle peridotites in Mado Megamullion, Shikoku Basin

*秋澤 紀克[1]、町田 嗣樹[2]、沖野 郷子[1]、小原 泰彦[3] (1.東京大学　大気海洋研究所、2.千葉工業大学　次世代海洋資源研究センター、3.海上保安庁　海洋情報部)

16:00 ~ 16:15

[SMP30-09] **Magmatism-hydrothermalism interaction along the crust-mantle transition below oceanic spreading centres**

★Invited Papers

*Mathieu Rospabe[1,2]、Mathieu Benoit[1]、Georges Ceuleneer[1] (1.GET, OMP, Univ. of Toulouse, CNRS, IRD, F-31400 Toulouse, France、2.JAMSTEC, Yokosuka 237-0061, Japan.)

16:15 ~ 16:30

[SMP30-10] **Serpentinization and carbonation of dunites in the western part of the Isua Supracrustal Belt, Southwestern Greenland**

*Juan Miguel Ramirez Guotana[1]、Tomoaki Morishita[1]、Akihiro Tamura[1]、Ikuya Nishio[1]、Kenichiro Tani[2]、Yumiko Harigane[3]、Kristoffer Szilas[4]、D. Graham Pearson[5] (1.Kanazawa University、2.National Museum of Nature and Science, Japan、3.Institute of Geology and Geoinformation Geological Survey of Japan/AIST、4.University of Copenhagen、5.University of Alberta)

16:30 ~ 16:45

[SMP30-11] **Petrogenesis of fertile abyssal peridotites of the Pujada Ophiolite, SE Mindanao, Philippines**

*Valerie Shayne Vargas Olfindo[1]、Betchaida Duetes Payot[1]、Gabriel Theophilus Valera[1]、Shoji Arai[2]、Tomoyuki Shibata[4]、Masako Yoshikawa[3] (1.Rushurgent Working Group, National Institute of Geological Sciences, University of the Philippines、2.Department of Earth Sciences, Kanazawa University, Kakuma, Kanazawa, Ishikawa 920-1192, Japan、3.Institute for Geothermal Sciences, Graduate School of Science, Kyoto University, Beppu 874-0903, Japan、4.Department of Earth and Planetary Systems Science, Hiroshima University, Hiroshima 739-8526, Japan)

16:45 ~ 17:00

[SMP30-12] 飛騨変成帯中に産する超苦鉄質岩：島弧深部起源岩石の例として

小楠 陽平[1]、*森下 知晃[1]、田村 明弘[1] (1.金沢大学)

Introducing an oceanic core complex in the Shikoku Basin: Mado Megamullion

*小原 泰彦[1,2]、沖野 郷子[3]、秋澤 紀克[3]、藤井 昌和[4]、針金 由美子[5]、平野 直人[6]、平内 健一[7]、石塚 治[5]、町田 嗣樹[8]、道林 克禎[9]、Sanfilippo Alessio[10]、Snow Jonathan[11]、山下 浩之[12]
*Yasuhiko Ohara[1,2], Kyoko Okino[3], Norikatsu Akizawa[3], Masakazu Fujii[4], Yumiko Harigane[5], Naoto Hirano[6], Ken-ichi Hirauchi[7], Osamu Ishizuka[5], Shiki Machida[8], Katsuyoshi Michibayashi[9], Alessio Sanfilippo[10], Jonathan E. Snow[11], Hiroyuki Yamashita[12]

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1. Hydrographic and Oceanographic Department of Japan, 2. Japan Agency for Marine-Earth Science and Technology, 3. Atmosphere and Ocean Research Institute, University of Tokyo, 4. National Institute of Polar Research, 5. Geological Survey of Japan/AIST, 6. Tohoku University, 7. Shizuoka University, 8. Chiba Institute of Technology, 9. Nagoya University, 10. University of Pavia, 11. University of Houston, 12. Kanagawa Prefectural Museum of Natural History

Oceanic core complexes (OCCs) are domal bathymetric highs with axis-normal corrugations, and with exposure of serpentinized peridotite and gabbroic rocks, interpreted as exhumed footwalls of low-angle detachment faults. OCCs provide a valuable opportunity to directly study the architecture of oceanic lithosphere, together with the tectono-magmatic processes associated with its formation and evolution.

A significant fraction of the ocean floor is created in backarc basins where water plays a major role in generating backarc basin basalts, strikingly contrasting to magmatic process at mid-ocean ridges. The opportunity to explore the recent formation of backarc basin lower crust and upper mantle is, therefore, an important contribution to understanding the ocean basins. The extensive multi-beam bathymetric mapping by Japan’s continental shelf survey has revealed the presence of potential OCCs in the multiple portions of the Philippine Sea Plate, such as in the Parece Vela Basin, Shikoku Basin, Kita-Daito Basin and West Philippine Basin. Among these, Godzilla Megamullion in the Parece Vela Basin is the largest known OCC on the Earth, and is one of the well-studied OCCs in the world.

In order to advance our understanding of the lithospheric composition of the Philippine Sea Plate, we need to utilize the potential Philippine Sea OCCs as tectonic windows to sample the lower crust and upper mantle materials. However, these potential OCCs have been remained largely unsampled and unstudied except only a few locations. We thus have started a new project focusing on the Shikoku Basin OCCs. Two cruises in the 2018 summer (YK18-07 and KH-18-2) collected peridotites and gabbros from the main Shikoku Basin OCC, here we named “Mado Megamullion”. The scheduled YK19-04S cruise in 2019 April will collect more datasets on this OCC.

In this contribution, we will show the general tectono-magmatic characteristics of Mado Megamullion. The

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OCC provides the information on the Shikoku Basin lower crust and upper mantle for the first time. Mado Megamullion is an ~20 km square OCC, the areal size is comparable to Kane Magamullion in the Mid-Atlantic Ridge. Thus it should be easier for us to make a comparative study between the two OCCs, providing useful information to understand the difference of the lithospheric characteristics between the two major ocean environments.

キーワード：マドメガムリオン、四国海盆、海洋コアコンプレックス
Keywords: Mado Megamullion, Shikoku Basin, Oceanic Core Complex

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Spatial variation of petrological and geochemical characteristics of mantle peridotites in Mado Megamullion, Shikoku Basin

*秋澤 紀克[1]、町田 嗣樹[2]、沖野 郷子[1]、小原 泰彦[3]
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Oceanic core complex is one of the tectonic windows, where mantle peridotites are exposed directly to the ocean floor. The mantle peridotites can provide petrological and geochemical information of the inaccessible oceanic mantle. However, the mantle peridotites from the oceanic core complex bear a possibility that their petrological and geochemical characteristics were modified during exhumation to the ocean floor via detachment faulting. Thus, formation process of the oceanic core complex must be elucidated in order to better presume the pristine oceanic mantle materials therein. Here, we present petrological and geochemical characteristics of mantle peridotites collected from a newly termed backarc oceanic core complex, “Mado (window in Japanese)” Megamullion in the Shikoku Basin, Philippine Sea. The samples were collected through a series of scientific cruises, YK18-07 by R/V Yokosuka with DSV Shinkai 6500, and KH-18-2 by R/V Hakuho. A total of 16 samples is used here: 13 peridotites and 3 dunites. Vein-like oxide gabbros are included in some peridotite samples from a region close to the ridge axis (proximal region), whereas none of the peridotites showing such lithological characteristics were found from a region far from the ridge axis (distal region). In contrast, the dunite samples were found only from the distal region. Since dunites are commonly interpreted as fossil channels for primitive (silica-depleted) melts beneath mid-ocean ridges, they likely transported parental melts of mid-ocean ridge basalt (MORB) beneath paleo-ridge axis. With regards to the spatial variation of petrological and geochemical characteristics of the mantle peridotites, we delineate a scenario of Mado Megamullion formation, where the exhumed mantle materials were getting modified by evolved magmas with time proceeding, indicating magma stagnation due probably to time-dependent cooling of the ridge spreading system. Therefore, the mantle peridotites in the distal region might show relatively pristine geochemical compositions in comparison with those in the proximal region.

キーワード：Oceanic core complex、かんらん岩、ダナイト、MORB、全岩化学組成、鉱物化学組成
Keywords: Oceanic core complex, Peridotite, Dunite, MORB, Whole-rock chemical composition, Mineral chemical composition

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Magmatism-hydrothermalism interaction along the crust-mantle transition below oceanic spreading centres

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Beneath oceanic spreading centres, the transition from the upwelling and partially molten peridotitic mantle and the accreting gabbroic lower crust appears as a major chemical, thermal and rheological interface. In most ophiolites worldwide, it is underlined by a dunitic horizon whatever the paleo-tectonic setting (mid-ocean ridges vs. supra-subduction zone). Since dunite is observed in present-day oceans in different geodynamic environments, in association with mantle harzburgite and with troctolitic-gabbroic veins and sills, it is reasonable to suppose that ophiolitic dunitic transition zone (DTZ) formed prior to the intra-oceanic thrusting leading to obduction.

As a matter of fact, the understanding of the petrological processes occurring in the mantle-crust transition zone beneath oceanic ridges can be studied in the Oman ophiolite. Particularly, the Maqsad area (Sumail massif) evolved in a MORB-like magmatic environment and presently exposes a >300 m thick DTZ above a paleo-mantle diapiric structure. It has been attributed to peridotite reactional melting or to the accumulation of olivine from Mg-rich melts, whether a combined origin is more likely. Following the reactional origin, a partially molten harzburgite reacts with interstitial melts, enhancing the orthopyroxene dissolution and the crystallization of secondary olivine, resulting in a rock essentially made of olivine. Interstitial mineral fractionation during melt migration between olivine grains (or melt-rock reaction) is partly responsible of the extensive petrological and geochemical variability observed at Moho level.

Recent studies evidenced a large interstitial mineral variety in dunites from the DTZ with, in addition to plagioclase and clinopyroxene expected in a MORB magmatic environment, the presence of orthopyroxene and amphibole among others. These minerals are also observed, together with mica, as silicate inclusions in chromite grains scattered in the dunite. This calls for the early involvement of hydrated, Si- and alkali-rich melts in the formation of dunite and chromitite ore bodies at Moho level beneath oceanic ridges. Since the presence of this peculiar mineralogy is ubiquitous within the DTZ and absent in mantle harzburgite, this distribution supports that the hydrated component originated from above, probably seawater in origin. These fluids interacted with surrounding rocks and with the variably evolved MORB issued from the Maqsad diapir, allowing to generate the hybrid melts, i.e. a blend between supercritical hydrothermal fluids rich in silica or trondhjemitic melts issued from hydrous melting of the country rocks.

The chemical variations observed along the Maqsad DTZ define trends with a characteristic vertical scale of few tens of meters. The chemical variation patterns are spatially correlated to the distribution of ridge-related faults or fracture zones (i.e. active at an early, high temperature magmatic stage), not only for fluid-mobile elements but also for immobile elements (e.g. REE, HFSE). These faults seem to have

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enhanced (i) melt migration and extraction, from the mantle to the crust, and (ii) deep hydrothermal fluids introduction down to the Moho level. In other words, they are the main vectors for upwelling melt modification by hybridization, with hydrothermal fluids and/or silicic hydrous melts, and crystallization. In this context, the DTZ appears as a reactive interface that developed by the combination of three primary processes: tectonics, magmatism and deep, high temperature hydrothermal circulations. Fluid-melt-rocks reactions occurring at Moho level may have a significant impact on the MORB variability surveyed along present-day mid-ocean ridges and may contribute to part of the signatures observed at hydrothermal vents.

Keywords: Oman ophiolite, dunitic transition zone, melt-rock reactions

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Serpentinization and carbonation of dunites in the western part of the Isua Supracrustal Belt, Southwestern Greenland

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The 3.7 Ga Isua supracrustal belt (ISB) hosted in Itsaq Gneiss Complex in southwestern Greenland preserves one of the oldest metamorphosed mafic-ultramafic complex in the world which provides opportunity to study early petrological processes on Earth. Ultramafic bodies are common throughout the Isua supracrustal belt. These ultramafic rocks are interpreted to be possible mantle residues while other studies consider a cumulate origin. In the western limb of the ISB, less altered dunitic bodies enveloped by metasomatized dunites and amphibolites are exposed. The studied dunite lens is also referred as Lens B by previous studies. The northern part of Lens B dunites are highly deformed, highly serpentinized and carbonatized. The central and lower Lens B are less deformed and composed of olivine, serpentine, magnesite, magnetite, stichtite and Ti-rich humites. Ti-chondrodite (Ti-Chn) and Ti-clinohumite (Ti-Chu) are present in the central and southern part of Lens B. Ti-Chn and Ti-Chu occur commonly as irregular patches in olivine. In some portions, intergrowths of Ti-Chn and Ti-Chu are present. The F contents of the the Ti-Chn and Ti-Chu are also very low. Olivine grains are highly forsteritic and are comparable to those derived by deserpentinization process. The major serpentine phase is antigorite which occur as platy grains and minor amounts as inclusion in olivine. Stichtite, a magnesium-chromium hydroxycarbonate mineral, also includes clinohumite minerals. The clinohumite intergrowth in ISB dunites can be associated to the breakdown of Ti-Chn to Ti-Chu (Ti-Chn+Atg+Ol=Ti-Chu+H2O). The clinohumites are also almost F-free which suggests a lower temperature within the antigorite stability field compared to F-bearing clinohumites. Petrographic and geochemical results suggest that the dunites reached P-T conditions within the Ti-Ch and Atg stability field and retrogressed and carbonated (stichtite and magnesite) at lower pressure and temperature where Ti-Chu is stable.

Keywords: Isua Supracrustal Belt, archaean, peridotites

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Petrogenesis of fertile abyssal peridotites of the Pujada Ophiolite, SE Mindanao, Philippines

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Fresh mantle peridotites of the Pujada Ophiolite are extensively exposed in southeast Mindanao, Philippines. Despite its good preservation, its origin and formation is not constrained due to lacking geologic data. In this study, petrographic and geochemical characteristics of the mantle section of the Pujada Ophiolite are investigated to determine its tectonic setting and the magmatic processes operating during its formation.

The mantle section of the Pujada Ophiolite is composed of massive and pyroxene-rich lherzolites and harzburgites and interlayers of variably serpentinized lherzolites, harzburgites and dunites. Mineral chemistry of the spinel peridotites reveal spinel Cr# =0.10-0.50 and olivine Fo =89-91 typical of abyssal peridotites. The mantle peridotites are classified into three based on their field occurrence and spinel Cr#: Group I - massive lherzolites and harzburgites with Cr# =0.10-0.40, Group II - interlayered lherzolites and harzburgites with Cr# =0.10-0.40, and Group III - interlayered harzburgites and dunites with Cr# >0.4. The Group I peridotites are protogranular with minor vermicular spinel. The Group II peridotites are highly serpentinized. Preserved portions show porphyroclastic texture with vermicular to subhedral spinel. The Group III peridotites are also highly serpentinized but porphyroclastic texture in the harzburgites can be observed. Clinopyroxene and orthopyroxene compositions of the peridotites reveal an increasing depletion in Al_2O_3 from Group I to Group II and III with increasing Mg#. Groups I and II show lower Mg# =0.90-0.93 and 0.92-0.93, respectively. The Group III peridotites have the highest Mg# =0.925-0.935. The clinopyroxene Na_2O and TiO_2 of the three groups are within the same range of 0.10-0.40 and 0.10-0.25, respectively. The orthopyroxenes also show the same range of Na_2O and TiO_2 of 0.01-0.10 and 0.01-0.20, respectively. In general, rare earth element composition shows depletion of light rare earth element (LREE) and relatively flat heavy rare earth element (HREE) which further suggest an abyssal origin. Trace element compositions of the peridotites are indicative of low degrees of partial melting within 6%-14%. A few peridotite samples also show LREE enrichment suggesting that metasomatism may have affected these rocks.

Keywords: Pujada Ophiolite, peridotites, mid-oceanic ridge, LREE enrichment

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飛騨変成帯中に産する超苦鉄質岩：島弧深部起源岩石の例として
Ultramafic rock in the Hida metamorphic belt: an example of arc plutons

小楠 陽平[1]、*森下 知晃[1]、田村 明弘[1]
Yohei Ogusu[1], *Tomoaki Morishita[1], Akihiro Tamura[1]

1. 金沢大学
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飛騨変成帯が分布する白山市尾添地域に超苦鉄質岩石が産することが金沢大学の卒業研究で報告されていた(長岡,1970 金沢大学理学部卒論)．そこで本発表では，この超苦鉄質岩の記載岩石学的特徴と鉱物化学組成を報告する．これらのデータから，今回報告する超苦鉄質岩石は島弧深部起源の岩石であると考え，その意義について発表する．

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[E] 口頭発表 | セッション記号 S (固体地球科学)：S-MP 岩石学・鉱物学

2019年5月28日(火) 10:45 ~ 12:15 | A08 東京ベイ幕張ホール

[S-MP31] Supercontinents and Crustal Evolution

コンビーナ:Satish-Kumar Madhusoodhan(Department of Geology, Faculty of Science, Niigata University)、外田 智千(国立極地研究所)、Sajeev Krishnan(Centre for Earth Sciences, Indian Institute of Science)、小山内 康人(九州大学大学院比較社会文化研究院地球変動講座)、座長:M. Satish-Kumar(Niigata University)、外田 智千(国立極地研究所)

Supercontinent formation and dispersion has been enigmatic in the Earth's history. Eurasia is one such current supercontinent and incredible progress in the understanding of its geological evolution has been achieved in the past decade. Earlier supercontinents in the Earth's history such as Gondwana (0.5 Ga), Rodinia (1.0 Ga), Columbia/Nuna (2.0 Ga), Kenorland (2.5 Ga) and Vaalbara (3.1 Ga), have been the focus of several studies, however limited information on older supercontinents has restricted an understanding of their tectonic evolution. In this session, we invite authors around the world to present new data as well as review existing results on the continental scale crustal processes and tectonic evolution that are associated with supercontinent formation and breakup events in the Earth's history. The well-studied Eurasia and Gondwana supercontinents are of particular focus. Topics of interest include, but not restricted to, extremes in metamorphism, P-T-d-t evolution, magmatism, and the role of fluids. We hope to provide a platform for scientific discussions that will enlighten our understanding of the physical and chemical processes in the continental crust that records episodes of orogenesis that contributed to the formation and evolution of supercontinents.

10:45 ~ 11:00

[SMP31-01] Tectonic development of the East Indian cratonic margin and its status in Columbia Supercontinent

★Invited Papers

*Kaushik Das[1] (1.Hiroshima University)

11:00 ~ 11:15

[SMP31-02] **Continental crust formation and metamorphism during the Neoarchean–Paleoproterozoic: an example from the Nilgiri Block, southern India**

★Invited Papers

*VINOD O SAMUEL[1] (1.Yonsei University)

11:15 ~ 11:30

[SMP31-03] Preliminary paleomagnetic studies on the mafic dykes in Western Dharwar craton, South India.

*Silpa Ammini Sasidharan[1]、Madhusoodhan Satish-Kumar[2]、Naoto Ishikawa[3]、Krishnan Sajeev[4] (1.Graduate School of Science and Technology, Niigata University、2.Department of Geology, Faculty of Science, Niigata University、3.Graduate School of Human and Environmental Studies, Kyoto University, Kyoto, Japan、4.Centre for Earth Sciences, Indian Institute of Science, Bangalore, India)

11:30 ~ 11:45

[SMP31-04] Syn-metamorphic boron-bearing fluid infiltrations deduced from tourmaline in the Main Central Thrust zone, eastern Nepal Himalayas

★Invited Papers

*河上 哲生[1]、酒井 治孝[1]、佐藤 活志[1] (1.京都大学大学院理学研究科)

11:45 ~ 12:00

[SMP31-05] **レッサーヒマラヤの現地性堆積物層下部（1.9-1.75 Ga）に産出する火成岩の岩石学的特徴：広域的組成変化とテクトニック場の推定**

*新城 竜一[1]、安室 朝基[1]、大浦 晃平[1]、大城 和哉[1]、田原 史朗[1]、酒井 治孝[2] (1.琉球大学理学部物質地球科学科、2.京都大学大学院理学研究科)

12:00 ~ 12:15

[SMP31-06] Petrogenesis and tectonic implications of orbicular granodiorite from Yangtze cratonic nucleus

*Yihe Li[1] (1.China University of Geosciences Wuhan)

Tectonic development of the East Indian cratonic margin and its status in Columbia Supercontinent

*Kaushik Das[1]

1. Hiroshima University

The East Indian cratonic margin is an important geological area towards understanding the tectonic development of the Precambrian India co-evolving with its erstwhile continental neighbors, including Antarctica. It, at present spreads out several linearly arranged Mesoproterozoic sedimentary basins (Chhattisgarh Basin and its satelite basins) unconformably lying on the Archean Bastar cratonic basement rocks and also juxtaposed on its east by a Proterozoic orogenic belt (Eastern Ghats Belt, EGB). While the basement rocks reveal the origin and evolution of the Archean craton and later tectonics affecting it, the sedimentary basins preserve the history of basin tectonics and fluctuation of different geological and geochemical proxies indicating the fluctuation of paleoenvironment, and also the tectonics of surrounding areas. The adjacent orogenic belt also has a variegated history of its developement and final cratonization, at least the tectonic history of the southern part was older while major part of the northern part was younger than the formation of those sedimenatry basins.
Our group in recent years have carried out detailed sedimentological, geochemical, and geochronological studies of the early sediment fills of these Mesoproterozoic basins (Chakraborty et al., 2012, Precam. Res., 200-203, 129-148; Das et al., 2015, Geol. Soc. London, Memoirs, 43, 207–221; Saha et al., 2016, Precam. Res., 281, 363-383) In this presentation, the collated data on the paleo-environmental facies analysis, variation in Nd-isotope geochemistry and U-Pb detrital zircon geochronology will be presented for the sediments of Singhora Basin, Khariar Basin and Ampani Basin, and also the geochemical character with tectonic affinity of the ca. 1450 Ma felsic porcellanitic tuff layer in all these basins. This will help to have an integrated understanding of the evolution of deep- to shallow continental crust in the East Indian Craton margin, as well as the connection between its neighbors in the supercontinent, "Columbia".

Keywords: East Indian Craton margin, Mesoproterozoic Chhattisgarh Basin, Felsic volcanism, Columbia Supercontinent

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Continental crust formation and metamorphism during the Neoarchean–Paleoproterozoic: an example from the Nilgiri Block, southern India

*VINOD O SAMUEL[1]

1. Yonsei University

Earth is a unique planetary body with an evolved felsic continental crust on its surface. Had this continental crust not evolved, Earth’ s crust would have been basaltic/gabbroic in composition, and covered almost completely by water. It is important to understand how the mafic crust, which formed after the differentiation of Planet Earth transformed to one that is felsic in composition. Presently active processes capable of transforming crust from mafic to felsic composition, on a large scale, are subduction and subsequent arc magmatism. However, whether such processes were active during the Hadean–Archean eon is highly debated. Field evidence from major cratons show that partial melting of the earlier formed mafic crust (e.g., processes like sagduction) formed felsic continental crust. Thus, understanding when subduction-related process started on the planet is important. Here we present evidence from metamorphosed magmatic rocks such as pyroxenite, metagabbro, two-pyroxene granulite, charnockite, hornblende-biotite gneiss and rhyolite from the Nilgiri Block, southern India. U-Pb zircon age data shows that all these rocks formed during the late Neoarchean (core ages between 2600–2500Ma) and that they underwent subsequent metamorphism during the early Paleoproterozoic (rim ages between 2500–2450Ma). If felsic rocks formed from the partial melting of earlier formed mafic rocks, the mafic rocks should be older. Since all these rocks were formed and metamorphosed simultaneously, it is possible that protoliths of these rocks formed through melt differentiation followed by partial melting in the mantle wedge during the subduction-related arc magmatic process. An enrichment in light field strength elements and REE compared to heavy ones, and Nb-Ta depletion are common signatures in rocks formed through the arc magmatic process, where fluids or melts formed from subducted basaltic crust and the overlying sediments enrich the mantle wedge in lighter elements. Further, during metamorphism, these rocks could partially melt and form granitic melts. However there is no field evidence that suggests partial melting during metamorphism in these rocks. Textural relations and vein networks of silicate-oxide-sulfide-phosphate minerals in these rocks suggest that they could have possibly metasomatized in the presence of saline fluids during the early Paleoproterozoic. Such saline fluids could have been released during the waning stages of the magmatic process, probably due to the collapse and mixing of the accretionary wedge to the mantle wedge.

Keywords: Arc Magmatism, Metamorphism, southern India

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Preliminary paleomagnetic studies on the mafic dykes in Western Dharwar craton, South India.

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Mafic dykes of varying dimensions and ages are well exposed all along the Archean Dharwar craton of south India. The mafic dykes in the Eastern Dharwar craton (EDC) have been studied in detail by several researchers previously (French and Heaman, 2010; Kumar et al., 2012, Srivastava et al., 2014). However, limited information is available for the dyke in Western Dharwar craton (WDC) and is considered in the present study. Representative samples were collected from dykes in the WDC and detailed petrography and geochemistry were carried out. The thin section observation revealed two different types of dykes based on the mineral assemblage, texture and the degree of alteration. First category of dykes is dolerites with typical ophitic texture and lath-shaped plagioclase. The other group of dyke samples showed high degree of alteration and remnant ophitic textures with the preservation of very less plagioclase laths as well as original mineralogy. This group termed as meta-dolerites, because of the prominent metamorphism. The dolerites and meta-dolerites are found to exhibit different distribution of major oxides as well as distinct trace and rare-earth element concentrations (Silpa and Satish-Kumar, 2018). The difference in petrography and geochemistry between the dolerites and meta-dolerites can lead to a preliminary inference that these two suits of rocks might not be co-genetic.

Understanding paleo- positions in which the dykes were emplaced is key while correlating the present, spatially distant cratons. Paleomagnetic studies will help to understand the paleo-position of the cratons and mafic dykes are expected to provide excellent records of the earth’s magnetic field as they cool rapidly when emplaced (Belica et al., 2014). For the preliminary paleomagnetic analyses, 86 core specimens were prepared from 33 sites including both dolerite and meta-dolerites and progressive demagnetization experiment has been conducted to assess the stability of natural remanent magnetization (NRM). Pilot specimens were subjected to alternating-field or thermal demagnetization and the NRMs were measured with a spinner magnetometer. Dolerite specimens yielded better magnetic behaviors with stable magnetic components. On the other hand, meta-dolerites show magnetic components probably carried by pyrrhotite and the magnetic behaviors were very unstable. Fig. 1 shows demagnetization behaviors of dolerite sample plotted on orthogonal vector-endpoint diagrams and equal area stereonets.

Studying the dykes in the Dharwar craton is key to understanding the evolution of the mantle during the Precambrian, especially in the Archean to Proterozoic transitional period. Dykes are emplaced after the period of major continental crust formation at around 2.7 Ga and hence the variation in mantle composition through time can be constrained. The dykes can be a result of a plume activity or an indicator of large igneous province and hence the study of which will give valuable information about the mantle source, the degree of melting and the source regions where melting occurred. Dyke swarms and LIPs are the products of major magmatic events in the Earth’s history that probably was the driving force in the breaking up of supercontinents, and they provide clues regarding the cratonic evolution through time. Due to their wide distribution, geochemically coherent dykes can be found in many cratons, thus providing key information on the close proximity of now separated supercontinents.

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Keywords: Mafic dykes, Precambrian, Paleomagetism, Geochemistry

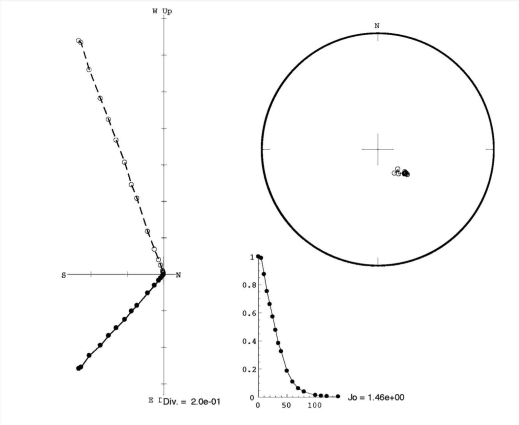


Fig. 1. Orthogonal vector plot, equal area stereonet and alternating-field demagnetization behavior for the dolerite showing typical characteristic remanent magnetization directions.

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Syn-metamorphic boron-bearing fluid infiltrations deduced from tourmaline in the Main Central Thrust zone, eastern Nepal Himalayas

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Mode of occurrence and chemical composition of tourmaline in pelitic schists from the Main Central Thrust (MCT) zone of the Lesser Himalayan Sequences (LHS) are described in detail to deduce the chemical characteristics of tourmaline formed through boron-bearing fluid infiltration, and to estimate the syn-metamorphic fluid compositions.

Metasomatic tourmaline from the tourmalinized wall rocks of tourmaline-quartz veins and a plagioclase-quartz vein shows significant increase in X_{Ca} [=Ca/(Ca+Na)] at almost constant X_{Mg} [=Mg/(Mg+Fe_{total})]. Plagioclase present in such veins are anorthite-rich, and is not in equilibrium with tourmaline. These chemical characteristics of tourmaline are also confirmed in some of the tourmaline-rich pelitic schists that contain more than 1.0 vol% tourmaline. The tourmaline-rich pelitic schists, therefore, are considered to have formed through boron-bearing fluid infiltration. Ca-metasomatism observed in the pelitic schists adjacent to the metadolostone layers points to Ca-enrichment of the fluid composition when passing through the metadolostone layers. Episodic infiltration of such fluids into pelitic schists resulted in production of abundant tourmaline with increasing X_{Ca} trend at almost constant X_{Mg}. Most of the tourmaline in tourmaline-rich pelitic schists are in equilibrium with plagioclase, suggesting rock-buffered environment during the fluid infiltration. The pelitic schists without tourmaline enrichment mostly show increase in X_{Ca} at broad X_{Mg} values, reflecting its growth during longer range of metamorphism.

The fluid compositions that coexisted with tourmaline were estimated by applying experimentally-determined fluid/tourmaline chemical relationships to the vein, tourmaline-rich pelitic schist and tourmaline-poor pelitic schist samples. Assuming coexisting anion to be Cl, they all gave salinity similar to the sea water (~0.6 mol/l NaCl) and slightly above it (~0.4-0.9 mol/l NaCl+$CaCl_2$). The tourmaline-bearing veins and tourmaline-rich pelitic schists indicative of syn-metamorphic boron-bearing fluid infiltrations are widely distributed in the MCT zone of the LHS.

This observation supports that such fluid infiltrations into the High Himalayan Crystallines (HHC), contemporaneous with the inverted metamorphism of the MCT zone, caused vapor-saturated partial melting of the HHC and formed tourmaline leucogranite melts.

キーワード：変成流体、ホウ素、電気石、逆転変成作用
Keywords: metamorphic fluid , boron, tourmaline, inverted metamorphism

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レッサーヒマラヤの現地性堆積物層下部（1.9-1.75 Ga）に産出する火成岩の岩石学的特徴：広域的組成変化とテクトニック場の推定
Geochemical characteristics of mafic and felsic igneous rocks (1.9-1.75 Ga) in the Lesser Himalaya: Regional variation and its implications for tectonic setting

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*Ryuichi Shinjo[1], Tomoki Amuro[1], Kohei Oura[1], Kazuya Oshiro[1], Shiro Tahara[1], Harutaka Sakai[2]

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We present geochemical characteristics of mafic and felsic intrusive rocks (1.9-1.75 Ga) in the Lesser Himalaya and discuss about its tectonic setting. Rocks are taken from wide range of the Lesser Himalaya.

Models of tectonic setting for these rocks are controversial, which include subduction-zone setting (Kohn et al., 2010) and continental rift setting (Sakai et al., 2013).

Analyses of immobile trace element compositions suggest that mafic rocks (metagabbro) from the eastern Nepal have within-plate (or OIB) type composition, while the rocks from central and western Nepal have chemical compositions similar to subduction-related (active continental margin) basalt. It is noted that both types occur in the western Nepal. Based on these results, we suggest that plume-related rift system is more likely tectonic setting for these mafic magmatism than arc setting. Arc-like signature in western Nepal rocks may be derived from sub-continental lithospheric mantle.

Similar regional variation in trace element compositions for felsic rocks was observed. Initial 143Nd/144Nd and 176Hf/177Hf of felsic rocks are lower than those of mafic rocks; thus crustal component might involved significantly in generation of felsic magmas.

キーワード：Nepal、Lesser Himalaya、tectonic setting
Keywords: Nepal, Lesser Himalaya, tectonic setting

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Petrogenesis and tectonic implications of orbicular granodiorite from Yangtze cratonic nucleus

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Orbicular granodiorite outcropped in the Yangtze cratonic nucleus (Huangling Dome), where at least six Precambrian (3.4-0.8 Ga) tectonic events have been recorded. Hence, Huangling Orbicluar Granodiorite (HOG) could help us to investigate both petrogenesis and tectonic implications.

The HOG exposed in the northern margin of Neoproterozoic (~0.8 Ga) Huangling batholith, merely 30 meters long and 5 meters wide. They are composed of obicules (5-12 centimeters in diameter) and matrix. The obicules have different structure as no shell, one-layer shell and multiple-layer shells. In detail, one-layer shell are formed by dark color minerals such as amphibole and biotite; multiple-layer shells are made up of dark layers (dominated by amphibole) and light layers (dominated by plagioclase) at random intervals (0.2-4.3 millimeters). Their inner parts (core) are major plagioclase with minor amphiboles.

Mineral chemistry data are obtained by Electron Probe Micro Analyzer (EPMA) from two profiles crossing obicules. The An (An=100 Ca/(Ca+Na+K)) of plagioclase in matrix, shell and core from one-layer obicule are 26-30, 30-35 and 35-40, indicating the crystallization sequence is from core to shell and then matrix. The An of plagioclase in matrix, shell and core from multiple-layer obicule are more complicate, as 33, 36-46 and 42-45. The data suggest that the obicule crystallized before matrix, without distinct sequence between core and shells.

P-T conditions are calculated by Hb-Pl thermobarometry (Holland and Blundy, 1994; Bhadra and Bhattacharya, 2007). 0.63 GPa and 728℃ are obtained from core of one-layer obicule, while 0.49 GPa and 706℃ are gained from core of multiple-layer obicule. Moreover, P-T condition of multiple-layer shells vary from 0.50-0.80 Gpa and 669-713 ℃, showing pressure decrease towards core with few sharp increasing. The average P-T condition of shells are 0.60 Gpa and 700 ℃, whose pressure is higher than the core. As a result, the multiple-layer obicules may form during decompression. Besides, the sharp increase of An and P-T condition suggest that more basic (Ca-rich) composition may be added into shells during formation.

Chemical distribution patterns of shells and *in-situ* zircon structure have been examined by field emission scanning electron microscopy (FESEM). Energy-dispersive X-ray spectrometers (EDS) mapping shows that no obvious chemical differentiation have been observed in the rhythm shells. Core-mantle-rim structure zircons have been found in the matrix near the shells of obicules. Short columnar zircons with oscillatory bands have been found in amphiboles, while long columnar zircons with wide bands and overgrowth rims/patches have been found in plagioclase.

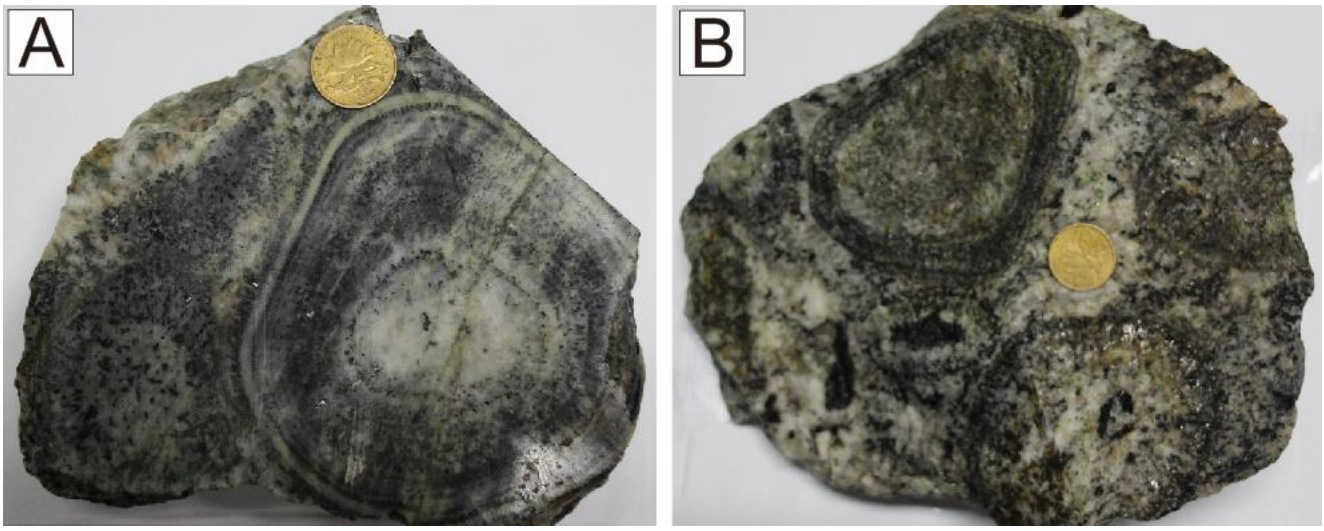
Zircons with Core-mantle-rim structure present concordant U-Pb ages as 1.95 Ga, 1.85 Ga and 0.88 Ga, with corresponding Epsilon Hf(t) values of -17.2 to -4.6, -10.8 to 0.36 and -23.6 to -21.5. Both short and long columnar zircons present concordant U-Pb ages of 0.88 Ga with Epsilon Hf(t) values of -23.7 to -19.85.

Based on new data and geological background, a model for generation of the HOG has been proposed as:

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1) sediments metamorphosed at 1.95 Ga during continent-continent collision (Yin et al., 2013); 2) A-type granitic magma intruded the metasediments at 1.85 Ga (Xiong et al., 2009); 3) dioritic magma intruded the metasediments via the A-type granitic channel at 0.88 Ga; 4) water-rich superheating caused by dehydration of metasediments; 5) rapid crystallzation caused by undercooling while pressure decreasing.

Keywords: Huangling Orbicluar Granodiorite, Cratonic nucleus, Petrogenesis, Tectonic implications



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[E] 口頭発表 | セッション記号 S (固体地球科学)：S-CG 固体地球科学複合領域・一般

2019年5月28日(火) 9:00 ~ 10:30 | A07 東京ベイ幕張ホール

[S-CG49] ハードロック掘削科学～陸上掘削から深海底掘削、そしてオマーン～

コンビーナ:道林 克禎(名古屋大学大学院環境学研究科地球環境科学専攻地質・地球生物学講座岩石鉱物学研究室)、高澤 栄一(新潟大学理学部地質科学科)、秋澤 紀克(東京大学　大気海洋研究所　海洋底科学部門)、座長:高澤 栄一(新潟大学)、秋澤 紀克(東京大学　大気海洋研究所)

ハードロック掘削計画が進展している．本セッションでは，オマーン掘削プロジェクトを中心としてICDPならびにIODPの掘削プロジェクトの成果発表を期待する．さらに，掘削研究にこだわらず，関連するオフィオライト研究などの野外研究や実験研究等の発表の機会となることも期待したい．

9:00 ~ 9:15

[SCG49-06] Melt transport and compositional heterogeneity of the mantle: a case study of peridotite, dunite, and wehrlite from Atlantis Massif

*秋澤 紀克[1]、Gretchen L. Früh-Green[2]、田村 明弘[3]、田村 千織[1]、森下 知晃[3] (1.東京大学　大気海洋研究所、2.ETH　地球科学科、3.金沢大学　理工研究域)

9:15 ~ 9:30

[SCG49-07] **Lower crustal accretion processes revealed from the study of gabbroic cores in Holes GT1A and GT2A, the ICDP Oman Drilling Project**

*Sayantani Chatterjee[1]、Eiichi TAKAZAWA[1]、Katsuyoshi Michibayashi[2]、Peter B Kelemen[3]、Damon A.H. Teagle[4]、Oman Drilling Project Phase I Science Party (1.Department of Geology, Faculty of Sciences, Niigata University, Japan、2.Department of Earth and Environmental Sciences, Nagoya University, Japan、3.Lamont Doherty Earth Observatory, Columbia University, USA、4.Southampton Marine and Maritime Institute, University of Southampton, United Kingdom)

9:30 ~ 9:45

[SCG49-08] オマーンに産するリストベナイトの岩石学: 沈み込み帯の炭素循環の解明に向けて

*髙橋 藤馬[1]、森下 知晃[2]、佐藤 宏樹[3]、Guotana Juan[2]、川本 竜彦[4]、Peter Kelemen[5]、Jude Coggon[6]、Michelle Harris[7]、Juerg Matter[6]、道林 克禎[8]、高澤 栄一[9]、Damon Teagle[6]、The Oman Drilling Project Phase 1 science Party (1.国立大学法人金沢大学理工学域自然システム学類地球学コース、2.国立大学法人金沢大学自然科学研究科自然システム学専攻、3.国立大学法人京都大学理学部、4.国立大学法人静岡大学理学部地球化学科、5.Lamont-Doherty Earth Observatory, Columbia university、6.School of Ocean and Earth Science, National Oceanography Center Southampton, University of Southampton、7.School of Geography, Earth and Environmental Sciences, Plymouth University、8.国立大学法人名古屋大学理学部地球惑星学科、9.国立大学法人新潟大学自然科学研究所)

9:45 ~ 10:00

[SCG49-09] PGE and Os isotope variation in the gabbros and peridotites from the Oman DP drilling cores in the Samail ophiolite, Oman

*仙田 量子[1,2]、鈴木 勝彦[2]、森下 知晃[3]、高澤 栄一[4]、道林 克禎[5]、Kelemen Peter[6]、Teagle Damon[7]、Coggon Jude[7]、Godard Marguerite[8]、The Oman DP Science Party (1.九州大学比較社会文化研究院、2.国立研究開発法人海洋研究開発機構・海底資源研究開発センター 、3.金沢大学理工研究域自然システム学系 、4.新潟大学理学部地質科学科、5.名古屋大学大学院環境学研究科、6.コロンビア大学、7.サウザンプトン大学、8.モンペリエ大学)

10:00 ~ 10:15

[SCG49-10] オマーンオフィオライト・ワジタイン岩体のCM1およびCM2サイトにおける地殻-マントル境界の掘削結果の概要

*高澤 栄一[1]、Damon Teagle[2]、道林 克禎[3]、田村 芳彦[4]、Jude Coggon[2]、Juerg Matter[2]、Peter Kelemen[5]、Oman Drilling Project Phase 2 Science Party (1.新潟大学理学部地質科学プログラム、2.サウサンプトン大学、3.名古屋大学、4.海洋研究開発機構、5.コロンビア大学)

10:15 ~ 10:30

[SCG49-11] オマーン掘削プロジェクトPhase2　マントルセクションから得られた掘削コア試料の岩石学的観察

*市山 祐司[1]、Oman Drilling Project Phase 2 Scientific Party (1.千葉大学)

Melt transport and compositional heterogeneity of the mantle: a case study of peridotite, dunite, and wehrlite from Atlantis Massif

*秋澤 紀克[1]、Gretchen L. Früh-Green[2]、田村 明弘[3]、田村 千織[1]、森下 知晃[3]
*Norikatsu Akizawa[1], Gretchen L. Früh-Green[2], Akihiro Tamura[3], Chiori Tamura[1], Tomoaki Morishita[3]

1. 東京大学　大気海洋研究所、2. ETH　地球科学科、3. 金沢大学　理工研究域
1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. Department of Earth Sciences, Eidgenössische Technische Hochschule-Zürich, 3. Institute of Science and Engineering, Kanazawa University

Harzburgitic, dunitic, and wehrlitic rocks drilled at Atlantis Massif (Mid-Atlantic Ridge, 30˚N), where mantle-derived rocks were exhumed to the sea floor via detachment faulting, were investigated employing *in situ* geochemical analyses. Since dunitic and wehrlitic rocks are commonly interpreted as fossil melt channels, they likely represent transported parental melts of mid-ocean ridge basalt (MORB) beneath the paleo-ridge axis. Although the rocks are severely serpentinized, primary olivines, chromian spinels, orthopyroxenes, and clinopyroxenes were found in several samples. The Cr/(Cr + Al) ratios (Cr#) of the chromian spinel show a bimodal distribution, where one group records higher Cr# (0.35–0.5) and the other group is represented by lower Cr# (0.2–0.3). The extent of mantle melting is strongly correlated to the Cr# of the chromian spinel, thus the mantle-derived lithologies of the Atlantis Massif record at least two end-members with regards to the extent of melting: refractory mantle material with higher Cr#, and enriched mantle material with lower Cr#. To quantitatively evaluate mantle melting and melt transport mechanisms in the suboceanic mantle beneath this section of the Mid-Atlantic Ridge, a one-dimensional, steady-state decompositional mantle melting model was carried out based on rare-earth element concentrations of clinopyroxene. Our modelling results demonstrate that the melting region of the mantle extends unevenly across the ridge axis, with deeper melting occurring on-axis from the garnet-stability field, and shallower melting occurring off-axis from the spinel-stability field. We propose that depleted melts generated at depths in the absence of garnet within the off-axis region were possibly focused to the ridge axis via fracture-induced melt channels and produced wehrlite. It is likely that fracture-induced melt migration was dominantly a response to a decrease of temperature as the mantle was exhumed during detachment faulting.

キーワード：IODP Exp 357、大西洋中央海嶺、ハルツバーガイト、メルト輸送、MORB、ultra-depleted melt
Keywords: IODP Exp 357, Mid-Atlantic Ridge, Harzburgite, Melt transport, MORB, ultra-depleted melt

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Lower crustal accretion processes revealed from the study of gabbroic cores in Holes GT1A and GT2A, the ICDP Oman Drilling Project

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1. Department of Geology, Faculty of Sciences, Niigata University, Japan, 2. Department of Earth and Environmental Sciences, Nagoya University, Japan, 3. Lamont Doherty Earth Observatory, Columbia University, USA, 4. Southampton Marine and Maritime Institute, University of Southampton, United Kingdom

Transition between middle crustal foliated and to lower crustal layered gabbros of Oman ophiolite was drilled at Hole GT2A and GT1A in Wadi Gideah of Wadi Tayin massif (22˚51.793'E/58˚31.198'N and 22˚53.535'/58˚30.904' respectively) during Phase 1 of Oman drilling project. With total depth of 406.77m long Hole GT2A core samples the middle foliated to layered gabbro. Hole GT1A drilled the lower crustal section in the southern Oman ophiolite and recovered 401.52 m of total cores (99.6% recovery). Petrographic observation of representative samples from GT2A and GT1A, we found two dominant rock types: gabbbro and olivine gabbro, where later dominates the lower part of the drill hole.

The layered structure is mainly controlled by the variable grain size and modal composition of minerals. Gabbros contain plagioclase and clinopyroxene (showing poikilitic texture) as primary minerals associated with few amounts of oxides. Clinopyroxenes are often replaced by brown amphibole along cleavages or at the rim. Olivine gabbros are constituted of plagioclase, clinopyroxene, olivine, some orthopyroxene and oxide minerals. Texturally, olivine grains are present as subhedral to skeletal in nature. Magmatic foliation is often demarcated by laths of plagioclase followed by elongated clinopyroxene. The contact between olivine and plagioclase frequently marked by presence of symplectitic intergrowth between spinel and orthopyroxenewhich suggests, olivine was reacting with late stage liquid and produce simultaneous coprecipitation of magnetite and orthopyroxene. Downhole evolution present from bottom to top for both in gabbro and olivine gabbro samples in terms of Mg#,TiO2, and Cr2O3 in clinopyroxene, olivine and plagioclase, particularly at 270mt and 130mt Mg# increase (influx of primitive melts at several intervals). TiO2 and Cr2O3 correspond with Mg#, and eventually follow fractionation trend. Data from rare earth elements implies that ol-gabbros are crystallized from different parent melts (at least two types) supported by the evidence from evolution with depth profile.

Gabbroic lithologies in GT1A represented by anhedral olivine with tabular to elongate shape. Plagioclase are partly or totally enclosed by large clinopyroxene. Clinopyroxenes are tabular to subequant in habit. Some thin films of orthopyroxene present as corona around olivine. Most of the samples have undergone alteration and obscured the igneous origin. In case of Hole GT2A, gabbros are much less affected by alteration compared to GT1A. Downhole variation in mineral composition (in-situ composition) can be correlated with several cycles of crystallization history. Detailed petrographic, microstructural and geochemical study of all the representative samples will be presented. We have also attempted to determine the oxygen fugacity, where (fO2 vs.T plot) oxide pairs are plotted within FMQ field (fO2 vs. T plot). Temperature estimation ranges from 600-800˚C (shallow level gabbro to deeper gabbro) cover total range of temperature from high to low and also have a clue to determine the thermal evolution by rate of cooling.

Keywords: Oman Drilling Project, Lower crust, Gabbro

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オマーンに産するリストベナイトの岩石学: 沈み込み帯の炭素循環の解明に向けて

Petrology of Oman listvenite : Implications for carbon cycle in the subduction zone

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Listvenites obtained during the Phase 1 of the Oman Drilling Project can be generally divided into two main groups based on color: red series and green-white series. Although there is a clear color difference, the mineral assemblage is mainly composed of magnesite and quartz. Dolomite occurs as late veins and/or small patches. Opaque minerals are abundant in the red series which occur either as veins or disseminated grains which are commonly enveloped by carbonate minerals and quartz. The opaque minerals are hematite based on Raman spectrometry analysis. In the green-white listvenite series, opaque minerals are very scarce. Greenish portions in both listvenites were observed on a hand sample scale. In the green-white series, dark green and light green portions are present while only light green portions are observed in the red listvenites. These greenish features are interpreted as mainly polymineralic pseudomorphic replacement of orthopyroxene. In the same hole, pyroxene relics in serpentinites exhibit the same shape as with the previously described greenish pseudomorphs. The dark green portions in the green-white listevenites contain fuchsite (Cr-mica) around spinel relics. Silicified relic pyroxenes with fuchsite along relic cleavages are also present in the light green portions. On the other hand, the greenish portions in the red listvenite series are characterized by magnesite with intergranular fuchsite (?). Hematites in the red listvenites have similarities in form with the opaque minerals occurring as discontinuous veinlets in the serpentinite. The combined similarities in the petrographic features suggest that some listvenites were formed from serpentitnites. Quartz veins with Ni-bearing magnesite were observed in the red series and were formed in the last stage.

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キーワード：リストベナイト、オマーン掘削計画、オマーンオフィオライト、元素移動、炭酸塩岩化
Keywords: Listvenite, Oman drilling project, Oman ophiolite, elements mobility, Carbonation

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PGE and Os isotope variation in the gabbros and peridotites from the Oman DP drilling cores in the Samail ophiolite, Oman

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It is well known that oceanic crust covers almost 70 % of Earth’ s surface. It is formed at mid-ocean ridge and is subducted into mantle at convergent plate margin. This plate motion is pull many kinds of surface materials in inside the mantle and contributed to a global recycling system. However the details of the oceanic crusts and underlain upper mantle are still poor understanding. The construction of the oceanic crusts is defined by constructions of ophiolites which were the ancient oceanic plates exposed onto land.

To have better understandings of the oceanic crust, underlain upper-most mantle and related other things, the Oman Drilling Project by ICDP was done the drilling from 2016 to 2018 in Samail ophiolite, Oman. The Samail ophiolite in the northern part of Oman is the largest and having better exposed section of the oceanic lithosphere in the world.

We will report the preliminary results of the PGE abundances and Os isotope ratios in the whole-rock gabbros and mantle related peridotites from the drilling cores and compering to the data from the Oman surface data. These data will be help us to better understanding of the relationships between the oceanic crust and underlying upper mantle, mechanisms of making oceanic crust, and planning the future Mohole projects.

キーワード：オマーン掘削プロジェクト、はんれい岩、かんらん岩、オスミウム同位体組成、白金族元素存在度
Keywords: Oman DP, gabbro, peridotite, Os isotope ratio, PGE abundance

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オマーンオフィオライト・ワジタイン岩体のCM1およびCM2サイトにおける地殻-マントル境界の掘削結果の概要

Overview of drilling of crust-mantle boundary at CM1&2 sites of Wadi Tayin massif of Oman ophiolite: the ICDP Oman Drilling Project

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At the boundary between the crustal section and the mantle section of the Oman ophiolite there are several tens to hundreds of meters thick, mainly composed of dunite called the crust-mantle transition zone (MTZ) [1]. Since it often accompanies thin veins or clots of plagioclase and clinopyroxene and several centimeters to meters thick gabbro sills, it leaves traces of magma activity right under the ridge. The origin of dunite in MTZ is still under debate: the accumulation of olivine crystallized from melt [2], or the reaction of harzburgite with pyroxene-undersatulated melt [3], or both [4]. Recently, the presence of water at the time of formation has also been pointed out [5]. To clarify the origin of MTZ, more detailed research by continuous core through MTZ is necessary.

From November 2017 to January 2018 MTZ of Wadi Zeeb (CM1&2 sites) in Wadi Tayin massif was drilled by the International Continental Scientific Drilling ProgramOman Drilling Project [6]. Geological mapping on ground associated with information from the recovered cores the thickness of the MTZ is estimated as about 150 m. The upper and lower boundaries of the MTZ has a strike in the east-west direction, and it is inclined about 30 degrees south. In the summer of 2018, the drilled cores were carefully described by scientists on the deep-sea drilling vessel "CHIKYU". The stratigraphy has been divided into four igneous sequences based on the abundance of different lithologies: Layered Gabbro Sequence, Dunite Sequence, Dunite with Gabbro Sequence, and Mantle Sequence. Dunite Sequence and Dunite with Gabbro Sequence are summarized as Crust - Mantle Transition.

Hole CM1A is inclined 60˚ northward. The upper 160 m of the core is the Layered Gabbro Sequence, mostly composed of olivine gabbro, interlayered with gabbro and a small amount of wehrlite, dunite, anorthosite and troctolite. From 160 to 310 m the Crust-Mantle Transition is divided into an upper 90 m Dunite Sequence and a lower 60 m Dunite with Gabbro Sequence containing small lenses of gabbro, troctolite and wehrlite. The dunites are highly serpentinized, and rodingite and diopsidite commonly replace minor gabbroic rocks in these sequences. The lower 80 m of the hole is the Mantle Sequence, with alternating layers of dunite and increasingly abundant, residual mantle harzburgite.

Hole CM2B is a vertical hole located 400 m north of CM1A, and samples the Crust-Mantle Transition and the Mantle Sequence. As in CM1A, the transition is divided into an upper Dunite Sequence and a lower Dunite with Gabbro Sequence. In contrast to Hole CM1A, a small amount of olivine has escaped complete serpentinization in the lower portions of the CM2B transition zone. In the Mantle Sequence, harzburgite is dominant. Dunite accounts for about 25% of this Sequence, less than in CM1A. The lowermost peridoties

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in Hole CM2B are strongly altered to talc+carbonate.

[1] Boudier and Nicolas, 1995, J. Petrol., 36, 777-796, [2] Pallister and Hopson, 1981, J. Geophys. Res., 86, 2593-2644, [3] Kelemen et al., 1995, Nature, 375, 747-753, [4] Abily and Ceuleneer, 2013, Geology, 41, 67-70, [5] Rospabé et al., 2017, Geol. Soc. Am., Data Rep. 2017139, [6] Kelemen et al., 2013, Scientific Drilling, 15, 64-71.

キーワード：オフィオライト、地殻-マントル境界、モホ遷移帯、国際陸上科学掘削プログラム、オマーン掘削プロジェクト
Keywords: ophiolite, crust-mantle boundary, Moho Transition Zone, ICDP, Oman Drilling Project

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オマーン掘削プロジェクトPhase2　マントルセクションから得られた掘削コア試料の岩石学的観察

Petrological observation of core samples drilled from a mantle section of the Oman ophiolite: A preliminary report of the Oman Drilling Project Phase 2

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The Oman ophiolite is the world’s largest ophiolite and will help us to understand the crustal formation, processes in the mantle, and evolution and modification of the oceanic lithosphere through the time. The drillings and investigations of the crust-mantle boundaries and mantle sections were operated in the Oman Drilling Project Phase 2. We report the preliminary results of the petrological observation of the drilling samples from the mantle sections in the Phase 2 Holes BA1B, BA3A, and BA4A.

The Hole BA1B is composed of upper dunite and lower harzburgite associated with mafic dikes. The Hole BA3A is dominated mainly by harzburgite and also contains a minor amount of thin dunitic layers and mafic dikes. The Hole BA4A consists of alternation of dunite and harzburgite with abundant mafic dikes. The mafic dikes observed in each hole are gabbro to olivine gabbro, and sometimes wehrlitic. Brown to pale brown hornblende is usually included in almost all lithology. Phlogopite is also present in association with hornblende. Chromian spinel in an olivine-gabbro sample from the BA4A is characterized by high $Fe^{3+}/(Cr + Al + Fe^{3+})$ ratio (>0.15) and intermediate TiO_2 content (1–2 wt.%), which are comparable with those in island arc basalts. In the contact between the mafic dikes and peridotite, orthopyroxene is formed as a reaction product between the mantle peridotite and mafic melt. The petrological characteristics of the mafic dikes indicate that they crystallized from hydrous, oxidized magmas, which imply that the intrusion event occurred in a convergent margin rather than a typical spreading axis.

キーワード：国際陸上科学掘削計画、オマーンオフィオライト、マントルかんらん岩、苦鉄質岩脈
Keywords: ICDP, Oman ophiolite, Mantle peridotite, Mafic dike

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[E] 口頭発表 | セッション記号 S (固体地球科学)：S-CG 固体地球科学複合領域・一般

2019年5月28日(火) 10:45 ~ 12:15 | A07 東京ベイ幕張ホール

[S-CG49] ハードロック掘削科学〜陸上掘削から深海底掘削、そしてオマーン〜

コンビーナ:道林 克禎(名古屋大学大学院環境学研究科地球環境科学専攻地質・地球生物学講座岩石鉱物学研究室)、高澤 栄一(新潟大学理学部地質科学科)、秋澤 紀克(東京大学　大気海洋研究所　海洋底科学部門)、座長:森下 知晃(金沢大学)、道林 克禎

ハードロック掘削計画が進展している．本セッションでは，オマーン掘削プロジェクトを中心としてICDPならびにIODPの掘削プロジェクトの成果発表を期待する．さらに，掘削研究にこだわらず，関連するオフィオライト研究などの野外研究や実験研究等の発表の機会となることも期待したい．

10:45 ~ 11:00

[SCG49-12] ちきゅう船上のXCTデータによる超マフィック岩の構造解析

*道林 克禎[1]、柿畑 優季[1]、片山 郁夫[2]、岡本 敦[3]、岡崎 啓史[4]、Peter Kelemen[5]、高澤 栄一[6]、Damon Teagle[7]、Oman Drilling Project Phase 2 Science Party[8] (1.名古屋大学大学院環境学研究科、2.広島大学、3.東北大学、4.JAMSTEC 高知コアセンター、5.コロンビア大学、6.新潟大学、7.サウサンプトン大学、8.ICDP)

11:00 ~ 11:15

[SCG49-13] Petrophysical characteristics of serpentinized peridotites of Hole BA1B, BA3A and BA4A

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11:15 ~ 11:30

[SCG49-14] Physical properties of the Moho TZ: Implications from ICDP Oman Drilling Project Phase I & II on-board measurements

*阿部 なつ江[1,12]、岡崎 啓史[1]、片山 郁夫[2]、畠山 航平[2]、赤松 祐哉[2]、Ildefonse Benoit[3]、Ole Ulven[4]、Hong Gilbert[5]、Zhu Wenlu[6]、Cordonnier Benoit[4]、道林 克禎[7]、高澤 栄一[8]、Harris Michell[10]、Teagle Damon[11]、ケレメン ピーター[9]、Godard Marguerite[3]、Matter Jurg[11]、Coggon Jude[11]、Scientific Party Oman Drilling Project (1.国立研究開発法人海洋研究開発機構、2.広島大学、3.モンペリエ大学、4.オスロ大学、5.ソウル大学、6.メリーランド大学、7.名古屋大学、8.新潟大学、9.コロンビア大学、10.プリマス大学、11.サウザンプトン大学、12.金沢大学)

11:30 ~ 11:45

[SCG49-15] Oman Drilling Project Phase IIから採取されたハルツバージャイトの高圧条件下における地震波異方性

*畠山 航平[1]、片山 郁夫[1]、阿部 なつ江[2]、The Oman Drilling Project Phase II Science Party (1.広島大学大学院理学研究科地球惑星システム学専攻、2.国立研究開発法人海洋研究開発機構)

11:45 ~ 12:00

[SCG49-16] 海洋底の拡大モードと海洋地殻構造の解明〜ハワイ沖モホール候補地における深海掘削

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12:00 ~ 12:15

Discussion

ちきゅう船上のXCTデータによる超マフィック岩の構造解析
Structural analyses of ultramafic rocks used by X-ray CT core imaging (Oman Drilling Project Phase 2, D/V CHIKYU)

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X-ray computed tomography (X-ray CT) images were obtained on all cores drilled during Oman Drilling Project (OmanDP) Phase 2 (Holes CM1A, CM2B, BA1B, BA3A and BA4A) as a routine part of the IODP measurement protocol onboard D/V Chikyu. X-ray CT scanning enables the non-destructive observation of the internal structure of the core, providing information about chemical composition and density. The data are useful for assessing sample locations and quality. X-ray CT images can be used for 3D fabric analyses even after core has been cut in half and subsampled for other analyses.

The X-ray CT scanner (Discovery CT 750HD, GE Medical Systems) scans and reconstructs an image of a 1.4 m section in 10 minutes and produces a series of scan images, each 0.625 mm thick. The X-ray source and detector are installed inside of the gantry opposite each other. The excitation voltage and current for X-ray tube are 140kV and 100 mA, respectively.

Core samples are scanned in the gantry with a scanning rate of 20 mm/sec. The distribution of attenuation values mapped to an individual slice comprises the raw data that are used for subsequent image processing. Successive two-dimensional (2D) slices of 512 x 512 pixels yield a representation of attenuation values in three-dimensional (3D) voxels of 512 x 512 by ~1600 in length. Data generated for each core consist of core-axis-normal planes (XY planes) of X-ray attenuation values with dimensions of 512 ×512 pixels in 9 cm ×9 cm cross-section, with a resolution of 0.176 mm/pixel.

X-ray intensity varies as a function of X-ray path length and the linear attenuation coefficient (LAC) of the target material, which is a function of the chemical composition and density of the target material. The basic measure of attenuation, radiodensity, is the CT number given in Hounsfield units (HU). CT numbers of air and water are -1000 and 0, respectively.

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CT numbers of OmanDP cores reveal structural features such as the attitude of foliation in primary peridotites, defined by spinel and orthopyroxene crystal shape. Combined with microstructural analyses such as EBSD mapping, we can study petrophysical properties of the uppermost mantle in the mantle section. Moreover, comparing with density profiles measured onboard, we can also estimate the degree of serpentinization in core from Holes BA1B, BA3A and BA4A, ranging from 80 to almost 100%. Profiles of the degree of serpentinization with depth may provide insight into ongoing serpentinization processes.

キーワード：オマーン、XCT、構造解析、蛇紋岩化作用
Keywords: Oman, XCT, Structural Analyses, Serpentinization

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Petrophysical characteristics of serpentinized peridotites of Hole BA1B, BA3A and BA4A

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Structural characteristics within peridotites of Hole BA1B, BA3A and BA4A have been described during the Oman Drilling Project Phase 2 from 5th August to 3rd September, 2018 on D/V Chikyu. The peridotites consisted of intensely serpentinized harzburgite and dunite, which exhibited foliations defined by elongation and alignment of constituent minerals. Crystal plastic fabrics in harzburgite were described prior to those in dunite because orthopyroxene grains are clearer than spinel grains in serpentinized peridotites at macro scale.

Harzburgites in BA1B show variously deformed textures ranging from pophyroclastic to protomylonitic textures in dependent on the depth. In BA3A, harzburgites with protogranular texture were observed in relatively shallow sections (10-90 m), whereas porphyroclastic to strongly foliated textures were dominant in deeper sections. Most of hartzburgites in BA4A show porphyroclastic texture, partly clear foliation and protomylonitic textures by strongly elongated orthopyroxene grains. Dip angles of measured foliations in BA1B are mostly 0-20˚, which are nearly horizontal. Most of dip angles in BA3A are at around 30˚, up to 50˚. In BA4A, dip angles of orthopyroxene grains take various values between 10-50˚. In BA3A and BA4A show similar dip angles, but significantly steeper than those in BA1B. In each hole, dip angles were nearly constant independent on the depth.

Pyroxene and spinel grains in strongly foliated to protomylonitic peridotites are intensely elongated and aligned, exhibiting clear foliation at thin section scale. In protogranular peridotites, pyroxene and spinel grains have rounded shapes and are not elongated and aligned, and foliations are unclear. Elongated pyroxene and olivine grains in protomylonitic peridotites show kink bands and wavy extinction, whereas few rounded pyroxene grains in protogranular peridotites show these features.

キーワード：オマーン掘削プロジェクト、かんらん岩、変形組織
Keywords: Oman Drilling Project, Peridotite, Crystal plastic fabric

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Physical properties of the Moho TZ: Implications from ICDP Oman Drilling Project Phase I & II on-board measurements

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We report physical property measurements of core samples from the Samail ophiolite in Oman, drilled by the ICDP Oman Drilling Project. Onboard core logging was conducted on D/V Chikyu for 4 months in total in the summers of 2017 and 2018. We analyzed 4 holes (GT1A, GT2A, GT3A and BT1B) in 2017, and 5 holes (CM1A, CM2B, BA1B, BA3A and BA4A) in 2018. The total core length of those 9 holes is about 3200 m. Cores from Holes GT1A and GT2A in the lower crust section of the ophiolite are mainly composed of gabbros (gabbro and olivine gabbro), with small amounts of ultramafic rocks (wehrlite and dunite), whereas those from Hole GT3A at the boundary between the sheeted dikes and gabbro are mainly composed of basalt and diabase, followed by gabbros (gabbro, olivine gabbro and oxide gabbro). Minor felsic trondhjemite and tonalite dikes intrude the mafic rocks. In contrast, Hole BT1B penetrated from mantle section through the basal thrust and into the metamorphic sole. The CM holes were drilled through the crust-mantle transition, from gabbroic lower crust, through dunite with minor gabbros, and in to residual mantle harzburgite. BA holes were taken from the mantle section and are composed of dunite and harzburgite intruded by minor gabbroic and pyroxenite dikes. Ultramafic rocks at both sites were extensively serpentinized, but the names of igneous protoliths are used here.

Whole-round data, including X-ray CT images, natural gamma radiation (NGR), gamma ray attenuation (GRA) density, magnetic susceptibility (MS), P-wave velocity (Vp) and noncontact electrical resistivity were obtained. Split core color spectroscopy data were also collected. Magnetic susceptibility, electrical resistivity under both nominally dry and brine-saturated conditions, P-wave velocity, bulk/grain density, porosity and thermal conductivity were measured in discrete samples. Nearly 100% core recovery allowed us to take a large data set of petrophysical data on the cores from Oman ophiolite including fault zones and highly altered intervals.

Generally, gabbroic rock types have higher density, P-wave velocity, and electrical resistivity, and lower porosity than ultramafic lithologies. Serpentinized dunite have lower density, P-wave velocity and electrical resistivity, and higher porosity than serpentinized harzburgite, and these physical properties are correlated with magnetic susceptibility, probably due to crystallization of magnetite during alteration. Average X-ray CT values are also correlated with many other physical properties in most lithologies. Those physical property data and the lithological characteristics of the Moho transition zone in the Oman

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ophiolite revealed apparent difference and similarities with the oceanic data, especially in the seismic profiles from the oceanic plate. In this paper, we would like to compare the data from ocean drilling, Oman Drilling and seismic profiles.

キーワード：陸上掘削、オマーン掘削、オフィオライト、モホ遷移帯、海洋地殻
Keywords: ICDP, Oman Drilling Project, ophiolite, Moho TZ, Oceanic crust

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Oman Drilling Project Phase IIから採取されたハルツバージャイトの高圧条件下における地震波異方性

Seismic anisotropy under high pressure conditions of harzburgite collected from Oman Drilling Project Phase II

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オマーンオフィオライトの陸上掘削計画であるOman Drilling Project Phase IIでは，かつての海洋マントルに相当する掘削が行われた．これらのコア記載が掘削船ちきゅう船内で行われ，大気圧下で測定されたハルツバージャイトのP波速度は掘削孔の深さ方向（Z方向）が直交する2方向(X, Y方向)よりも遅い傾向が見られ、4%程度の異方性を示した(ChikyuOman2018)．海洋マントルではカンラン石の選択配向が原因と考えられる異方性が観測される一方で，オフィオライトのハルツバージャイトのカンラン石はほとんど蛇紋石に置換されており，輝石の選択配向による異方性が示唆される．また、空隙が選択配向している場合においても弾性波速度に異方性を生じ，間隙流体の種類によって異方性の大きさは変化する(Anderson et al., 1974)．大気圧下での測定ではこれらの要因が混在しているため、掘削試料における異方性の支配的要因は明らかにされていない．そこで本研究ではOman Drilling Projectから採取されたハルツバージャイトの弾性波速度を高封圧下で測定し、空隙が閉鎖した条件下での異方性を調べる．

実験試料にはOman Drilling Project Phase II のHole BA1BおよびHole BA3Aから採取されたハルツバージャイトを用いる．これらの試料の密度および空隙率は2.60ー2.64 g/cm^3，0.5%ー1.0%である．実験には広島大学設置の容器内変形透水試験機を使用し，弾性波速度はZ方向とそれに直交するY方向を測定する．実験手順は，無水条件の速度を測定した後，間隙水を注入した含水条件の測定を連続して行なう．どちらの条件においても封圧200 MPaまでの測定を行い、間隙水圧はシリンジポンプを使用することで一定（10 MPa）に制御する．弾性波速度は電圧5 V，周波数2 MHzの1周期の正弦波を印加するパルス透過法からP波とS波を測定する．

Hole BA3Aの試料を用いた予察的な実験では，封圧200MPaの無水条件においてY方向のP波速度とS波速度は5.86 km/s，3.03 km/s，Z方向では5.49 km/s，2.95 km/sを示した．異方性はP波速度で6.5%，S波速度で2.7%であり，高封圧条件下においても顕著な異方性が認められた．これらの結果から弾性波速度の異方性は鉱物の選択配向が支配的である可能性が高い．

キーワード：オマーンオフィオライト陸上掘削、ハルツバージャイト、異方性、選択配向、輝石、クラック
Keywords: Oman Drilling Project, Harzburgite, Anisotropy, Preferred orientation, Pyroxene, Crack

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海洋底の拡大モードと海洋地殻構造の解明～ハワイ沖モホール候補地における深海掘削

Understanding of the mode of seafloor spreading and the architecture of upper oceanic crust by oceanfloor drilling at off-Hawaii MoHole candidate site

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Understanding how seafloor spreading and mantle melting are linked to ocean crust architecture is Challenge 9 of the IODP Science Plan for 2013-2023 and is one of the major goals of the mantle drilling project MoHole to Mantle (M2M). Deep basement drilling is skewed to young and slow-spread crust, with a wide gap of crust age between 20 and 110 Ma, including the world average of 62.5 Ma and spreading rate of 7.6 cm/a. Among the three candidate sites of M2M, only off-Hawaii site can provide the information of oceanic crust of the missing age and spreading rate. We propose a deep drilling off-Hawaii to penetrate through the upper crust and into the gabbros to understand the architecture and governing processes of the upper oceanic crust.

ODP Holes 504B and 1256D have brought invaluable information and fruitful insight into the architecture and formation processes of the upper oceanic crust.

Hole 504B is the deepest drill hole that penetrated 1815 m into 6.9-Ma basement formed at an intermediate rate of 6.6 cm/a at the Costa Rica Rift (Dick et al., 1992). The 504B upper crust, consisting of less dense extrusive rocks underlain by denser sheeted dikes than their source magmas, yields an apparent level of neutral buoyancy that traps accreted magma as dike intrusions. Thus, the 504B crust relaxes stress induced by plate movement and extends by both fault displacement and dike intrusions, which leads to development of rugged summit and axial troughs.

On the contrary, the 15-Ma 1256D crust, formed at the East Pacific Rise, has a distinctly high extrusive to intrusive ratio (814 m / 343 m) compared to that of the 504B crust (780 m / >1056 m). As is expected for the ultrafast spreading rate of 22 cm/a, the extrusive rocks are dominantly of massive and lobate sheet flows, which are as dense as the extruding magma (Umino et al., 2008). This results crust without an apparent level of neutral buoyancy and the persistently over pressurized axial magma chamber (AMC). Only a small increase in magmatic pressure or reduction in horizontal stress leads to dike intrusions followed by eruptions. Conversely, extension of the 1256D upper crust was primarily accomplished by dike intrusions without large faults.

These examples articulate how the density structures of upper crust partition magma into extrusive and intrusive rocks and form characteristic architectures.

Density structures are intimately correlated with magma budget, the amount of magma supplied and

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consumed to keep the same cross-sectional area of the ridge for a time scale of 100 ky.

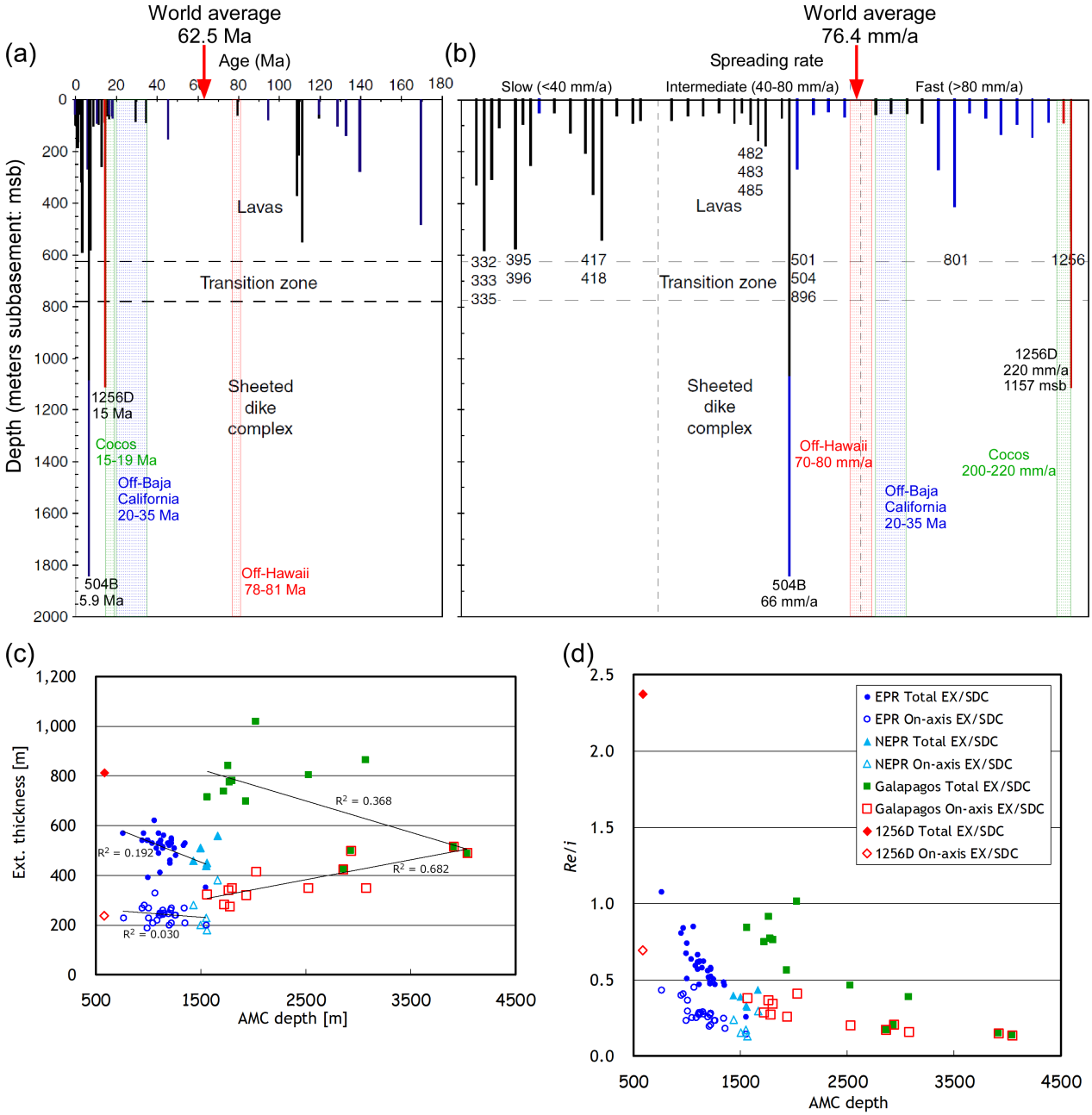
The Galapagos Spreading Center (GSC) shows thickening on-axis and thinning total extrusive rocks with AMC depth, indicating axial valleys develop to trap thick on-axis flows with deepening AMC and decreasing magma budget (Blacic et al., 2004). For the GSC spreading rate of 4.5–5.5 cm/a, more than 50 % of flows in the axial valleys are pillows. Consequently, the GSC is underlain by less dense pillows interbedded with fault breccias. The density structure of this crust is essentially the same as the 504B crust.

Likewise, the magmatically robust East Pacific Rise (EPR) shows a negative correlation of total extrusive thickness and AMC depth, while on-axis flow thickness remains constant (Hooft et al., 1996, 1997). Accordingly, the axial troughs do not develop, and the upper crust extends mainly by dikes intrusions. This is facilitated by the presence of dense extrusive rocks comprising more than 80 % sheet flows, considering the spreading rates of 11–14 cm/a, primarily the same as the 1256D crust.

How two types of upper crust architecture change from one type to the other is yet to be understood. If any critical threshold that distinguishes two crust types exists, it would reside in the crust with a spread rate between 7 cm/a and 10 cm/a. The off-Hawaii crust spread at 7–8 cm/a will provide a missing link that connects the two crust architectures and brings us thorough understanding of the seafloor spreading.

キーワード：深海掘削、モホール、ハワイ沖サイト、海洋地殻構造、密度構造、プレート拡大
Keywords: Oceanfloor Drilling, MoHole, Off-Hawaii site, Upper crust architecture, Density structure, Plate spreading

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Above: Ocean drill holes deeper than 50 m into the oceanic basement plotted against the basement age (a) and categorized on the basis of spreading rate that formed the basement crust (b). World average age and spreading rate are based on the 3.6 min grid data from EarthByte agegrid 2008 (Muller et al., 2008).
Below: Extrusive thickness (c) and Re/i (ratio of extrusive to intrusive thickness) (d) plotted against the AMC depth for the present GSC and EPR segments and the 15-Ma 1256D crust. Solid and open symbols are data based on total and on-axis extrusive thicknesses.

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[E] 口頭発表 | セッション記号 B (地球生命科学)：B-CG 地球生命科学複合領域・一般

2019年5月28日(火) 9:00 ~ 10:30 | 201A 2F

[B-CG06] 地球惑星科学　生命圏フロンティアセッション

コンビーナ:高野 淑識(海洋研究開発機構)、鈴木 庸平(東京大学大学院理学系研究科)、加藤 真悟(国立研究開発法人理化学研究所)、福士 圭介(金沢大学環日本海域環境研究センター)、座長:諸野 祐樹(JAMSTEC)、金子 雅紀(産業技術総合研究所)、加藤 真悟(理化学研究所)

我が国の学術水準は、科学の４大フロンティアである宇宙・地底・極域・深海の極限環境から試料を直接採取し、生命の起源や進化を研究することが可能である。また、ヒトゲノムに代表されるハイスループットな遺伝子配列決定法やナノテクノロジーの適用は、地球惑星科学に新たな知見をもたらす可能性を秘める。一方で、人類活動により地球は温暖化し、生態系の変化を介して生元素や微量元素の循環に大きな影響が及ぶことが懸念される。本セッションは「セクションの垣根」を越えて、地球惑星科学の生命圏フロンティアを開拓する研究を幅広く募集する。

9:00 ~ 9:15

[BCG06-01] 宇宙への開放系としての地球システムと、生命惑星をつくる五層構造

*丸山 茂徳[1] (1.東京工業大学地球生命研究所)

9:15 ~ 9:30

[BCG06-02] Holocene Antarctic subglacial weathering and ice-sheet history reconstructed using the $^{10}Be/^{9}Be$ ratios of lake Maruwan Oike sediments

*Adam David Sproson[1]、Yusuke Yokoyama[1,2]、Yoshinori Takano[2]、Yosuke Miyairi[1]、Takahiro AZE[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo、2.Department of Biogeochemistry, Japan Agency for Marine Science and Technology)

9:30 ~ 9:45

[BCG06-03] Chemical speciation and solubility of heavy elements (lead, zinc, copper, arsenic and cadmium) in contaminated soil from Kamegai mine tailing, Toyama, Japan

*Baasansuren Gankhurel[1]、Keisuke Fukushi[2]、Akitoshi Akehi[1]、Yoshio Takahashi[3]、Kazuo Kawasaki[4] (1.Graduate School of Natural Science and Technology, Kanazawa University、2.Instutute of Nature and Environmental Technology, Kanazawa University、3.Department of Earth and Planetary Science, The University of Tokyo、4.Graduate School of Science and Engineering for Research, Toyama University)

9:45 ~ 10:00

[BCG06-04] High-mass resolution molecular imaging of organic compounds on the Murchison meteorite.

★Invited Papers

*橋口 未奈子[1]、奈良岡 浩[1,2] (1.九州大学惑星微量有機化合物研究センター、2.九州大学大学院理学研究院)

10:00 ~ 10:15

[BCG06-05] Fe(II) oxidation processes at the surface of bacterially colonized iron deposits

★Invited Papers

*白石 史人[1]、中尾 鴻兵[1]、高島 千鶴[2]、狩野 彰宏[3]、板井 啓明[3] (1.広島大学、2.佐賀大学、3.東京大学)

10:15 ~ 10:30

[BCG06-06] Heme: The distribution and dynamics of a ubiquitous iron-tetrapyrrole molecule

*伊左治 雄太[1]、高野 淑識[1]、小川 奈々子[1]、大河内 直彦[1] (1.海洋研究開発機構)

宇宙への開放系としての地球システムと、生命惑星をつくる五層構造
Earth as an open system to the Universe, and five multi-layered spheres to produce a habitable planet

*丸山 茂徳[1]
*Shigenori Maruyama[1]

1. 東京工業大学地球生命研究所
1. Earth-Life Science Institute, Tokyo Institute of Technology

<Purpose>

To understand the Earth’s history including life, we need to treat the Earth as an open system within the Universe. Such an approach has not yet fully considered. Here, I demonstrate it for the first time.

<Method>

Utilizing data set derived from geological evidences that have been collected through systematic rock sampling from all the continents over 30 years, we consider the Earth system as five multi-layered spheres, 1) atmosphere-ocean, 2) biosphere, 3) crust and upper mantle inn the framework of plate tectonics, 4) lower mantle driven by plume and superplume, and 5) metallic core to cause magnetosphere which protect the life on the surface. And this Earth system is driven by the internal heat of the solid Earth and/or the solar energy for the surface. Mutual interaction between these five spheres produce the Earth’s history including life.

<Result>

The most important key factor to keep mutual interactions between spheres is the function of plate tectonics continuing over 4.4 Gyr, which has been maintaining the Earth system as the robust systematic and dynamic equilibria. Specifically, plate tectonics has circulated carbon between atmosphere-ocean, biosphere, and crust and upper mantle through carbon fixation within sediments to produce a habitable planet. Biosphere plays another significant role as a buffer of CO_2 to stabilize atmospheric temperature within habitable status (not to evolve into Venus-like planet). However, biosphere has been critically influenced by galaxy-galaxy collisions happened at 4.5-4.0 Ga (birth of Earth and Prokaryote), 2.5-2.2Ga (birth of Eukarya), 0.8-0.5 Ga (plants and metazoans) appeared in association with frequent mass extinctions.

<Discussion>

Based on the understanding of Earth’s system and its history, we are able to extend it to our future, and predict the Earth’s history including final event of disappearance of the Earth in 8 billion years. I propose the biggest 20 events of Earth’s history including future Earth.

キーワード：地球システム、ハビタブル惑星、地球史20大事件
Keywords: Earth system, Habitable planet, The biggest 20 Earth's events

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Holocene Antarctic subglacial weathering and ice-sheet history reconstructed using the $^{10}Be/^{9}Be$ ratios of lake Maruwan Oike sediments

*Adam David Sproson[1], Yusuke Yokoyama[1,2], Yoshinori Takano[2], Yosuke Miyairi[1], Takahiro AZE[1]

1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. Department of Biogeochemistry, Japan Agency for Marine Science and Technology

Glaciers play an important role in the climate system via freshwater storage and the transportation of various materials from the continents to the oceans. Enhanced discharge of the former during melting events can influence global sea-level, while enhanced silicate weathering resulting from the latter can drive a reduction in atmospheric CO_2. Although these processes are known to be important through geological time, temporal changes in chemical weathering intensity and meltwater flux for the East Antarctic Ice Sheet (EAIS) are not well understood. During the last deglaciation, the EAIS retreated significantly (*1, 2*), forming isolated basins via glacio-hydro-isostatic adjustment (GIA) related crustal uplift. Sediment accumulated in these lakes provide a unique record of subglacial weathering and ice-sheet history throughout deglaciations when global temperatures and pCO_2most notably rose.

Meteoric ^{10}Be is produced in the atmosphere by cosmic rays and delivered to the Earth and ocean surface via dust and precipitation. In Antarctica, these sources of ^{10}Be become locked up in ice sheets and are subsequently released to the continental shelf during periods of melting and freshwater discharge (*3*), where they adhere to suspended particles in the water column and subsequently accumulate on the basin floor (*4, 5*). Stable ^{9}Be is present in silicate rocks and is released during subglacial weathering (*5*), with little simultaneous release of ^{10}Be (*4*), and transported to the oceans via meltwater outflow. When Be is incorporated into the authigenic phase of marine sediments, the $^{10}Be/^{9}Be$ reflects that of the overlying water column (*6*), which in turn reflects the relative dominance of freshwater flux and/or subglacial weathering.

Here, we present authigenic $^{10}Be/^{9}Be$ ratios for a sedimentary core from Lake Maruwan Oike situated at the head of the Rundvåg glacier in the Lützow-Holm Bay area of East Antarctica. Sedimentary material from L. Maruwan Oike provides an ~6,000 year record of subglacial weathering and nutrient input from the nearby glacier (*7*). Authigenic $^{10}Be/^{9}Be$ records reflect variations in freshwater flux and subglacial weathering and indicate several periods of enhanced melting of the Rundvåg glacier. This study provides further constraints on EAIS fluctuations during the Holocene and offers an insight into the behaviour of beryllium in high-latitude subglacial-marine systems.

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Keywords: Beryllium, Holocene, Antarctica, Weathering, Glacier

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Chemical speciation and solubility of heavy elements (lead, zinc, copper, arsenic and cadmium) in contaminated soil from Kamegai mine tailing, Toyama, Japan

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Heavy metals such as lead, zinc, copper, arsenic and cadmium are usually found in surface soils affected by mining or smelting activities, agricultural practices and industrial areas [1,2,3]. Hara et al., [4] showed that some heavy metals including lead, arsenic and cadmium in soil surrounding the mine tailing area in Toyama Prefecture, Japan has largely exceeded the environmental standards. The total amount of trace metals in soils is generally not sufficient to assess environmental impacts of metal contamination. Therefore, chemical forms and binding types of metals enables evaluation of their behavior and bioavailability in the soil environment.The objectives of the present study were to understand the chemical speciation of As, Zn, Cu, Pb and Cd from Kamegai mine tailing area by means of sequential extraction procedure combined with synchrotron based XAFS and electron microscope.

Thirty-two soil samples were analyzed, determining the chemical fractionation of Pb, Cd, As, Zn and Cu using by the five-step sequential extraction (SEP), X-ray absorption fine structure (XAFS), X- ray diffractometer (XRD) and scanning electron microscopy. The results of SEP showed that most of the Pb was associated with non-residual fractions, mainly in crystalline iron oxides (goethite). The Cd appeared mainly associated carbonate fraction in the roots of the dried plants in the soils. The XAFS spectra of the samples showed that Pb in the soil are adsorption forms with Fe-(hydr)oxides surface. Results of XAFS analysis showed Cd in the samples are $CdCO_3$, coprecipitated with $CaCO_3$. Zn, Cu and As appeared mainly associated with the amorphous and crystalline iron oxides. Heavy metals associated with carbonates, amorphous and crystalline iron oxides, thus being potentially more mobile to the environment if conditions were more acidic or reducing.

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Keywords: soil, heavy metals, speciation

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High-mass resolution molecular imaging of organic compounds on the Murchison meteorite.

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Introduction: Primitive meteorites contain a wide variety of organic molecules. The CHO, CHNO, CHNOS and CHN species have been identified using high-resolution mass spectroscopy for the solvent extracts of carboneceous chondrites [1-3]. These organic compounds could be synthesized and evolved via interaction of fluid with minerals [3-5]. Therefore, spatial distribution of meteoritic organic compounds is important to reveal the organic-mineral association on the parent bodies. Recently, in-situ analysis of polar organic compounds on the meteorite surface was achieved by desorption electrospray ionization/high-resolution mass spectrometry (DESI/HRMS) [7]. In this study, we further performed the DESI-HRMS imaging on the Murchison meteorite to understand the relationship between spatial distribution of polar organic compounds and minerals.
Experimental: The fragment of the Murchison meteorite (CM2) (~ a few mm) obtained by chipping was embedded in indium (In). The DESI-HRMS imaging was performed using a DESI ion source (Omni Spray 2-D, Presolia) equipped with an Orbitrap mass spectrometer (Q-Exactive Plus, Thermo Scientific) with mass resolution of ~140,000 at *m/z* 200. Methanol (LC-MS grade) was sprayed on the sample surface with a 1 or 2 μl/min flow rate. The spatial resolution was approximately 100 μm. FESEM-EDS analysis was also carried out without coating and polishing after the DESI-HRMS imaging. The surface of the Murchison meteorite fragment embedded in indium was also extracted with MeOH, and the resulting solution was applied for HPLC-HRMS to obtain chemical structural information on the organic compounds.
Results and Discussion: Alkylated homologues of $C_nH_{2n-1}N_2^+$ (n = 7–9) and $C_nH_{2n}NO^+$ (n = 9–14) were detected on the sample surface by the DESI-HRMS imaging. HPLC/HRMS analysis of MeOH extracts from the sample surface after the DESI/HRMS imaging indicated that the $C_nH_{2n-1}N_2^+$ homologues correspond to alkylimidazole, and that a few structural isomers of the $C_nH_{2n}NO^+$ homologues were present in the sample.The alkylimidazoles and $C_nH_{2n}NO^+$ homologues displayed different spatial distributions in the Murchison fragment. Moreover, the distribution pattern of compounds also different among the same homologues. These results may be due to the separation of isomers by similar chromatographic effects, or different synthetic pathways. The alkylimidazoles and $C_nH_{2n}NO^+$ homologues are mainly distributed in the matrix region of the Murchison by mineralogical observations, which is consistent with previous reports. Altered minerals (e.g., Fe-oxide, Fe-sulfide, and carbonates) occurred in this region. However, no clear relationship was found between these minerals and the organic compounds detected by DESI/HRMS imaging. Although this result might be due to scale differences between the spatial resolution of DESI-HRMS imaging and the grain size in the matrix of the Murchison, our results would indicate that alkylimidazoles and the $C_nH_{2n}NO^+$ homologues in the Murchison fragment were mainly synthesized by different processes from hydrothermal alteration on the parent body.

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キーワード：炭素質コンドライト、有機分子イメージング
Keywords: Carbonaceous chondrite, Molecular imaging of organic compounds

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Fe(II) oxidation processes at the surface of bacterially colonized iron deposits

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Fe(II) oxidation processes at the surfaces of bacterially colonized iron deposits are examined at three hot springs in Japan for which the chemical profiles of the pH, redox, and O_2 and Fe(II) concentrations at the water/deposit interface are measured via microelectrodes. The three hot springs share similar bulk chemistry with a weakly acidic pH of 5.7–6.3, a high iron concentration of 50–130 μM, and a high dissolved inorganic carbon concentration of 20–60 mM. At the Sambe and Shionoha hot springs where the bulk water O_2 concentration is ca. 80 μM, abiotic Fe(II) oxidation via autocatalysis prevails. At the Okuoku-hachikurou hot spring where the bulk water O_2 concentration is ca. 50 μM, autocatalytic Fe(II) oxidation is suppressed and biotic Fe(II) oxidation induced by cyanobacterial photosynthesis is effective. These observations indicate that an O_2 concentration of ca. 50 μM is the threshold of reversing the relative contribution of biotic and abiotic Fe(II) oxidation. Protons from Fe(II) oxidation are compensated by reactions among the dissolved inorganic carbon species, which sustain the pH condition and continuous Fe(II) oxidation at the deposit surface. The observations of this study provide implications for understanding the deposition of banded iron formations in the geological past.

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Heme: The distribution and dynamics of a ubiquitous iron-tetrapyrrole molecule

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*Yuta Isaji[1], Yoshinori Takano[1], Nanako O. Ogawa[1], Naohiko Ohkouchi[1]

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Hemes are Fe(II)-tetrapyrrole complexes that catalyze various electron transfer and redox reactions. They are essential for biological systems, and are possessed by all life forms. Because heme-iron represents as much as 40% of the iron pool in phytoplankton (Gledhill, 2007), hemes in the biomass likely comprise a major fraction in the bioavailable-iron pool which limits primary productivity in over 30% of the world oceans (Moore et al., 2013). They are also expected to be found in the sediments, either as allochthonous compounds deposited from the water column or synthesized in situ by the benthic and subsurface microorganisms. It is noteworthy that etioporphyrin III preserved in various sedimentary rocks, which is supposedly derived from heme, has a highly distinct carbon and nitrogen isotopic compositions ($\delta^{13}C$, $\delta^{15}N$) with respect to other chlorophyll-derived porphyrins in Cretaceous black shales (Ohkouchi et al., unpub. results). As such, hemes are ubiquitous in any environment where life exists, but little is known on their distribution and dynamics in natural environments.

Here, we established a new analytical method to quantify, isolate, and purify heme *b*, a major homolog of hemes, from various environmental samples. Detection of picomole levels of heme *b* is achieved with a photodiode-array detector connected to HPLC, which covers the heme *b* concentration range in particulate (> 0.7 μm; 0.15 nmol L^{-1}) and dissolved organic matter (> 3000 Da; ~0.006 nmol L^{-1}) in the coastal seawater of Tokyo Bay, as well as that in the surface sediments of the Japan Sea (~0.03 $\mu g\ g^{-1}$ dry weight). Importantly, concentration of heme *b* in the dissolved phase was contrastingly low with respect to that in the particulate phase of the coastal seawater, which imply that hemes may constitute a major fraction of the regenerated iron in the ocean. The $\delta^{13}C$ and $\delta^{15}N$ values of heme *b* isolated and purified from various environmental samples are determined with our modified EA/IRMS (Ogawa et al., 2010). These isotopic values will be compared with those of chlorophylls and amino acids, which will reveal the sources of hemes in natural environments and the isotopic fractionation associated with their biosynthesis. Our new analytical approach will provide first detailed insights into the ubiquitous iron-tetrapyrrole molecule playing an essential role in biogeochemical cycle.

キーワード：ヘム、鉄循環、炭素・窒素同位体比、高速液体クロマトグラフィー
Keywords: Heme, Iron cycle, Carbon and nitrogen isotopes, HPLC

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[E] 口頭発表 | セッション記号 B (地球生命科学)：B-CG 地球生命科学複合領域・一般

2019年5月28日(火) 10:45 ~ 12:15 | 201A 2F

[B-CG06] 地球惑星科学　生命圏フロンティアセッション

コンビーナ:高野 淑識(海洋研究開発機構)、鈴木 庸平(東京大学大学院理学系研究科)、加藤 真悟(国立研究開発法人理化学研究所)、福士 圭介(金沢大学環日本海域環境研究センター)、座長:高野 淑識(JAMSTEC)、福士 圭介、鈴木 庸平(東京大学)

我が国の学術水準は、科学の４大フロンティアである宇宙・地底・極域・深海の極限環境から試料を直接採取し、生命の起源や進化を研究することが可能である。また、ヒトゲノムに代表されるハイスループットな遺伝子配列決定法やナノテクノロジーの適用は、地球惑星科学に新たな知見をもたらす可能性を秘める。一方で、人類活動により地球は温暖化し、生態系の変化を介して生元素や微量元素の循環に大きな影響が及ぶことが懸念される。本セッションは「セクションの垣根」を越えて、地球惑星科学の生命圏フロンティアを開拓する研究を幅広く募集する。

10:45 ~ 11:00

[BCG06-07] クロロフィル色素の生合成酵素の多様性と進化

★招待講演

*塚谷 祐介[1] (1.国立研究開発法人海洋研究開発機構)

11:00 ~ 11:20

[BCG06-08] **Microdolomites are not MDACs: microbially-derived carbon source for microcrystalline dolomite found within massive gas hydrates and implications for the shallow marine carbon cycle**

★Invited Papers

*Glen Snyder[1]、Ryo Matsumoto[1]、Naizhong Zhang[1]、Yoshihiro Kakizaki[2]、Yohey Suzuki[2]、Yuji Sano[3]、Naoto Takahata[3]、Kentaro Tanaka[3]、Takumi Imajo[5]、Stephen Bowden[4] (1.Gas Hydrate Research Laboratory, Meiji University、2.University of Tokyo、3.AORI, University of Tokyo、4.University of Aberdeen, Scotland、5.Tokyo University of Marine Science and Technology)

11:20 ~ 11:35

[BCG06-09] **Discriminative biogeochemical signatures of methanotrophs inhabiting different chemosynthetic fields in an active mud volcano of the Canadian Beaufort Sea**

*Dong-Hun Lee[1]、Yung Mi Lee[2]、Jung-Hyun Kim[2]、Young Keun Jin[2]、Charles Paull[3]、Helge Niemann[4,5]、Ji-Hoon Kim[6]、Kyung-Hoon Shin[1] (1.Hanyang Univ.、2.KOPRI、3.MBARI、4.NIOZ and Utrecht Univ.、5.CAGE, UiT 、6.KIGAM)

11:35 ~ 11:50

[BCG06-10] メタン生成アーキアのコア脂質主成分2-ヒドロキシアーキオールのアルキル鎖側の水酸基の絶対立体配置決定

*山内 敬明[1]、金子 雅紀[2] (1.九州大学大学院理学研究院地球惑星科学部門、2.産業総合研究所)

11:50 ~ 12:10

[BCG06-11] Mineral-Microbe interaction – Identification of extracellular electron transfer mechanisms by using MetaOmics approach

★Invited Papers

*石井 俊一[1]、鈴木 志野[1]、Kenneth Nealson[2] (1.国立研究開発法人海洋研究開発機構、2.南カリフォルニア大)

12:10 ~ 12:15

[BCG06-12] Interactive discussion with the invited speakers

*高野 淑識[1] (1.海洋研究開発機構)

クロロフィル色素の生合成酵素の多様性と進化
Diversity and evolution of biosynthetic enzymes for chlorophyll pigments

*塚谷 祐介[1]
*Yusuke Tsukatani[1]

1. 国立研究開発法人海洋研究開発機構
1. Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Photosynthesis is the process converting light energy to chemical potential energy. In phototrophic organisms, chlorophyll (Chl) and bacteriochlorophyll (BChl) pigments are essential for harvesting light energy, migrating excited energy, and transferring electrons. How photosynthesis is emerged on early earth is enigmatic, but pigments are theoretically required first in the ancient phototrophs to absorb light and start photo-induced reactions. A classic question on the evolution of pigment biosynthesis is whether Chl was evolved first or BChl first? Chl molecules mainly absorb visible light wavelength, whereas BChls absorb longer wavelength including near-infrared light region. Therefore, to know which pigment is first evolved is important to know atmospheric environment on early earth. The steps diverging to Chl or BChl in pigment biosynthetic pathways are catalyzed by enzymes similar to nitrogenase. One of the nitrogenase-like enzymes is chlorophyllide oxidoreductase which also catalyzes branching steps toward BChl-*a* and BChl-*b*. BChl-*b* absorbs longest light wavelength among naturally occurring pigments. In my talk, pigment structures and their diversified biosynthetic pathways that we recently revealed will be introduced and experimental approach to solve the evolution of chlorophyllous pigments will be presented.

キーワード：光合成進化、色素、バクテリオクロロフィル、クロロフィル
Keywords: Evolution of photosynthesis, Pigment, Bacteriochlorophyll, Chlorophyll

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Microdolomites are not MDACs: microbially-derived carbon source for microcrystalline dolomite found within massive gas hydrates and implications for the shallow marine carbon cycle

*Glen Snyder[1], Ryo Matsumoto[1], Naizhong Zhang[1], Yoshihiro Kakizaki[2], Yohey Suzuki[2], Yuji Sano[3], Naoto Takahata[3], Kentaro Tanaka[3], Takumi Imajo[5], Stephen Bowden[4]

1. Gas Hydrate Research Laboratory, Meiji University, 2. University of Tokyo, 3. AORI, University of Tokyo, 4. University of Aberdeen, Scotland, 5. Tokyo University of Marine Science and Technology

Methane derived authigenic carbonates (MDACs) are commonly found associated with both active and remnant submarine seeps and, under favorable conditions of pressure and temperature, are also found in close contact with marine methane hydrate. Recently, we have discovered microdolomitic aggregates inside of massive Japan Sea gas hydrates. These are fundamentally different, both in chemistry, stable isotopic composition and growth habit to the MDACs encountered outside of the hydrates. Phylogenetic analysis of microbial DNA within the dolomites reveals primarily Bacteriodetes, bacteria whose principal energy source is the degradation of complex macromolecules such as oils. Actual analysis of the oils found inside of the Sea of Japan gas hydrate confirms that they are biodegraded during burial. Previous investigations of MDACs have focused on ANME methane oxidizers (ANME) and sulfate reducing bacteria (SRB) as the primary drivers for MDAC precipitation in shallow sediment. The discovery of microbial dolomites inside saline gas-hydrate inclusions opens up a number of research avenues and applications such as: Mars-analogue studies, microbial remediation of marine oil-spills, and investigations into the role of shallow marine microbes in the conversion of organic carbon into dissolved inorganic carbon. This study was conducted under the commission from AIST as part of the methane hydrate research project funded by the Ministry of Economy, Trade and Industry, Japan. Ongoing work is being carried out thanks to a Grant-in-aid provided by the Japan Society for Promotion of Science and the Japanese Ministry of Education, Culture, Sports, and Technology (Kaken Project # 17K05712).

Keywords: Gas Hydrate, Sea of Japan, Dolomite, Biomineralization

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Discriminative biogeochemical signatures of methanotrophs inhabiting different chemosynthetic fields in an active mud volcano of the Canadian Beaufort Sea

*Dong-Hun Lee[1], Yung Mi Lee[2], Jung-Hyun Kim[2], Young Keun Jin[2], Charles Paull[3], Helge Niemann[4,5], Ji-Hoon Kim[6], Kyung-Hoon Shin[1]

1. Hanyang Univ., 2. KOPRI, 3. MBARI, 4. NIOZ and Utrecht Univ., 5. CAGE, UiT , 6. KIGAM

In this study, we investigated vertical variations in methanotrophic communities in assosication with varying methane fluxes within a mud volcano (420 m water depth, MV420) of the Canadian Beaufort Sea, by analysing geochemical properties, microbial lipids, and nucleic acid signatures. Three push cores were collected from visually discriminative chemosynthetic fields that were (i) bare of organisms (BO) to the naked eye, (ii) covered with bacterial mats (BM), or (iii) siboglinid tubeworms (ST), by using a remotely operated vehicle (ROV). The methane fluxes were highest at the sites of BO (0.06 mmol cm^{-2} y^{-1}) and BM (0.04 mmol cm^{-2} y^{-1}) and substantially lower at the ST site (0.01 mmol cm^{-2} y^{-1}). All MV420 sites showed the presence of aerobic methane oxidation (MOx)- and anaerobic methane oxidation (AOM)-related lipid biomarkers (4-methyl sterols and *sn*-2-hydroxyarchaeol, respectively), which were distinctly different in comparison to the reference site where these compounds could not be detected. Our lipid biomarker results are furthermore in good agreement with 16S rRNA analyses, which revealed the presence of MOx-related bacteria (*Methlyococcales*) and AOM-related archaea (ANME-2 and ANME-3 groups) at the MV420 sites. The 4-methyl sterols derived from *Methlyococcales* were predominant in the surface layer at the BM site with a moderate methane flux, while their occurrence was limited at the BO and ST sites. Notably, the abundances of AOM-related lipid biomarkers were minor at the BO site where the methane flux was highest. However, ANME-3 and sulfate reducing bacteria (*Desulfobacteraceae* and *Desulfobulbaceae*) were abundant in the downcore sediments at the BM site. On the other hand, the abundances of the ^{13}C-depleted *sn*-2-hydroxyarchaeol potentially derived from ANME-2 and/or ANME-3 groups was predominant at the ST site, indicating their co-occurrence under a lower methane flux. Accordingly, our results suggest that a niche diversification within this MV system has shaped distinct methanotrophic communities due to the availability of electron acceptors in association with varying degree of methane fluxes and bioirrigation activity.

Keywords: Arctic, Mud volcano, chemosynthetic organism, Anaerobic methane oxidation, Aerobic methane oxidation, Methanotroph

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メタン生成アーキアのコア脂質主成分2-ヒドロキシアーキオールのアルキル鎖側の水酸基の絶対立体配置決定

Determination of the absolute stereochemistry of the hydroxyl group in 2-hydroxyarchaeol, the main lipid core of methanogenic and methanotrophic archaea

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*Noriaki YAMAUCHI[1], Masanori Kaneko[2]

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1. Department of Earth and Planetary Sciences, Faculty of Sciences, Kyushu University, 2. National Institute of Advanced Industrial Science and Technology

様々な極限環境で生育する特徴的な微生物の一群であるアーキアの主な特徴は，膜脂質が，イソプレノイドがグリセロールにエーテル結合したものであることである。特にメタン生成，メタン資化性アーキアにおいては，イソプレノイドのアルキル基のC-3位に水酸基が結合したアルキル基を持ったヒドロキシアーキオールが主成分となっている。またこの水酸基を持ったアルキル基のグリセロール結合位置に関する異性体として，*sn*-2-ヒドロキシアーキオール(**1**)と*sn*-3-ヒドロキシアーキオール(**2**)が存在し，これらは微生物種によって特異的である[1]。

ヒドロキシアーキオールは海底下におけるメタンハイドレート形成と蓄積から，嫌気的メタン酸化，湖沼から反芻動物の消化管のような小さなフィールドでのメタン生成に至るまで様々なC-1代謝に関わっている微生物の活動を示す分子（バイオマーカー）として重要な化合物であり，構造の決定[1]と，フィールド試料の分析[2][3][4]が各地で行われてきたが，この水酸基の絶対立体化学については未だ決定されていなかった。

発表者は2-ヒドロキシアーキオールの標準物質供給を目的としてこの水酸基がラセミ体である化合物の合成を行い，誘導体のガスクロマトグラフィー分析等を行ったところ，水酸基の立体化学に由来する1:1化合物のように見えるという結果を得た[5]。多くの文献資料ではこの化合物は単一化合物として分析されている結果とは異なっていた。

そこで今回この水酸基の立体化学について，あらかじめ不斉合成によって絶対立体配置の定まった２つの立体異性体のエーテル鎖に相当する部分を合成し，さらにヒドロキシアーキオールに導き，実際の生産菌の脂質コアと比較することで絶対立体配置を決定することにした。

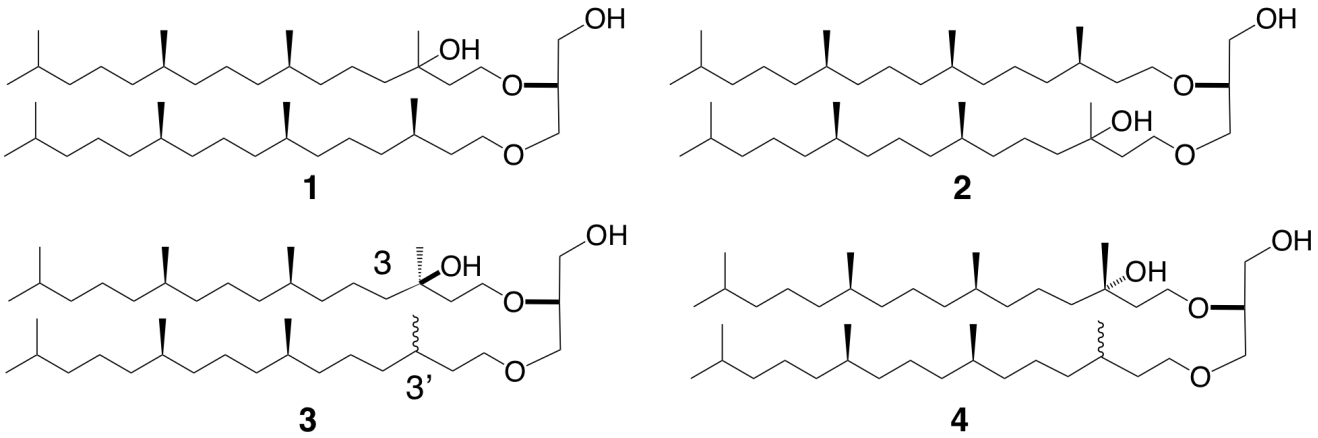
化学合成はフィトールのKatsuki-Sharpless反応により生成した立体選択的エポキシドからエーテル鎖相当部分を合成し，キラルグリセロール誘導体とのエーテル結合形成を含む過程で行い二異性体（**3**および**4**）を得た。一方2-ヒドロキシアーキオールの生産菌*Methanosarcina barkii*より脂質コアを抽出調製し，2-ヒドロキシアーキオールを調製した。“ラセミ化体” 2-ヒドロキシアーキオール，化学合成による２つの立体異性体，そして微生物由来の2-ヒドロキシアーキオールを比較したところ，誘導体のガスクロマトグラフィーにより，微生物由来の2-ヒドロキシアーキオールと3*R*体（**3**）が一致し，2-ヒドロキシアーキオールの水酸基の絶対立体配置は3*R*であることが決定できた。また合成品（**3**および**4**）は水酸基を含まない飽和アルキル鎖をフィトールの水素添加で調製したことより，相当するメチル基の立体化学に伴いC-2‘位炭素が等価な２ピークを与えるのに対し，微生物由来の試料ではこれが１ピークであるといった興味深い結果も得られた。これは微生物由来試料は１つの異性体であり，水酸基を含まないアルキル鎖のメチル基の絶対立体配置も膜の性質に影響を与える可能性が高いことを示唆する。

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キーワード：メタン生成菌、メタン資生化菌、アーキオール、構造決定
Keywords: methanogenic archaea, methanotrophic archaea, archaeol, structural determination



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Mineral-Microbe interaction –Identification of extracellular electron transfer mechanisms by using MetaOmics approach

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Microbial reduction of solid minerals such as iron-oxides and manganese-oxides is known to occur as a result of microbial extracellular electron transfer (EET). These electron transfer activities coupled with the oxidation of organic carbon or hydrogen are considered to play important roles within complex microbial communities in soil, sediment, and the deep subsurface environments. The surface redox potentials of solid-phase oxide minerals are known to be highly variable because of variations in the crystal structure, pH, salinity, and levels of hydration, posing major challenges for EET-capable microbes to adapt in the habitats. In fact, the *in situ* redox potentials of solid-state electron acceptors have been regarded as significant geochemical variables linked to the regulation of functional genes in the EET-capable microbes. However, mechanisms that the microbes use to perform respiration of insoluble metal-oxide minerals showing different surface redox potentials are complex and are not yet well understood.

Here, we used bioelectrochemical systems to systematically evaluate the effects of surface redox potentials (e.g. +100 mV, −50 mV, −200 mV vs SHE) on EET-active microbial community development and the overall electron transfer rates. The results clearly indicate that faster biocatalytic rates were observed under electropositive electrode surface potentials than the electronegative potentials. Temporal 16S rRNA-based microbial community analyses showed that *Geobacter* phylotypes were highly diverse and apparently dependent on the surface potentials. The well-known dissimilatory metal-reducing microbes affiliated with *Geobacter metallireducens* clade were associated with lower surface potentials and less current generation, whereas *Geobacter* subsurface clades were associated with higher surface potentials and greater current generation. These results suggest that surface potentials provide a strong selective pressure, at the species and strain level, for solid mineral respirators throughout the EET-active community development.

Next, we show metabolic and transcriptional responses of the EET-active microbial communities established on the three different poised electrodes to changes in the surface redox potentials. Combination of genome-centric stimulus-induced metatranscriptomics and metabolic pathway investigation revealed that nine *Geobacter* / *Pelobacter* microbes performed EET activity differently according to their preferable surface potentials and substrates. While the *Geobacter* / *Pelobacter* microbes coded numerous numbers of multi-heme *c*-type cytochromes and conductive e-pili, wide variations in gene expression were seen in response to altering surrounding substrates and surface potentials, accelerating EET via poised electrode or limiting EET via an open circuit system. These flexible responses suggest that a wide variety of EET-active microbes utilizing diverse EET mechanisms may work together to provide such EET-active communities with an impressive ability to handle major changes in surface potential and carbon source availability.

Conclusively, these results presented here offer a new perspective on the complexity of the EET-active members in the microbial communities that were adapted to the different surface redox conditions, and some initial insights into how they may regulate community function and provide adaptability to the

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different minerals on the earth. Overall, these results have opened a door toward unraveling the diverse microbial life within the various geological settings especially in the mineral-rich subsurface environments.

キーワード：メタトランスクリプトミクス、電気微生物、酸化還元電位
Keywords: Metatranscriptomics, Electromicrobiology, Redox potential

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Interactive discussion with the invited speakers

Interactive discussion with the invited speakers

*高野 淑識[1]
*Yoshinori Takano[1]

1. 海洋研究開発機構
1. Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Time for interactive discussion with the invited speakers.

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[E] 口頭発表 | セッション記号 M (領域外・複数領域)：M-IS ジョイント

2019年5月28日(火) 13:45 ~ 15:15 | 101 1F

[M-IS05] New technologies to monitor thunderstorm and severe weather activities

コンビーナ:佐藤 光輝(北海道大学 大学院理学研究院)、高橋 幸弘(北海道大学・大学院理学院・宇宙理学専攻)、久保田 尚之(北海道大学)、山下 幸三(足利大学工学部)、座長:佐藤 光輝(北海道大学)、山下 幸三(足利工業大学工学部)

In order to predict the intensity development of severe weather, lightning and thunderstorm are markers of severe weather, often accompanied by precipitation, hail and strong winds that can create significant natural hazards, especially in disaster-prone area. Lightning is also a strong indicator of convection, and it becomes a key parameter to predict the intensity development of tropical cyclones (typhoons and hurricanes). As the climate warms in the first decades of the 21st century, the intensity and frequency of thunderstorms is projected to increase. The need for detecting and monitoring the development of thunderstorms and lightning activities on global, local, and regional scales is therefore clear and urgent.
This session seeks topics presenting new technologies to monitor thunderstorm and severe weather activities. In addition, observational and theoretical contributions on thunderstorm microphysics and dynamics, convective systems and tropical storms are welcome. Present patterns and distributions of lightning and extreme weather events derived from the ground-based networks and satellites, as well as forecasts of future trends, are also of interest. Lightning detecting and monitoring system performance and validation, and early-warning schemes are requested, either in operational or planning phase. The session will also highlight regional and global lightning and atmospheric electricity networks and invite contributions on technological innovations in this field.

13:45 ~ 14:00

[MIS05-01] Quasi real-time observation of typhoon and thunderstorms by the system of micro-satellites and ground-based lightning sensors

*高橋 幸弘[4,1]、佐藤 光輝[1,4]、久保田 尚之[4]、山下 幸三[2]、石田 哲朗[4]、Castro Ellison[3]、プルワディ プルワディ[1]、坪木 和久[5]、山田 広幸[6]、篠田 太郎[5]、Estrebillo Loren Joy[1]、Pulutan Doreena Karmina[1] (1.北海道大学・大学院理学院、2.足利大学・工学部、3.フィリピン大学ディリマン校、4.北海道大学・大学院理学研究院、5.名古屋大学・宇宙地球環境研究所、6.琉球大学)

14:00 ~ 14:15

[MIS05-02] Towards the Implementation of the Understanding Lightning and Thunderstorms for Extreme Weather Monitoring and Information Sharing in the Philippines (ULAT) Project

★Invited Papers

*Glenn Vincent C. Lopez[1] (1.Advanced Science and Technology Institute)

14:15 ~ 14:30

[MIS05-03] Airborne observation of Super Typhoon Trami in 2018 for understanding the intensity of tropical cyclone in the Philippine Sea

★Invited Papers

*久保田 尚之[1]、坪木 和久[2]、山田 広幸[3]、高橋 幸弘[1]、篠田 太郎[2]、大東 忠保[4]、山口 宗彦[5]、伊藤 耕介[3]、中澤 哲夫[5]、長浜 則夫[6]、清水 健作[6]、佐藤 光輝[1] (1.北海道大学、2.名古屋大学、3.琉球大学、4.防災科学研究所、5.気象研究所、6.明星電気)

14:30 ~ 14:45

[MIS05-04] Relation between Lightning and Typhoon Activities (Typhoon LAN) in the Western Pacific Region

*佐藤 光輝[1]、高橋 幸弘[1]、久保田 尚之[1]、山下 幸三[2]、浜田 純一[3]、Marciano Joel[4] (1.北海道大学 大学院理学研究院、2.足利大学 工学部、3.首都大学東京 都市環境学部、4.先端科学技術研究所)

14:45 ~ 15:00

[MIS05-05] Infrasound multi-site observation of thunders 3: preparation process for SATREPS
★Invited Papers

*山本 真行[1] (1.高知工科大学　システム工学群)

15:00 ~ 15:15

[MIS05-06] Data Acquisition System for an Infrasound Network for Thunderstorm Monitoring

*Doreena Karmina Abril Pulutan[1]、Yukihiro Takahashi[1]、Mitsuteru Sato[1]、Hisayuki Kubota[1]、Kozo Yamashita[2]、Masa-yuki Yamamoto[3] (1.Department of Cosmosciences, Hokkaido University、2.Department of Engineering, Ashikaga University、3.Department of Systems Engineering, Kochi University of Technology)

Quasi real-time observation of typhoon and thunderstorms by the system of micro-satellites and ground-based lightning sensors

*高橋 幸弘[4,1]、佐藤 光輝[1,4]、久保田 尚之[4]、山下 幸三[2]、石田 哲朗[4]、Castro Ellison[3]、プルワディ プルワディ[1]、坪木 和久[5]、山田 広幸[6]、篠田 太郎[5]、Estrebillo Loren Joy[1]、Pulutan Doreena Karmina[1]

*Yukihiro Takahashi[4,1], Mitsuteru Sato[1,4], Hisayuki Kubota[4], Kozo Yamashita[2], Tetsuro Ishida[4], Ellison Caparas Castro[3], Purwadi Purwadi[1], Kazuhisa Tsuboki[5], Hiroyuki Yamada[6], Taro Shinoda[5], Loren Joy De Vera Estrebillo[1], Doreena Karmina Abril Pulutan[1]

1. 北海道大学・大学院理学院、2. 足利大学・工学部、3. フィリピン大学ディリマン校、4. 北海道大学・大学院理学研究院、5. 名古屋大学・宇宙地球環境研究所、6. 琉球大学
1. Graduate School of Science, Hokkaido University, 2. Department of Engineering, Ashikaga University, 3. University of the Philippines, Diliman, 4. Faculty of Science, Hokkaido University, 5. Institute for Space-Earth Environmental Research (ISEE), Nagoya University, 6. University of the Ryukyus

We are conducting a SATREPS project “ULAT” and e-ASIA project for the development of extreme weather, including typhoon and individual thunderstorm, monitoring and alert system in the Philippines in 2017-2021 under international cooperation among Japan, Philippines, Indonesia and other SE-Asian countries supported by JST, JICA, PHL-Microsat and other funds. It is well known that intensification of lightning activity is precursor of typhoon growth as well as an indicator of individual thunderstorm activity. In these projects, we apply two new technologies, that is, the lightning activity estimated by the ground-based lightning networks with 12 sites for VLF radio wave measurement in nation-wide of Philippines and with 50 sites for electrostatic field measurement in Metro Manila together with infrasound sensor and automated weather station, and the 3 dimensional capturing of thunderstorms by the on-demand operation of 50-kg micro-satellites, including the Philippine-developed DIWATA-1 and 2, RISESAT, etc. Also few more lightning stations installed in Indonesia and Japan are used. We plan to establish a new methodology to obtain very detail semi-real time information of typhoon and thunderstorm activities that cannot be achieved only with conventional observational equipment. Based on these new observations together with advanced radar measurements and drop/radio sondes campaigns, we will try to construct the cutting-edge observation system to monitor the development of typhoons and thunderstorms, which may greatly contribute to the prediction of disasters and the public alerting system.

By the end of March 2017 we started the test observation for lightning at Quezon city, Philippines, Palau and Guam, forming the network for typhoons. We also succeeded in making 3-D cloud structure with telescope and wide angle spectral camera onboard DIWATA-1, achieving high resolution of ten to several meters. Now we are establishing the real-time target pointing operation with micro-satellites based on the last-minute lightning data measured by ground networks. Adding to DIWATA-1, three more our satellites, namely, RISESAT, MicroDragon and DIWATA-2 with advanced cameras will be used in 2018-2019. In September 2018, drop sonde campaign using aircraft in the eastside of Philippines was carried out under collaboration with Nagoya University team. Here we introduce the latest results of 3-D cloud modeling using images taken by satellite and on the ground together with preliminary lightning analysis, adding to the outline of the project.

キーワード：雷放電、超小型衛星、台風、雷雲

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Keywords: lightning, micro-satellite, typhoon, thunderstorm

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Towards the Implementation of the Understanding Lightning and Thunderstorms for Extreme Weather Monitoring and Information Sharing in the Philippines (ULAT) Project

*Glenn Vincent C. Lopez[1]

1. Advanced Science and Technology Institute

Monitoring and understanding thunderstorms are key components of mitigating the effects of torrential rainfall and typhoons. The Philippines, where year-round numerous thunderstorms are experienced, the integration of lightning data has the potential to provide short term forecasts of thunderstorms, further meteorological studies, and supplement disaster risk response strategies.

This presents the activities and updates on the Understanding Lightning and Thunderstorm for Extreme Weather Monitoring and Information Sharing in the Philippines (ULAT) Project. The ULAT Project aims to deploy a highly dense lightning detection network scattered throughout Metro Manila to gather, analyze, and archive lightning data in order to provide thunderstorm “now-casting” and supplement weather-related research and disaster response strategies.

To enable the study of the correlation between lightning activity and localized severe weather disturbances (such as thunderstorms), the Japan International Cooperation Agency (JICA) and Hokkaido University through the Science and Technology Research Partnership for Sustainable Development (SATREPS) Program has partnered with the Department of Science and Technology Institute through the Advanced Science and Technology Institute to develop local expertise and build relevant lighting monitoring infrastructure in the Philippines.

This presents the activities and updates on the Understanding Lightning and Thunderstorm for Extreme Weather Monitoring and Information Sharing in the Philippines (ULAT) Project. The ULAT Project is aimed at the following: a) establishment of a dense network of lightning and weather devices in Metro Manila and nearby municipalities to a) establish of a dense network of lightning and weather devices in the Philippines in order to provide thunderstorm “now-casting” and supplement weather-related research and disaster response studies and strategies; b) establishment of a ground receiving station for direct reception of satellite imagery and utilizing existing ground receiving facilities to develop effective observation methods by comparing to compare 3D structures of thunderclouds from satellite images with lightning/precipitation data; c) establishment of a methodology for short term forecasts; and d) development of software for sharing information on short term forecast weather to concerned agencies.

To further meet the goals of the project, there are challenges during the implementation of the project activities that needs to be addressed in the areas of equipment security, public safety, partnership agreements, site identification and selection, logistics, process, etc. The encountered challenges, alongside with their corresponding solutions, recommendations, next steps and other plans relevant to the project will be also discussed during the meeting.

Keywords: Understanding Lightning and Thunderstorms for Extreme Weather Monitoring and Information Sharing in the Philippines (ULAT) Project, Advanced Science and Technology and Institute (ASTI)

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Airborne observation of Super Typhoon Trami in 2018 for understanding the intensity of tropical cyclone in the Philippine Sea

*久保田 尚之[1]、坪木 和久[2]、山田 広幸[3]、高橋 幸弘[1]、篠田 太郎[2]、大東 忠保[4]、山口 宗彦[5]、伊藤 耕介[3]、中澤 哲夫[5]、長浜 則夫[6]、清水 健作[6]、佐藤 光輝[1]
*Hisayuki Kubota[1], Kazuhisa Tsuboki[2], Hiroyuki Yamada[3], Yukihiro Takahashi[1], Taro Shinoda[2], Tadayasu Ohigashi[4], Munehiko Yamaguchi[5], Kosuke Ito[3], Tetsuo Nakazawa[5], Norio Nagahama[6], Kensaku Shimizu[6], Mitsuteru Sato[1]

1. 北海道大学、2. 名古屋大学、3. 琉球大学、4. 防災科学研究所、5. 気象研究所、6. 明星電気
1. Hokkaido University, 2. Nagoya University, 3. University of the Ryukyus, 4. National Research Institute for Earth Science and Disaster Resilience, 5. Meteorological Research Institute, 6. Meisei Electronic

Airborne observation of tropical cyclone (TC) had been conducted until 1987 over the western north Pacific region to measure the TC intensity directly. After that TC intensity was estimated by Dvorak technique using satellite data. Here we conducted dropsonde observation by the aircraft in 2018 under the two projects of T-PARCII (Tropical Cyclone-Pacific Asian Research Campaign for Improvement of Intensity estimations/forecasts) and ULAT (Understanding Lightning and Thunderstorm) of SATREPS (Science and Technology Research Partnership for Sustainable Development) in the Philippines and penetrated the eye of Super Typhoon Trami during Sep. 25 to 28. TC Trami reached its mature stage when we observed on Sep. 25. The structure of sharp eyewall and warm core in the eye were observed. On the other hand, the intensity of TC was weakened when we observed on the following day. We need to capture the signal of intensification and decay of TC by combining multiple observations for understanding the structure for a short term forecast of tropical cyclone intensity.

キーワード：台風、航空機観測、ドロップゾンデ観測
Keywords: Tropical cyclone, Airborne observation, Dropsonde observation

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Relation between Lightning and Typhoon Activities (Typhoon LAN) in the Western Pacific Region

*佐藤 光輝[1]、高橋 幸弘[1]、久保田 尚之[1]、山下 幸三[2]、浜田 純一[3]、Marciano Joel[4]
*Mitsuteru Sato[1], Yukihiro Takahashi[1], Hisayuki Kubota[1], Kozo Yamashita[2], Jun-Ichi Hamada[3], Joel J. Marciano[4]

1. 北海道大学 大学院理学研究院、2. 足利大学 工学部、3. 首都大学東京 都市環境学部、4. 先端科学技術研究所
1. Department of Cosmoscience, Hokkaido University, 2. Department of Engineering, Ashikaga University, 3. Graduate School of Urban Environmental Sciences, Tokyo Metropolitan University, 4. ASTI, DOST

Recent studies revealed that there is a close relation between the lightning activity and the tropical cyclone intensity, such as the maximum wind velocity and the minimum surface pressure. As many countries in the western Pacific region suffer from the attack of many tropical cyclones (typhoons) and related severe weather events, they have a strong demand to predict the intensity development of these phenomena by means of a cost-effective way. Thus, we started installing the new lightning and weather observation system, named as V-POTEKA, at Guam, Palau, and Manila in the Philippines since September 2017. The lightning observation system consists of a VLF receiver having the sensitivity in the frequency range of 1-5 kHz, an automatic data-processing unit, solar panels, and batteries. Lightning-excited pulse signals detected by the VLF receiver are automatically analyzed by the data-processing unit, and only the extracted information of the trigger time and the pulse amplitude is transmitted to the data server via the 3G data communications. From the V-POTEKA data analysis, we confirmed that there is clear relation between the lightning occurrence number in the typhoon and the maximum wind speed of Typhoon LAN, which is the category-1 weak typhoon. There is ~12-18 h time difference between the peak lightning occurrence number and peak typhoon intensity. At the presentation, we will show the results derived from these lightning observation systems and will present the relation between lightning and typhoon activities more in detail.

キーワード：雷放電活動、台風、直前予測
Keywords: lightning activity, typhoon, intensity prediction

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Infrasound multi-site observation of thunders 3: preparation process for SATREPS

*山本 真行[1]
*Masa-yuki Yamamoto[1]

1. 高知工科大学　システム工学群
1. Department of systems engineering, Kochi University of Technology

Infrasound, low-frequency sound of 20 Hz or less, is considered as one of the remote-sensing method of lightning/thunders. Sensor network to be deployed for a SATREPS project, Philippine, is planned in Manila region in early 2019. Here, we will deploy two types of infrasound sensors. Small but impulsive pressure changes caused by the rapid expansion of the heated plasma along the path of lightning strikes can be detected by infrasound sensors with higher sensitivity range of 1 mPa. Thus, we will use multiple film type (DC type) infrasound sensor for low frequency measurements. But for the thunder infrasound signals, lower-cost microphone type (AC type) sensors can be applied for measurements. Thus, we will mainly use many microphone type infrasound sensors in Metro Manila region.
For calibrating the both sensors, in order to evaluate precise pressure level as well as detectable frequency range, we used a chamber with a pushing/pulling mechanism on it. The infrasound multi-site observation can reveal the lightning activities as close as 100 m scale when the infrasound sensors can be installed with a mesh of 10 km scale or shorter by using the speed of sound as a precise remote-sensing scale. Recently, we also checked capability of remote-sensing in Fukui area and Kanazawa area by using real thunder signals with some other methods to compare.
In this talk, we will introduce a possibility of infrasonic remote-sensing and its calibration phase, in order to realize future disaster-mitigation studies.

キーワード：インフラサウンド、較正、遠隔観測
Keywords: Infrasound, Calibration, Remote sensing

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Data Acquisition System for an Infrasound Network for Thunderstorm Monitoring

*Doreena Karmina Abril Pulutan[1], Yukihiro Takahashi[1], Mitsuteru Sato[1], Hisayuki Kubota[1], Kozo Yamashita[2], Masa-yuki Yamamoto[3]

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Inside a thunderstorm, an updraft pushes ice crystals with positive charge to the top, while a downdraft pushes hailstones with negative charge to the bottom. This charge separation results in lightning. While the electric charge and peak current in lightning events have been extensively studied, they do not indicate the strength of the atmospheric convection that produces thunderstorms. Another parameter, the electrical energy from lightning, has not been thoroughly explored. We will look at the electrical energy from lightning as a possible indicator of the strength of a developing thunderstorm. Electrical energy, however, has not been clearly linked to the peak current of a lightning event. Thus, we cannot rely on peak current measurements to estimate electrical energy. Infrasound emitted by thunderstorms might be a possible way to estimate the electrical energy in lightning events. Microphones can be used to detect infrasound. This work will discuss the development of a data acquisition system that will be used to record and transmit sampled infrasonic data from microphones. This work is being undertaken under the SATREPS/ULAT Project.

Keywords: data acquisition, thunderstorm, lightning, energy

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[E] 口頭発表 | セッション記号 M (領域外・複数領域)：M-IS ジョイント

2019年5月28日(火) 15:30 ~ 17:00 | 101 1F

[M-IS05] New technologies to monitor thunderstorm and severe weather activities

コンビーナ:佐藤 光輝(北海道大学 大学院理学研究院)、高橋 幸弘(北海道大学・大学院理学院・宇宙理学専攻)、久保田 尚之(北海道大学)、山下 幸三(足利大学工学部)、座長:高橋 幸弘(北海道大学)、久保田 尚之(北海道大学 大学院理学研究院)

In order to predict the intensity development of severe weather, lightning and thunderstorm are markers of severe weather, often accompanied by precipitation, hail and strong winds that can create significant natural hazards, especially in disaster-prone area. Lightning is also a strong indicator of convection, and it becomes a key parameter to predict the intensity development of tropical cyclones (typhoons and hurricanes). As the climate warms in the first decades of the 21st century, the intensity and frequency of thunderstorms is projected to increase. The need for detecting and monitoring the development of thunderstorms and lightning activities on global, local, and regional scales is therefore clear and urgent.
This session seeks topics presenting new technologies to monitor thunderstorm and severe weather activities. In addition, observational and theoretical contributions on thunderstorm microphysics and dynamics, convective systems and tropical storms are welcome. Present patterns and distributions of lightning and extreme weather events derived from the ground-based networks and satellites, as well as forecasts of future trends, are also of interest. Lightning detecting and monitoring system performance and validation, and early-warning schemes are requested, either in operational or planning phase. The session will also highlight regional and global lightning and atmospheric electricity networks and invite contributions on technological innovations in this field.

15:30 ~ 15:45

[MIS05-07] Estimation of Lightning Location Using V-POTEKA Lightning Observation Network

*Loren Joy De Vera Estrebillo[1]、Mitsuteru Sato[2]、Yukihiro Takahashi[2]、Hisayuki Kubota[2]、Kozo Yamashita[3]、Junichi Hamada[4]、Joel Marciano[5] (1.Department of Cosmosciences, Hokkaido University、2.Faculty of Science, Hokkaido University、3.Faculty of Engineering, Ashikaga University、4.Graduate School of Urban Environmental Sciences, Tokyo Metropolitan University、5.ASTI/DOST)

15:45 ~ 16:00

[MIS05-08] **Observation system for thunderstorm development using ground lightning detection network and thermal infrared camera onboard satellite LAPAN-A4 in Indonesia**

*Purwadi Purwadi[1,2]、Yukihiro Takahashi[1]、Mitsuteru Sato[1]、Kozo Yamashita[3]、M. Arif Saifudin[4] (1.Department of Cosmosciences, Hokkaido University, Sapporo 0600810, Japan、2.Agency for Assessment and Application of Technology (BPPT), Jakarta 10340, Indonesia、3.Department of Technology, Ashikaga Institute of Technology, Tochigi 3268558, Japan、4.Indonesian National Institute of Aeronautics and Space (LAPAN), Jawa Barat 16310, Indonesia)

16:00 ~ 16:15

[MIS05-09] Remote Sensing Water Quality Determination using Multi-spectral Analysis

*Ahmad Shaqeer Mohamed Thaheer[1]、Yukihiro Takahashi[1] (1.Hokkaido University)

16:15 ~ 16:30

[MIS05-10] Study of cloud effects on atmospheric electric field during lightning activities and snowfall using the 95-GHz cloud radar FALCON-I

★Invited Papers

*大矢 浩代[1]、中森 広太[1]、鴨川 仁[2]、鈴木 智幸[2]、鷹野 敏明[1]、諸富 和臣[3]、中田 裕之[1]、塩川 和夫[4] (1.千葉大学大学院工学研究院、2.東京学芸大学、3.日本無線株式会社、4.名古屋大学)

16:30 ~ 16:45

[MIS05-11] Preferred environmental conditions of precipitation systems in and around Bangladesh observed by ground-based radars

★Invited Papers

*村田 文絵[1]、東 修平[2]、寺尾 徹[3]、Hassan Quamrul[4] (1.高知大学理工学部、2.高知大学理学部、3.香川大学教育学部、4.バングラデシュ気象局)

16:45 ~ 17:00

[MIS05-12] 雷ガンマ線観測：2018年度における冬の柏崎でのコリメータ付きガンマ線検出器の観測結果と夏の東京スカイツリーでの観測の試み

★招待講演

*中澤 知洋[1]、松元 崇弘[2]、和田 有希[2]、Fabiani Alexia[1]、榎戸 輝揚[3]、奥田 和史[2]、古田 禄大[4]、會澤 優輝[2]、湯浅 孝行[5]、土屋 晴文[4]、佐藤 光輝[6]、牧島 一夫[7] (1.名古屋大学、2.東京大学、3.京都大学、4.日本原子力研究開発機構、5.理化学研究所、6.北海道大学、7.東京大学 Kalvi IPMU)

Estimation of Lightning Location Using V-POTEKA Lightning Observation Network

*Loren Joy De Vera Estrebillo[1], Mitsuteru Sato[2], Yukihiro Takahashi[2], Hisayuki Kubota[2], Kozo Yamashita[3], Junichi Hamada[4], Joel Marciano[5]

1. Department of Cosmosciences, Hokkaido University, 2. Faculty of Science, Hokkaido University, 3. Faculty of Engineering, Ashikaga University, 4. Graduate School of Urban Environmental Sciences, Tokyo Metropolitan University, 5. ASTI/DOST

The Philippines is one of the most disaster-hit countries in the world. Its location in the western North Pacific (WNP) subjects it to numerous tropical cyclones (TC) each year that pose risk to lives, properties and infrastructures. There has been a significant development in the accuracy of TC track forecast that cross and/or make landfall within the Philippine Area of Responsibility (PAR) over the years with the use of ground-based synoptic observations, weather radars, and meteorological satellites. However, prediction of TC intensity remains a significant challenge. Lightning activity is an indicator of the dynamics and microphysics in thunderstorms, as well as severe weather phenomena, such as TCs and torrential rainfall among others. Recent studies suggest that lightning activity in tropical cyclones can give predictive information about its intensity development. Thus, a ground-based lightning observation system (V-POTEKA) has been developed, and it has been installed at three stations in the Philippines, Guam, and Palau to continuously monitor lightning activity in the WNP region since September 2017. The V-POTEKA system uses an event-trigger method that detects radio wave pulses from lightning discharges in the very low frequency (VLF) range of 1-50 kHz. It also consists of an automatic weather station (AWS), VLF sensors, and an automatic data-processing unit. The V-POTEKA system analyzes lightning data, extracts pertinent information, i.e., peak amplitude and time of the triggered waveform, and transmits data to a server through 3G communication. A geolocation software using the time-of-arrival method is being developed using the 3 sites along the WNP region. Further analysis will be conducted by incorporating data from other stations (Sapporo, Japan and Los Banos, Philippines), and an improved geolocation software will be used to investigate the relationship between the lightning activity and typhoon intensification during the dropsonde observation campaign conducted in September 2018.

Keywords: lightning location, V-POTEKA

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Observation system for thunderstorm development using ground lightning detection network and thermal infrared camera onboard satellite LAPAN-A4 in Indonesia

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Indonesia is the tropical maritime country which has potential disaster risk caused by thunderstorm cloud. In this study, we will observe the thunderstorm development using lightning detection networks and micro-satellite. A previous study has shown that electrification process on the cloud started when the peak of the cloud reaches the threshold height and continue to growth vertical with an upward ~8 m/s (Krehbiel, 1986). With the reverse though, the lightning activity can be used to indicate the updraft presence inside the cloud. Moreover, lightning activity represents the intensity and area of precipitation and/or an updraft area. In this study, the Asia VLF lightning Observation Network (AVON) will be used to detect electromagnetic wave emitted by lightning which has been installed in Manila - Philippines, Palau, and the next will be installed in Serpong and Padang Indonesia. We will show coverage area and ambiguity of lightning geolocation created by this lightning networks. The progress in development of algorithms in the determination of the location of lightning, peak currents, and charge moment changes will also be presented. Adding to the lightning observation, cloud observation using thermal infrared camera onboard LAPAN-A4, which will be launched in 2019 FSY, will provide the temperature distribution with the surface resolution of ~180 meters and field of view of ~ 56.3 x 42.2 kilometer. Using this high resolution thermal infrared camera, the cloud top altitude can be estimated, assuming temperature profile of the ambient atmosphere. By making such observation at some time interval, the developing speed of thunderstorm can be calculated in 3D. The first lightning occurrence detected by AVON, which could be assumed as the timing that the cloud has reached the threshold height to become a thunderstorm, will initiate the micro-satellite observation with the thermal infrared camera, from which we could make a prediction of torrential rainfall.

Acknowledgement: This work was supported by Japan Society for the Promotion of Science (JSPS), Core-to-Core Program, B. Asia-Africa Science Platforms, by Japan Science and Technology Agency(JST) together with Technology and Higher Education(RISTEKDIKTI) of the of Indonesia under the e-ASIA Joint Research Program, and by Japan International Cooperation Agency (JICA) and JST, SATREPS.

Keywords: thuderstorm, lightning detection network, microsatellite, infrared thermal camera

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Remote Sensing Water Quality Determination using Multi-spectral Analysis

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1. Hokkaido University

Wetlands have three distinct features which are the existence of a water body, hydric soil, and specific vegetation that thrived under those conditions as mentioned. The ecosystem provides benefits to the environment and humans as one of the significant natural resources. The contamination of the waters, especially in the river, poses a serious health and environmental risk. The destruction of the catchment area will lead to the deterioration in quality and quantity of the water resource in Malaysia. The Department of Environment (DOE) under the Ministry of Water, Land and Natural Resources (NRE) has identified that the Malaysian rivers are degraded by both point and non-point sources of pollution. The major point sources of pollution in rivers are from sewage treatment plants, agro-based industries, manufacturing industries, sullage or grey water from commercial and residential premises, and pig farms. Non-point source (or diffuse) pollution is largely due to storm runoff after a downpour. Current methods using in-situ measurements are shown to be infeasible while Remote Sensing methods helps to resolve these issues such as cost, time, accessibility, and repeatability effectively. Multi-spectral Imagery has been a useful in analyzing the spectral characteristics of wetlands.

Keywords: Multi-spectral, Remote sensing, Water quality

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Study of cloud effects on atmospheric electric field during lightning activities and snowfall using the 95-GHz cloud radar FALCON-I

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*Hiroyo Ohya[1], Kota Nakamori[1], Masashi Kamogawa[2], Tomoyuki Suzuki[2], Toshiaki Takano[1], Kazuomi Morotomi[3], Hiroyuki Nakata[1], Kazuo Shiokawa[4]

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It is known that cloud-to-ground lightning and precipitations generated from thunderclouds are a generator of global electric circuit (e.g., Williams, 2009). In the fair weather, the atmospheric electric field at the ground is generally 100 V/m and downward (positive). The atmospheric electric field varies during not only lightning/thunderstorms, but also snowfall/blizzard (e.g., Minamoto and Kadokura, 2011). The atmospheric electric field had positive correlations with flush rate (R^2 = 0.67) and clouds of more than 30 dBZ with temperature range of -35~-5˚C (R^2 = 0.62) observed by the TRMM satellite [Lavigne et al., 2017]. However, satellite observations cannot monitor cloud internal structures in detail. In this study, we investigate the variations of the atmospheric electric field during lightning activities of 4 July, 2016, and snowfall of 23-24 November, 2016, using a field mill, the 95 GHz cloud radar, FALCON (FMCW Radar for Cloud Observations)-I, and a X-band radar (9.4 GHz). We have observed the atmospheric electric field with a Boltek field mill, and cloud reflectivity and the Doppler velocity with the FALCON-I in Chiba University, Japan, (CHB, 35.63˚N, 140.10˚E). At 16.2 km southeast from the CHB, a phased array X-band radar operated by Japan Radio Corporation observed precipitations/cloud. During lightning activities of 4 July, 2016, there were two variations in the atmospheric electric field: short pulse signals and slow variations due to passage of thunderclouds. Small increase in the atmospheric electric field in the initial phase was caused by positive charges in anvil using the FALCON-I, although the cause of the initial phase has been regarded as negative charges in the bottom of the thunderclouds so far. The duration of the short pulse signals due to lightning itself had a positive correlation with the lightning peak current (r = 0.44). During the snowfall of 23-24 November, 2016, periodic oscillations in the atmospheric electric field with periods of 70-90 minutes were observed at four observation sites; CHB, Kakioka (KAK, 36.23˚N, 140.19˚E), Tokyo Gakugei University (KGN, Kokubunji, Tokyo, 35.71˚N, 139.49˚E), and Seikei High School (MSN, Musashino, Tokyo, 35.72˚N, 139.57˚E). The distances of CHB-KAK, CHB-TGU, and CHB-SHS are 64.8 km, 55.9 km, and 49.0 km, respectively. This is the first observations of similar oscillations in the atmospheric electric field at different observation sites separated by a long distance of 50-65 km. At the end of snowfall, the periods of the oscillations became shorter to be 20-50 minutes at all sites. Based on the FALCON-I and X-band radar observations, we found that the reflectivity of the snow cloud had the same period of 80 minutes at CHB at 0-2 km heights during the snowfall. In the presentation, we will discuss the cause of the variations in the atmospheric electric field.

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Preferred environmental conditions of precipitation systems in and around Bangladesh observed by ground-based radars

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Severe storms tend to occur in Bangladesh. In the pre-monsoon season (March-May) storms with intense rainfall, lightning, hails, and tornadoes are frequently observed. Precipitation systems in the monsoon season (June-September) bring large amount of rainfall and floods tend to occur. The purpose of this study is to elucidate the environmental conditions which cause severe weather. This study analyzed the ground-based radars observed during 2010-2014 with TRMM-based precipitation products and JRA55 reanalysis. The precipitation systems were classified into four types: arc-type (77 cases), line-type (59 cases), scattered-type (178 cases) and broad-type (172 cases) systems. Arc-type systems tended to occur in the pre-monsoon season, and the environmental condition had large vertical shear with dry in the mid troposphere. Line-type systems had no preferred season, and the environmental condition had weak vertical shear. The formation process seemed back building type. The scattered-type systems in the pre-monsoon season occurred in the large vertical shear, whereas that in the monsoon season occurred in the weak vertial shear. Most of the broad-type systems were occurred in the active spells of the intraseasonal variation during the monsoon season, and the scattered-type tended to appear in 1-3 days before the formation of the broad-type systems.

キーワード：モンスーン、降水システム、レーダー
Keywords: Monsoon, Precipitation system, Radar

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雷ガンマ線観測：2018年度における冬の柏崎でのコリメータ付きガンマ線検出器の観測結果と夏の東京スカイツリーでの観測の試み
Thundercloud gamma-ray observations at Kashiwazaki aiming at source altitude and beaming measurements and a new trial at Tokyo Skytree in FY2018

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*Kazuhiro Nakazawa[1], Takahiro Matsumoto[2], Yuuki Wada[2], Alexia Fabiani[1], Teruaki Enoto[3], Kazufumi Okuda[2], Yoshihiro Furuta[4], Yuki Aizawa[2], Takayuki Yuasa[5], Harufumi Tsuchiya[4], Mitsuteru Sato[6], Kazuo Makishima[7]

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1. Nagoya University, 2. University of Tokyo, 3. Kyoto University, 4. JAEA, 5. RIKEN, 6. Hokkaido University, 7. Kalvi IPMU, University of Tokyo

MeV gamma rays from lightning and thundercloud reaching the groud are sometimes observed from the winter thunderstorm activities along the coastline of Japan Sea. We, the Gamma-Ray Observation of Winter Thunderclouds (GROWTH) collaboration, are observing such phenomena from 2006 at Kashiwazaki, Niigata prefecture (e.g. Tsuchiya et al. 2007), and recently increasing the number of observation sites, including Ishikawa prefecture (e.g. Wada et al. at M-IS27 session). Since FY2016, we have been operating new detectors at Kashiwazaki dedicated to measure the altitude and beaming of gamma-ray source in thundercloud. Three collimated detectors aiming at different sky regions are deployed. A minute-long gamma-ray emission (or "long-burst") was observed on Jan 26th, 2019 with the system, and we are analyzing the peaking time difference among the three detectors to perform triangulation using the wind speed. Preliminary results suggest the altitude to be lower than ~300 m, but because the emission was relatively weak and photon statistics are not enough, we are estimating the upper-limit of the source altitude and its beaming. Independently, we also started an observation campaign at the 450 m altitude of Tokyo Skytree, aiming at gamma-ray detection from lightning (so called downward TGF) of summer thunderstorm. The tower is one of the locations most frequently hit by lightning. We had three hits on May-Sep. 2018, but no TGF was observed to date, confirming the fact that not all the lightnings are observationally associated with gamma rays. Because our team is observing several downward TGFs from winter thunderstorms (e.g. Enoto et al. 2017), increasing data will enable us to compare the difference among the lightning with and without TGF. The study will be also boosted with the launch of TARANIS satellite in early 2020, dedicated for simultaneous observation of TGF, electrons, optical and radio emission from lightning.

キーワード：雷雲、雷放電、ガンマ線、TGF
Keywords: Thundercloud, lightning, MeV gamma rays, TGF

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[E] 口頭発表 | セッション記号 M (領域外・複数領域)：M-GI 地球科学一般・情報地球科学

2019年5月28日(火) 10:45 ~ 12:15 | 301B 3F

[M-GI29] Near Surface Investigation and Modeling for Groundwater Resources Assessment and Conservation

コンビーナ:Jui-Pin Tsai(National Cheng Kung University, Taiwan)、Hwa-Lung Yu(National Taiwan University)、Ching-Chung Cheng(National Chiao Tung University Taiwan)、Jing-Sen Cai(China University of Geosciences)、座長:Jui-Pin Tsai(National Cheng Kung University, Taiwan)、Hwa-Lung Yu(National Taiwan University, Taiwan)

Groundwater resources serve as a vital source for regional water supply under the climate change condition. However, improper use of the available groundwater resources leads to serious environmental disasters such as land subsidence or seawater intrusion. Therefore, groundwater management is a key issue for groundwater resources conservation. Before applying any management practice, it is essential to accurately assess the groundwater system in multi-scales. In this session, we focus on the issues associated with the application of near-surface investigation and modeling on groundwater resources assessment. We welcome studies related to numerical modeling, spatiotemporal modeling, data fusion, and field investigation using hydrogeological approaches, geophysical approaches, geochemical approaches, and remote sensing. We also welcome the studies associated with groundwater contamination transport and remediation, geothermal energy exchange, groundwater microorganisms, hot spring, volcanic hydrology, and environmental disasters evaluation and prevention. We especially encourage the pilot groundwater management studies that solve multi-scale and interdisciplinary problems.

10:45 ~ 11:00

[MGI29-01] Groundwater management for global sustainability

★招待講演

*谷口 真人[1] (1.総合地球環境学研究所)

11:00 ~ 11:15

[MGI29-02] **Building the large-scale specific yields over the Zhuoshui river alluvial fan and Minzhu basin with gravimetric technique**

*Ren-Jhih Yang[1]、Shen Yu Hsiao[1]、Yan-Jyun Lin[1]、Zhen-Yu Wu[1] (1.National Chung Hsing University)

11:15 ~ 11:30

[MGI29-03] **Poro-elastic Deformation of a Heterogenous Geologic Medium due to Groundwater Withdrawal**

*Ajit Joshi[1]、Masaatsu Aichi[1] (1.Department of Environment Systems, Graduate School of Frontier Sciences, The University of Tokyo)

11:30 ~ 11:45

[MGI29-04] **Analytical Solution of a Ditch Drainage System for the restoration of waterlogged site considering a Subsurface Source/Sink**

*SHUBHAM TIWARI[1]、BRIJESH KUMAR YADAV[1]、RATAN SARMAH[2] (1.Indian Institute of Technology Roorkee、2.Indian Institute of Technology Ropar)

11:45 ~ 12:00

[MGI29-05] **Variable-density flow and mass transport in unsaturated-saturated aquifers under horizontal groundwater flow conditions**

*Jiaqi Liu[1]、Tomochika Tokunaga[1] (1.The University of Tokyo)

12:00 ~ 12:15

[MGI29-06] A practical approach to evaluating water inflow for underground water-sealed storage cavern

*Jing-Sen Cai[1] (1.China University of Geosciences)

Groundwater management for global sustainability
Groundwater management for global sustainability

*谷口 真人[1]
*Makoto Taniguchi[1]

1. 総合地球環境学研究所
1. Research Institute for Humanity and Nature

Groundwater management is important for global sustainability, because of not only large groundwater footprints through global trade of agricultural/industrial materials, but also climate change impacts on groundwater resources directly and indirectly, and carbon emissions through human activities using groundwater. Interactions between groundwater-food-energy nexus and environmental/economical impacts under the conditions of climate change and urbanization, are essential for global sustainability as the center of information among nature, society and humanity. Natural and social tipping points related to groundwater such as land subsidence and saltwater intrusion, regime shifts, and resilience, are the keys for the future of hydrogeology and a sustainable society. Sustainable groundwater management has cultural dependency because of differences in hydroclimate, hydrogeology, water management, and water culture in each area. Therefore, an interaction between humanity and nature is the most important for finding solutions of groundwater management towards sustainability for the current complicated and wicked global environmental problems.

キーワード：groundwater management、global sustainability、groundwater-energy-food nexus
Keywords: groundwater management, global sustainability, groundwater-energy-food nexus

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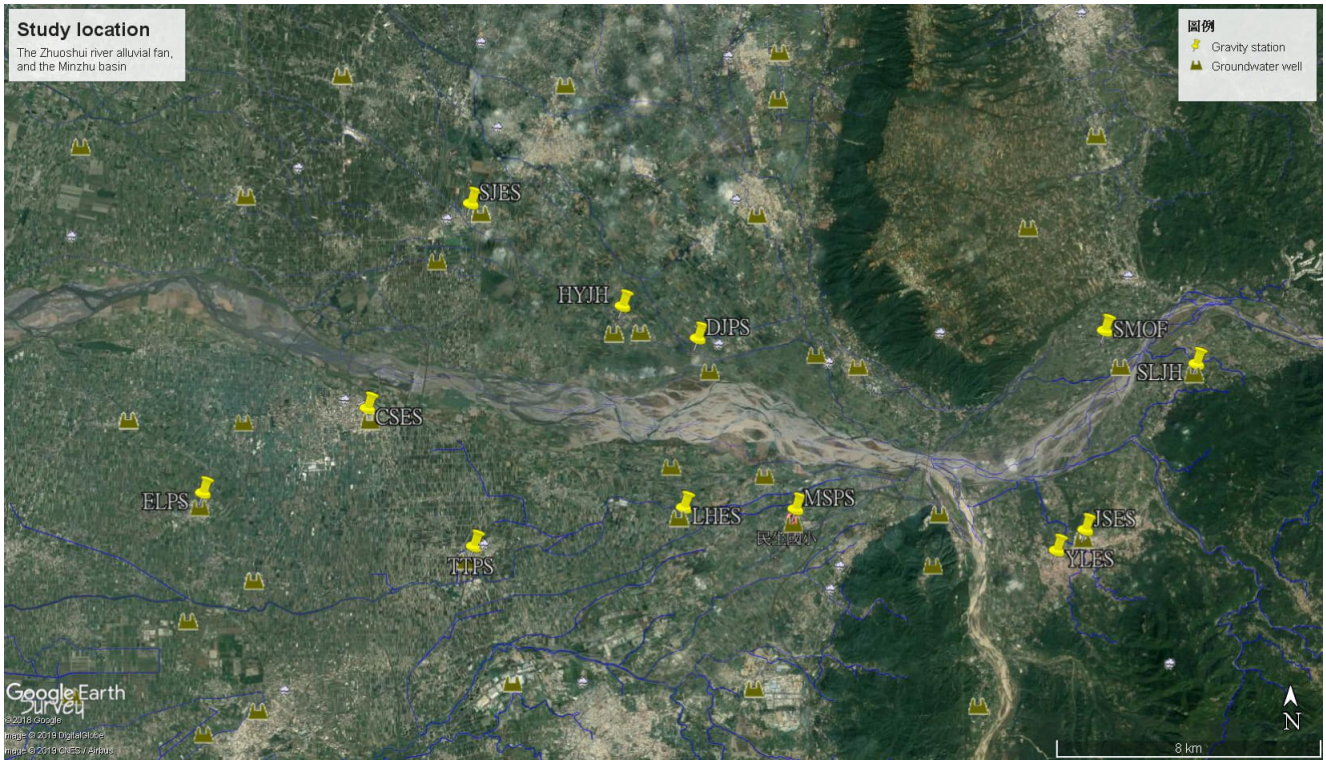
Building the large-scale specific yields over the Zhuoshui river alluvial fan and Minzhu basin with gravimetric technique

*Ren-Jhih Yang[1], Shen Yu Hsiao[1], Yan-Jyun Lin[1], Zhen-Yu Wu[1]

1. National Chung Hsing University

This study estimates the large-scale specific yields (S_y) of the aquifer in the Zhuoshui river alluvial fan and its upstream, Minzhu basin, by gravity data combined with groundwater level data and electrical resistivity tomography (ERT) data. The S_y results from gravimetric technique are rigorously compared with those from hydraulic technique. There are eight gravity stations over the Zhuoshui river alluvial fan, and four over the Minzhu basin.The distribution of all gravity stations is shown in the attached figure. The ERT data are only used for S_y estimation in the "SMOF" gravity station in the Minzhu basin. The strategies for modeling groundwater level changes include the terrain correction method and the Bouguer correction method. The environmental factors influencing the S_y estimation are also discussed. We expect that the groundwater resources in the Zhuoshui river alluvial fan and Minzhu basin can be accurately explored by this study and the results can provide an important reference for groundwater resource management.

Keywords: Gravimetry, Large-scale specific yield, Groundwater resource



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Poro-elastic Deformation of a Heterogenous Geologic Medium due to Groundwater Withdrawal

*Ajit Joshi[1], Masaatsu Aichi[1]

1. Department of Environment Systems, Graduate School of Frontier Sciences, The University of Tokyo

Land subsidence around coastal cities in the world have been recognized as a major concern due to risk of flooding from seawater. As an example, land surface near the Tokyo and surrounding regions in Chiba Prefecture in Japan have been subsiding at rates of few centimeters per year based on data from satellite observations and ground survey measurements. Such changes in land surface elevations may have caused due to subsurface fluid (water/methane) extraction from the Plio-Pleistocene sand reservoirs of the Kanto groundwater basin located in and around Tokyo and Chiba. Fluid removal from subsurface geologic medium can reduce pore fluid pressures underneath and subsequently strain the medium causing pore spaces to collapse. Stratigraphic and lithological interpretation of rocks exposed in outcrops from the Kujukuri region in Chiba showed alternations of sandstone-mudstone units and were characterized by transgressive-regressive cycles of vertical heterogeneity indicating a gradual transition of sediment size from coarse-grained sandstone to fine-grained siltstone/mudstone. The present research hypothesized that presence of local geological heterogeneities in a geologic medium can alter hydraulic properties of the medium affecting its deformation. The main purpose of this research was to determine effect of vertical heterogeneity on rock deformation and to predict land surface subsidence due to groundwater extraction. The research hypothesis was tested using a one-dimensional solution to equations for pore fluid mass conservation and Darcy’ s flow mechanics for a poro-elastic medium saturated with water. Porosity and permeability, both dependent upon clay content, were related by a modified form of Kozeny-Carman equation.

Simulations results for a hypothetical 130 m thick water-saturated porous medium under different geological conditions were compared to investigate heterogeneity effect on deformation. Results showed hydraulic strain in mudstone increased by orders of magnitude higher than less compressible and more diffusive sandstone. Simulation results also confirmed that geological heterogeneity would affect poro-elastic deformation by altering hydraulic diffusivity and bulk compressibility of a geologic medium. Moreover, model predicted land surface subsidence, using stratigraphic sections from the Kanto basin, were in good agreement with field deformation measurements from leveling survey. In addition, local heterogeneity can be more important for a geologic medium saturated with multiple fluids (methane/water) which will be addressed in future research.

Keywords: Poro-elastic modeling, Geological heterogeneity, Land subsidence

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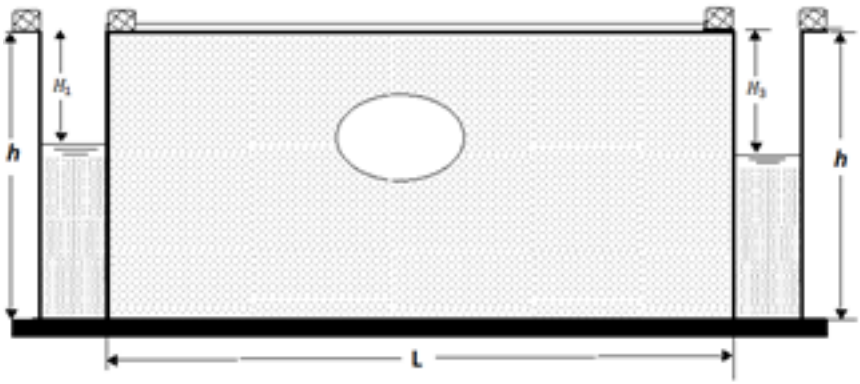
Analytical Solution of a Ditch Drainage System for the restoration of waterlogged site considering a Subsurface Source/Sink

*SHUBHAM TIWARI[1], BRIJESH KUMAR YADAV[1], RATAN SARMAH[2]

1. Indian Institute of Technology Roorkee, 2. Indian Institute of Technology Ropar

Drainage plays an important role in the field of agricultural science, as it helps in removing excess water from the soil quickly. An analytical solution is developed for the prediction of transient seepage to a fully penetrating ditch drainage system receiving water from a ponded surface with an influence of subsurface source/sink. The proposed solution is quite versatile to tackle the presence of source and sink effect in the flow domain. A subsurface flow domain of confined nature is assumed as study area which is having finite extends in horizontal and vertical directions. The hydraulic property of the soil matrix is considered as homogeneous and anisotropic in nature. The accuracy of this solution is analyzed by comparing with numerical solution obtained from finite difference method and other existing simplified case on MATLAB programming software. With the imposition of the source and sink term in the flow domain, the path line and travel time of water molecules started deviating from their original position. It was observed that discharge to the drains has a strong influence of the source/sink term. It is expected that the proposed model will help in the understanding of the flow dynamics associated with the ditch drainage system subjected to source/sink in real field conditions.

Keywords: Transient seepage, Ditch drains, Source/sink, Water logging



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Variable-density flow and mass transport in unsaturated-saturated aquifers under horizontal groundwater flow conditions

*Jiaqi Liu[1], Tomochika Tokunaga[1]

1. The University of Tokyo

Density-induced fingering is an important mass transport process in a variety of groundwater flow settings. This study numerically investigated density-driven flow and mass transport in a 2-D vertical conceptual model of an unsaturated-saturated aquifer. The modeled domain consisted of 300 m long, with horizontal groundwater flow and vertical injection of dense solute from the top. In total, 158 numerical simulation cases were designed with various configurations of horizontal groundwater flow, the rate of solute injection, aquifer properties, and dispersivity. The numerical code FEFLOW was adopted which can solve both variable-density groundwater flow and unsaturated-saturated flow in porous media. Three dimensionless numbers, the convective ratios M_x and M_z and the Rayleigh number Ra_d, were applied to quantitively evaluate the relative magnitudes among the driving forces in the simulation cases. Three end-member flow regimes were identified that were dominated by the horizontal hydraulically-driven flow, the vertical hydraulically-driven flow, and the vertical density-driven flow, respectively. The plots of the simulation results in the M_x-M_z-Ra_d diagram enabled a clear distinction among the clusters of flow regimes and suggested the dominant driving force of each flow regime. The parameter sensitivity and regime shifts were also analyzed with the M_x-M_z-Ra_d diagram. The classification of flow regimes and the proposed M_x-M_z-Ra_d diagram provided a basic reference and a useful tool for understanding the mechanisms of variable-density flow processes under complex field situations.

Keywords: Variable-density flow, Numerical simulations, Dimensionless numbers

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A practical approach to evaluating water inflow for underground water-sealed storage cavern

*Jing-Sen Cai[1]

1. China University of Geosciences

A practical approach that has been successfully applied to evaluate the water inflow for the project of underground water-sealed storage cavern in fractured granite in China are introduced. This approach consists of two steps: investigation of the distribution of groundwater flow path and modeling to evaluate the water inflow in the cavern. Firstly, field investigation methods such as geological survey and mapping, engineering drilling, borehole imaging and engineering geophysical prospecting are used to investigate the distribution of fracture zones and faults. Subsequently, the piecewise water pressure test is performed in the existing boreholes to search the seepage passage which is dictated by the section with large permeability coefficient. Based on this, models such as Hirishi Oshima empirical equation, Misaki Sato Kuniki empirical equation and the empirical analytical equation are utilized to evaluate the water inflow in the traffic tunnel, main cavern and shaft during the construction stage. Results indicate that the seepage passage determined by the piecewise water pressure test corresponds well to the location of fracture zones revealed by field investigation. The evaluation results are confirmed by the surrounding rock quality and water inflow location uncovered by the excavation afterward, which demonstrate the validity of this comprehensive approach.

Keywords: field study, underground water-sealed storage cavern, fractured granite, water inflow, borehole imaging, piecewise water pressure test

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[E] 口頭発表 | セッション記号 M (領域外・複数領域)：M-ZZ その他

2019年5月28日(火) 15:30 ~ 17:00 | 304 3F

[M-ZZ50] 越境火山災害をめぐるガバナンス

コンビーナ:阪本 真由美(兵庫県立大学大学院減災復興政策研究科)、中道 治久(京都大学防災研究所附属火山活動研究センター)、荒木田 勝(アジア防災センター)、座長:阪本 真由美(兵庫県立大学大学院減災復興政策研究科)、中道 治久(京都大学防災研究所)、荒木田 勝(アジア防災センター)

火山の観測システムは、国レベルにおいて特定の火山活動を観測する目的で構築・運用されている。他方、2010年に起こったアイスランドの火山噴火の事例は、被害が国境を超えて広範な地域に及ぶことを示した。このような越境災害による被害を防ぐには、原因物質の発生・拡散・沈着にいたるまでを予測・モニタリングし、その情報を迅速に各国の市民に伝えるための国際協調システムが求められる。本セッションでは、どのようなメカニズムの下で国際的協調システムを構築することができるのかを、防災、火山学、環境学、法学など異なる研究領域から検討する。

15:30 ~ 15:35

Introduction

15:35 ~ 15:50

[MZZ50-01] The development of the European collaborative mechanism of volcanic monitoring systems after 2010 Eyjafjallajokull eruption - from the perspective of European Union law -

*荒島 千鶴[1] (1.神戸学院大学)

15:50 ~ 16:05

[MZZ50-02] Preparing for volcanic disasters: Risk communication issues when dealing with international tourists.

★Invited Papers

*Ana Maria Cruz Naranjo[1]、Giuseppe Aliperti[1] (1.Kyoto University Disaster Prevention Research Institute)

16:05 ~ 16:20

[MZZ50-03] Mitigation of volcanic hazard in Sakurajima, Japan, through the coordinating committee and through communication with the public

*中道 治久[1] (1.京都大学防災研究所附属火山活動研究センター)

16:20 ~ 16:35

[MZZ50-04] An experimental forecasting technique for the ash hazard from Sakurajima volcano, Japan

*Alexandros Panagiotis Poulidis[1]、Tetsuya Takemi[1]、Masato Iguchi[1] (1.Disaster Prevention Research Institute, Kyoto University)

16:35 ~ 16:50

[MZZ50-05] 宇宙技術の早期警報への応用と越境型災害への効果的な対応

★招待講演

*鈴木 弘二[1] (1.アジア防災センター、神戸大学都市安全研究センター)

16:50 ~ 17:00

[MZZ50-06] Discussion -Research Framework for Trans-boudary Disaster

*Mayumi Sakamoto[1] (1.Graduate School of Disaster Resilience and Governance, University of Hyogo)

The development of the European collaborative mechanism of volcanic monitoring systems after 2010 Eyjafjallajokull eruption - from the perspective of European Union law -

*荒島 千鶴[1]
*Chizu Arashima[1]

1. 神戸学院大学
1. KOBE GAKUIN UNIVERSITY

The eruption of Icelandic volcano Eyjafjallajokull in 2010 caused huge international air traffic disturbances and left significant economic and social damages to the international society. The lesson learned from the disaster is that not only the estimates by Volcanic Ash Advisory Centre (VAAC) but also the on-going observations are needed to estimate the concentration more accurately. These observations are carried out by various volcanic observatory institutions. They play key roles in reducing/preventing possible economic, environmental, health or social damages caused by such trans-boundary volcanic disaster, by providing key scientific information and interpretation during eruption crises. To address the fragmentation of scientific data and make use of scientific information, the European collaborative mechanism of volcanic monitoring systems to share information should be established on a sufficient financial basis.
At present, European Network of Observatories and Research Infrastructures for Volcanology (EUROVOLC) is coordinated by Icelandic Meteorological Office with 16 other partners from 7 European countries. EUEOVOLC is a 3-year project from February 1 2018 and is funded by the European Commission of the European Union (EU) under “Horizon 2020” with 5 million Euros. Horizon 2020 - the Framework Programme for Research and Innovation (2014-2020) was established by REGULATION (EU) No 1291/2013. Its Article 7 provides association of third countries to Horizon 2020. Associated countries include European Free Trade Association members, including Iceland. Therefore, EUROVOLC is funded by the EU. Horizon 2020 falls under the areas of research, technological development and space where the EU has shared competence with the Member States and the EU “shall have competence to carry out activities, in particular to define and implement programmes; however, the exercise of that competence shall not result in Member States being prevented from exercising theirs” (Article 4(3) of the Treaty on the Functioning of the European Union (TFEU)).
Concerning natural disasters, the 2007 Treaty of Lisbon introduced new provisions of TFEU. They are included both in the areas of civil protection under PART THREE UNION POLICIES AND INTERNAL ACTIONS of TFEU and humanitarian aid under PART FIVE THE UNION'S EXTERNAL ACTION of TFEU. Disaster prevention is provided in the former, as Article 196(1) of TFEU provides that “(t)he Union shall encourage cooperation between Member States in order to improve the effectiveness of systems for preventing and protecting against natural or man-made disasters”. Civil protection is the area where “(t)he Union shall have competence to carry out actions to support, coordinate or supplement the actions of the Member States” (Article 6 of TFEU).
For the implementation, the Directorate-General for European Civil Protection and Humanitarian Aid Operations (ECHO) of the European Commission plays the role. Under ECHO, there is EU Civil Protection Mechanism (UCPM). It was established by DECISION No 1313/2013/EU. Iceland is a participating state of the UCPM. UCPM is not at present a forum to establish a European collaborative mechanism of volcanic monitoring systems. However, it is worthy to note that Proposal for a DECISION amending Decision No 1313/2013/EU in 2017 acknowledges that disaster prevention efforts are crucial to limit the

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need for crisis and emergency support. It proposes that UCPM "shall support, complement and facilitate coordination of Member States' action" "to increase the availability and use of scientific knowledge on disasters". It also proposes that the Commission shall "take actions to improve the knowledge base on disaster risks and facilitate the sharing of knowledge, the results of scientific research, best practices and information, including among Member States that share common risks".
At present, the European collaborative mechanism of volcanic monitoring systems is financially supported by project-based funds of Horizon 2020. However, if the Proposal is adopted and the importance of sharing scientific information in disaster prevention is recognized, more opportunity and regular financial support to develop European collaborative mechanism of volcanic monitoring systems may be given.

キーワード：EU、EU市民保護メカニズム、EUROVOLC、エイヤフィヤトラヨークトル火山、防災、火山噴火
Keywords: European Union, EU civil protection mechanism, EUROVOLC, Eyjafjallajokull, disaster prevention, volcanic eruption

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Preparing for volcanic disasters: Risk communication issues when dealing with international tourists.

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This paper provides insights on the risk communication behavior of international tourists visiting Japan. The study builds on the premise that even if tourism-oriented risk communication has been strongly investigated, tourists' risk information seeking and processing has been under-investigated. We thus explore risk information seeking and processing of international tourists in Japan. Japan has been selected as a case study for several reasons. First, the level of exposure of the country to natural hazards, such as volcanic eruptions, tsunamis, earthquakes, and typhoons, is high. Second, due to the increasing presence of tourists in recent years, the number of people exposed to disaster-related risk in Japan has also drastically increased. In the case of a major volcanic eruption with disruption to air traffic, the provision of risk information to tourists already in Japan, as well as those preparing to travel is of critical importance. The overall aim of the study consists on providing cross-country evidence to inform risk-communication strategies and improve tourists' disaster preparedness. In order to investigate the tourists' perspective, we adopted the Risk Information Seeking and Processing (RISP) model.

Keywords: risk communication, tourists, disasters

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Mitigation of volcanic hazard in Sakurajima, Japan, through the coordinating committee and through communication with the public

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The Sakurajima Volcanological Observatory, at present the Sakurajima Volcano Research Center (SVRC), was founded in 1960 as a part of the Disaster Prevention Research Institute, Kyoto University, following the request from local governments and residents of the volcanic area. The SVRC contributes to society by releasing scientific results and knowledge on volcanic hazard to the public, as well as by advising national and local governments on hazard mitigation strategies. Volcano experts are required to issue a warning when a volcanic eruption is ongoing or imminent. The SVRC evaluates volcanic activity using observational data. It communicates and interacts often with local government offices, such as the ones in Kagoshima Prefecture, Kagoshima City, Tarumizu City, local branches of ministries of the national government, the Osumi Office of Rivers and National Highways (OORNH), and the Kagoshima Local Meteorological Office (KLMO). The SVRC and these offices work in close cooperation. For example, the meeting of the Coordinating Committee for Hazard Mitigation of Sakurajima Volcano has been taking place regularly every two months since 2006. The purpose of the Coordinating Committee is to share up-to-date observational results, to cooperate and to examine special topics to respond in terms of hazard mitigation in case of volcanic eruptions of the Sakurajima. The KLMO provides information on the volcanic activity of the Sakurajima as necessary, on the basis of the continuous observation and monitoring conducted in cooperation with the SVRC, OORNH, and other relevant bodies.

The Kyoto University has research facilities located across Japan, and organizes open-doors weeks at these facilities, i.e. the “KYODAI Weeks”, every year in October and November. As a part of this event, the SVRC opens not only the observatory, but also an underground observation tunnel to the public, so that the visitors can understand the instrumentation employed to monitor volcanic phenomena. We installed a group of PC displays at the Sakurajima Visitor Center in March 2017 to show real-time seismic and ground deformation data to the general public visiting Sakurajima. In addition, we explained to “volcano guides” how to interpret these monitoring data, so that they can explain these data from the point of view of volcanology to the general public in a straightforward manner.

キーワード：火山災害、火山防災連絡会、観測データ表示、施設公開
Keywords: Volcano Hazard, Coordinating Committee, Monitoring Data Display, Doors Open

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An experimental forecasting technique for the ash hazard from Sakurajima volcano, Japan

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Introduction

The long-lasting activity from Sakurajima volcano introduces hazardous amounts of volcanic ash into the atmosphere, adversely affecting the surrounding areas (e.g. Biass *et al.* (2017), Poulidis *et al.*, (2018)), making accurate localized forecasts a necessity. Here, we present initial results from an experimental forecasting methodology carried out by the Sakurajima Volcanological Observatory (SVO), Kyoto University, focusing on three points: *(i)* high resolution (333m mesh), *(ii)* use of Eruption Source Parameters (ESPs) that are derived from geophysical signals (Iguchi, 2016) and allow for a proactive forecasting approach, and *(iii)* use of dedicated models in order to properly represent the plume structure.

Forecast Methodology

A combined modelling approach is presented: Japan Meteorological Agency (JMA) forecast data are dynamically downscaled to 333m using the Weather Research and Forecasting (WRF) model (Skamarock and Klemp, 2008), while the FALL3D volcanic ash transport and deposition (VATD) model (Folch *et al.*, 2009) is used for the introduction of the plume and dispersal modelling. A quasi-online coupling approach is used here, with WRF data output every 10mins so that the resolved variablity in the wind fields is well-represented in the ash dispersal simulations. In order to study the sensitivity of results to the timing relative to eruption, a total of 5 pseudo-forecast simulations were carried out using data up to 13 hours before the eruption.

June 16, 2018 Eruption

Sakurajima erupted at 0719 JST (JST=UTC+9), June 16 2018, with a reported plume height of 4700 m above the vent. Deposition occurred west and southwest of the volcano, reaching the southern coast of the Satsuma peninsula. Ashfall locations were reported by the JMA, while the SVO carried out a post-eruption survey to collect samples. A comparison of disdrometer observations (which measure airborne ash size) and ground deposits suggest the presence of large aggregates (e.g. Bagheri *et al.*, (2016)), a fact that needs to be accounted for in order to have successful simulations.

Forecast Simulation Results and Conclusions

Initially, a control simulation was carried out using the final mass discharge rate output. Although qualitatively similar to the JMA ash forecast, it offered two key improvements: *(i)* ash deposition over the volcano occured along a narrow path, correctly reproducing the observed pattern, and *(ii)* the observed area of maximum ashfall (>1 mm deposit thickness) was reproduced correctly at a distance from the vent, over the southwestern shore of the volcano.

Forecast time sensitivity simulations showed consistent ash dispersal patterns. Simulation results using forecast data up to 10 hours before the eruption time were qualitatively similar. Up to 4 hours before the eruption, the observation to estimate ratios for the two disdrometers were constrained to factor of 4, allowing for the proposed methodology to be confidently used in forecast timescales.

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Poulidis *et al.* (2018) *Atmos. Environ.*
Skamarock and Klemp (2008) *J. Comput. Phys.*

Keywords: Ash dispersal, Hazard forecasting, Sakurajima, FALL3D, Weather Research and Forecasting

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宇宙技術の早期警報への応用と越境型災害への効果的な対応
Utilization of Space Technology for Early Warning and Efficiently Response Against Transboundary Disaster

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センチネル・アジアの枠組みを通じて宇宙技術は災害リスクの軽減に貢献している。この枠組みでは、これまでほぼリアルアイムで宇宙からの観測・解析情報をオンラインで提供してきたが、緊急対応や災害後の復興計画策定や事業を効率的にするだけではなく、早期警報の発出にもスコープを拡大しようとしている。アジア地域の８つの宇宙機関がアジア各国に衛星データを提供し、緊急対応、地図作成、災害被害の評価、復旧・復興に貢献している。これに加えて日本が開発した準天頂衛星”みちびき”を利用することによって、拡声器やスマホを通じて早期警報を伝達することができるようになった。

キーワード：Space-based technology、Sentinel Asia、QZSS、Early warning message platform、Transboudary disaster
Keywords: Space-based technology, Sentinel Asia, QZSS, Early warning message platform, Transboudary disaster

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Discussion -Research Framework for Trans-boudary Disaster

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Volcanic disaster occurred in one country may cause different environmental or health effect in other country. In order to mitigate direct or secondary effect caused by eruption, it is important to discuss international collaborative mechanism to share information and take necessary measures. In this session, we discuss about how to establish a research framework for trans-boudary volcanic disaster.

Keywords: governance, trans-boudary, volcano, disaster

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