Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

PPS04-01 会場:105 時間:5 月 21 日 14:15-14:30

平原と山岳地帯での火星風力発電の見積もり
Evaluations of wind electric energy at Martian Planetia and Mons

西川 泰弘 [1*], 栗田 敬 [1], アイメリック スピガ [2]
Yasuhiro Nishikawa[1*], Kei Kurita[1], Aymeric Spiga[2]

[1] 東京大学地震研究所, [2]UPMC ソルボンヌ大学連合
[1]The university of Tokyo. Earthquake Research Institute, [2]UPMC Sorbonne Universites

惑星探査において、ローバーやランダーへの電力供給量はその運用能力を決定する重要な要因の１つである。現在、火星では太陽光が唯一の発電方法だと考えられている。しかし、火星表面に吹く強い風が太陽光発電に問題を引き起こすことがある。2010 年の 3 月 22 日、火星探査車の MER-A(rover spirits) が着陸から 2210 火星日で活動を停止した。理由は電力の低下によるものである。太陽光パネルの上に風によって砂が運ばれ、発電量が低下したことが原因である。今学会では火星上での風力発電能力について発表する。いくつかの観測結果から、火星は風の強い惑星であるということが分かっている。Kaydash ey al.,2006 らは雲の動きから火星の高度 30km では最大で 80m/s の風が吹いていると見積もった。また、地表面の風速は着陸機 Viking と Phoenix によって計測されている。また、火星上の風成地形からも表面の風速は見積もられている。Fenton et al., は砂の運搬能力から、Proctor クレーターの底の風速を 20m/s 以上だと見積もっており、Toyota et al.,2011 は傾斜面では更に強い風が吹いているとしている。

以上のことをふまえて我々は今回火星上の三カ所での風力発電量を見積もった。Elysium Planetia, Chryse Planetia, Arsia Mons の三カ所である。Arsia Mons その長い傾斜によって傾斜風が発生するため、火星上で最も風の強い場所の１つである。Elysium Planetia は InSight mission の着陸候補地の１つであり、Chryse Planetia は Viking Lander1 の着陸地である。これらの発電量は場所に強く依存する。同じ (sweep area が) １平方メーターの風車を設置した場合、Chryse Planetia では一日に 3.4[Watt hour] しか発電できない一方、Arsia Mons では 137[Watt hour] の発電が見込まれる。この風力発電量を他の電力供給方法 (太陽光発電と原子力電池) と比較し、火星上で風力発電は有効であると結論づけた。

キーワード: 火星, 風力発電, 惑星探査, 火星大気, 傾斜風
Keywords: Mars, Wind electric energy, Planetary exploration, Martian wind, Slope wind

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

PPS04-02　会場:105　時間:5 月 21 日 14:30-14:50

初期火星大気中の主成分凝結対流の二次元数値実験
A 2D numerical simulation of atmospheric convection with condensation of major component under early Mars condition

山下 達也[1*], 小高 正嗣[1], 杉山 耕一朗[1], 中島 健介[2], 石渡 正樹[1], 林 祥介[3]
Tatsuya Yamashita[1*], Masatsugu Odaka[1], Ko-ichiro SUGIYAMA[1], Kensuke Nakajima[2], Masaki Ishiwatari[1], Yoshi-Yuki Hayashi[3]

[1] 北海道大学, [2] 九州大学, [3] 神戸大学
[1]Hokkaido university, [2]Kyushu university, [3]Kobe university

初期の火星においては大気主成分の凝結が広範にわたって生じ, CO_2 氷雲の散乱温室効果が温暖な気候の実現に寄与したと考えられる (Forget et al., 2013). 散乱温室効果は雲の分布に強く依存し, 雲の生成と分布を決める要因の一つは対流運動である. しかし大気主成分の凝結を伴う対流の構造についてはこれまでほとんど調べられていない.

Colaprete et al.(2003) は大気主成分が凝結する場合においても, 臨界飽和比が 1.0 より大きく過冷却状態が維持されれば, 凝結する気塊が浮力を得ることで対流が生じる可能性があると主張した. しかし Colaprete et al.(2003) が行なったのは 1 次元モデル計算であり, 彼らの主張するシナリオが実現するかどうかは, 空間 2 次元の数値流体モデルを用いて調べる必要がある.

我々は大気主成分凝結を考慮した 2 次元雲解像モデルの開発と, 現在の火星の極夜での条件を与えた予備的な計算を行なってきた (例えば山下他, 2012 年連合大会). 本研究では初期火星条件の下での主成分凝結対流の数値計算を行い, 臨界飽和比と凝結核数密度を変化させた際に流れ場と雲の分布がどのように変化するかを調べた.

支配方程式は山下他 (2012) 同様, 大気主成分の凝結を考慮した 2 次元準圧縮方程式系である. 雲粒の形成過程は拡散成長のみを考慮し, 雲密度が閾値 (10^{-6}kg/m^3) 以下であれば過飽和が維持されると仮定する. この閾値は物理的には拡散成長する雲粒には臨界半径が存在することを考慮したものである. 放射過程は陽に解かず, 高度 0 km から 50 km までは水平一様な冷却, それより上空にはニュートン冷却を与える. 水平一様な冷却率の大きさは -0.1 K/day (Kasting, 1991) とする. 地表気圧は 2.0×10^5 Pa, 地表温度は 273 K に固定する. 初期の大気温度は高度 20 km 以下で乾燥断熱減率に従い, 高度 20 km から 50 km まで飽和蒸気圧曲線に従い, 高度 50 km より上で等温という分布を与える. 臨界飽和比は 1.0, 1.35(Glandorf et al., 2002), 凝結核数密度は 5.0×10^8, 5.0×10^6, 5.0×10^4 /kg とし (Forget et al., 2013), これらを組み合わせた 6 通りの数値実験を行なう. 計算領域は水平 100 km, 鉛直 80 km, 格子間隔は水平 500 m, 鉛直 400 m である.

臨界飽和比を 1.0 とした場合, 凝結高度より上空にほぼ水平一様な雲層が準定常的に存在する状態が得られた. 雲層内の鉛直流は凝結高度より下と比べると小さく, 最大で 0.5 m/s である. これらの特徴は凝結核数密度によって変わらない. 臨界飽和比が 1.35 の場合, 雲の分布は凝結核数密度によって変化する. 凝結核数密度を小さくすると, 凝結が生じる期間と凝結が生じない期間が交互に出現するようになり, 凝結期には厚い雲とともに 2–3 m/s の鉛直流が生じる. 非凝結期には, 雲密度が閾値未満である水平一様な雲層が存在し, そこでの鉛直流は最大で 0.5 m/s である.

以上より, 大気主成分が凝結する系においては, 臨界飽和比と凝結核数密度の値によって雲対流の時空間構造は大きく異なり, 時間的に雲や流れ場があまり変動しない準定常解と, 凝結期と非凝結期を交互に繰り返す準周期的な解が存在することが分かった.

キーワード: 大気主成分の凝結, CO2 氷雲, 雲解像モデル, 初期火星
Keywords: condensation of major atmospheric component, carbon dioxide ice cloud, cloud resolving model, early Mars

PPS04-03 会場:105 時間:5 月 21 日 14:50-15:05

火星の冬極における CO2 大気凝結と傾圧不安定波の影響
CO2 Snowfalls Affected by the Baroclinic Waves in the Winter Polar Atmosphere of Mars

黒田 剛史 [1*], Alexander S. Medvedev[2], 笠羽 康正 [1], Paul Hartogh[2]
Takeshi Kuroda[1*], Alexander S. Medvedev[2], Yasumasa Kasaba[1], Paul Hartogh[2]

[1] 東北大学, [2] マックスプランク太陽系研究所
[1]Tohoku University, [2]Max Planck Institute for Solar System Research

火星大気大循環モデル (MGCM) を用いて、火星冬極域における CO_2 大気の凝結について計算を行い、CO_2 氷雲の生成と地表面への堆積が傾圧不安定波と密接に関わっていることを示した。
CO_2 季節極冠は、大気中で凝結して生じた CO_2 氷雲の地表面への堆積と地表面で直接凝結する CO_2 大気により生成される。冬極における CO_2 氷雲の存在は観測により示唆されており、また北極におけるその存在は局所的な気象現象の影響で経度方向に不均質となることが先行シミュレーション研究より示されている。とりわけ傾圧不安定波の存在は火星の北半球冬季において顕著な現象であり、本研究ではそれに代表される大気力学的な効果がいかにして北極域における CO_2 氷雲や季節極冠の生成に影響しているかを示す。
今回我々は CO_2 氷雲の凝結と輸送に関する簡単なスキームを MGCM に導入し、冬の北極域における CO_2 降雪の再現実験を行った。数値計算結果では北緯 70 度以北・高度 40km 以下で CO_2 氷雲の生成が見られ、その生成は傾圧不安定波により大気が寒冷化する位相に沿って見られた。高度 10km 以上で生成された CO_2 氷雲はその大部分が地表面に達することなく、下部に存在する比較的温暖な大気層において蒸発する。また季節極冠となる地表面の CO_2 氷のうち、その 9 割は大気中で生じた CO_2 氷雲が地表面に堆積したものであり、地表面で直接大気が凝結して生じる季節極冠は全体のわずか 1 割である。そのため、CO_2 季節極冠の生成率は高度 10km 以下の傾圧不安定波の位相に強く依存する。傾圧不安定波の規則性から、本研究の結果は CO_2 氷雲の出現および地表面への堆積について予測の可能性を示唆するものであると言える。

キーワード: 火星, 大気力学, 大気大循環モデル, CO2 氷雲, 極冠
Keywords: Mars, atmospheric dynamics, general circulation model, CO2 ice clouds, polar ice cap

PPS04-04 会場:105 時間:5 月 21 日 15:05-15:20

火星気象オービター構想
Concept of Mars meteorological orbiter

今村 剛 [1*], 小郷原 一智 [1]
Takeshi Imamura[1*], Kazunori Ogohara[1]

[1]Japan Aerospace Exploration Agency
[1]Japan Aerospace Exploration Agency

A Mars meteorological orbiter mission is under study. The primary objective of the orbiter will be exploration of meteorological processes with focusing on dust cycle. Water cycle and photochemistry will also be addressed.

In spite of tremendous efforts in Mars weather monitoring in previous Mars missions, dust and water cycle are far from fully understood. Though Mars Global Surveyor and Mars Climate Orbiter has provided a wealth of information on the seasonal cycle of large-scale dust storm and water vapor distributions, observations of individual meso- to synoptic-scale transport processes are limited due to spatially and temporary sparse sampling inherent in low-altitude polar orbits.

The Mars orbiter under study will address material transport over wide spatial and temporal scales with continuous, high-resolution global monitoring of dust, clouds, water vapor, minor gases, and temperature field from an elliptical, equatorial orbit. The apoapsis of the orbit will be located always near the local noon. The observation strategy resembles that of Earth's meteorological weather satellites, but the instruments are optimized to Mars weather monitoring. A polarimetric camera will visualize lofted dust grains and characterize the dust size distribution. A sub-millimeter sounder will obtain three-dimensional distributions of atmospheric temperature, water vapor, other minor gases and their isotopes. A thermal imager will monitor the global distributions of dust and atmospheric temperature, and also vertical profiles of dust with limb imaging. Radio occultation will obtain high-precision temperature profiles. The observations will complement other future Mars missions such as ESA's Trace Gas Orbiter, which focuses on high-sensitivity trace gas observations.

キーワード: 火星, 気象, 探査, オービター
Keywords: Mars, meteorologgy, exploration, orbiter

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

PPS04-05 会場:105 時間:5 月 21 日 15:20-15:45

Prime Habitable Environment of Mars: Argyre Impact Basin
Prime Habitable Environment of Mars: Argyre Impact Basin

Dohm James[1*], 丸山 茂徳 [1], 宮本 英昭 [2], Ramy El Maarry[3], Richard Soare[4], Trent Hare[5]
James Dohm[1*], Shigenori Maruyama[1], Hideaki Miyamoto[2], Ramy El Maarry[3], Richard Soare[4], Trent Hare[5]

[1] 東京工業大学　地球生命研究所, [2] 東京大学総合研究博物館, [3]Physikalisches Instit., Bern Univ., [4]Dept. of Geog., Dawson College, [5]USGS, Flagstaff
[1]Earth-Life Science Institute, Tokyo Institute of Technology, [2]The University Museum, The University of Tokyo, [3]Physikalisches Instit., Bern Univ., [4]Dept. of Geog., Dawson College, [5]USGS, Flagstaff

The geologic provinces of Mars, as identified through a synthesis of geologic, paleohydro-logic, topographic, geophysical, spectral, and elemental information [1], are windows into its evolution, such as the Hellas-Argyre province (middle to early Mars). The Argyre basin and surroundings, in particular, records long-term water enrichment and heat-energy, likely nutrient-enriched materials, and solar radiation, collectively making Argyre a prime habitable environment for the exploration of possible life [2-4]. The giant impact event tapped into primordial mantle and granite-enriched crustal materials, including rocks enriched in elements which are critical to life (including P,O,N,C,H,S,Ca,Fe; see [Shigenori Maruyama, this conference]), creating a catchment for water and rock materials since its formation about 4.0 Ga [1-3].

A lake was formed directly subsequent to the event, feeding the far-reaching Uzboi Vallis system; other lakes filled the impact-derived local basins as well. The lakes soon froze, and the once lacustrine environment transitioned into glacial and periglacial environments. Through time, liquid water/water-ice waned, though not totally being depleted, as there was subsequent Tharsis superplume-driven, transient hydrological cycling at global scale [3] (including enhanced activities in the basin region).

Long-term water enrichment in and surrounding the Argyre basin includes geologically-recent and possibly present-day periglacial and glacial activity [5,6]. The major topographic variations between the deep catchment basin and nearby Tharsis-superplume plateau may have resulted in enhanced precipitation through time resulting from both endogenic activity (e.g., Tharsis) and exogenic activity (e.g., obliquity).

In addition, the impact produced a complex system of tectonic structures, many of which are thousands of kilometers in length and reach great depths (likely the Moho). Such basement structures served as conduits for the migration of volatiles and heat energy into the basin region from as far away as Tharsis [1-3].

Yet another important habitable-environmental condition is the long-term heat generated by the impact. There even appears to be geologically recent venting along the basin floor as well as reactivation of the impact-generated basement structures. Such an interplay among long-term water enrichment and heat-energy, likely nutrient-enriched materials, and solar radiation collectively point to Argyre basin as a prime habitable environment for exploration of possible life.

References

[1] Dohm, J.M. et al., (2013?in press), Nova Science Publishers, Inc.
[2] Dohm, J.M. et al., (2011), LPSC Abstract #2255.
[3] Dohm, J.M., et al. (in preparation) USGS geological map.
[4] Dohm, J.M., et al. (2007) In Superplumes: beyond plate tectonics. D.A Yuen, S. Maruyama, S-I Karato, and B.F. Windley (eds.). Springer, pgs. 523-537.
[5] Soare, R.J., et al. (2012). GSA Annual Meeting, Charlotte, North Carolina, 44, 7, 64.
[6] El Maarry M.R., et al. (2013), LPSC Abstract #2806.

PPS04-06 会場:105 時間:5 月 21 日 15:45-16:00

MELOS1 火星着陸機のサイエンスと着陸候補地点
Science and landing-site candidates of the MELOS 1 EDL demonstrator

宮本 英昭 [1*], 佐藤 毅彦 [2], 久保田孝 [2], 藤田和央 [2], 今村 剛 [2], 岡田 達明 [2], 山岸 明彦 [3], 小松吾郎 [4], 石原 吉明 [5], はしもとじょーじ [6], 出村 裕英 [7], 千秋 博紀 [8], 岩田 隆浩 [2], 佐々木 晶 [9], 大山聖 [2], 石上玄也 [2], 尾川順子 [2], 山田和彦 [2], ジェームズ・ドーム [10]
Hideaki Miyamoto[1*], Takehiko Satoh[2], Takashi Kubota[2], Kazumasa Fujita[2], Takeshi Imamura[2], Tatsuaki Okada[2], Akihiko Yamagishi[3], Goro Komatsu[4], Yoshiaki Ishihara[5], George HASHIMOTO[6], Hirohide Demura[7], Hiroki Senshu[8], Takahiro Iwata[2], Sho Sasaki[9], Akira Oyama[2], Genya Ishigami[2], Naoko Ogawa[2], Kazuhiko Yamada[2], James M. Dohm[10]

[1] 東京大学総合研究博物館, [2] 宇宙航空研究開発機構, [3] 東京薬科大学生命科学部, [4]IRSPS, [5] 産業技術総合研究所, [6] 岡山大学大学院自然科学研究科, [7] 会津大学, [8] 千葉工業大学惑星探査研究センター, [9] 国立天文台, [10] 東京工業大学
[1]University Museum, University of Tokyo, [2]JAXA, [3]Tokyo University of Pharmacy and Life Science, Department of Molecular Biology, [4]IRSPS, [5]National Institute of Advanced Industrial Science and Technology, [6]Department of Earth Sciences, Okayama University, [7]The University of Aizu, [8]Planetary Exploration Research Center, Chiba Institute of Technology, [9]National Astronomical Observatory of Japan, [10]Tokyo Institute of Technology

MELOS (Mars Exploration with a Lander-Orbiter Synergy) is a Japanese Mars-exploration mission proposed by the Japan Aerospace Exploration Agency. Through a few years of discussions of its both scientific and engineering aspects, the outline of the mission becomes clearer. Most importantly, MELOS now stands for a concept of a series of missions; the MELOS 1 will focus on an accurate orbital insertion with an entry-decent-landing (EDL) demonstrator for future Mars missions, which will be followed by a full-scaled MELOS 2 or later missions.
MELOS1 emphasizes its engineering aspects, however, the EDL and the orbiter carries a fair amount of science payload to perform geologic and atmospheric investigations to expand our knowledge of the red planet. In this talk, we will report an update on the EDL of the MELOS 1 mission, especially about its size/orbital parameters as well as its scientific goal and potential landing sites.

キーワード: 火星, 着陸機, 生命, ダスト, 水
Keywords: Mars, Lander, life, dust, water

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

PPS04-07 会場:105 時間:5 月 21 日 16:30-16:45

Magnetic hysteresis measurement of magnetite under high pressure: Implication for source of the Martian magnetic anomaly

Magnetic hysteresis measurement of magnetite under high pressure: Implication for source of the Martian magnetic anomaly

佐藤 雅彦 [1*], 山本 裕二 [2], 西岡 孝 [2], 小玉 一人 [2], 綱川 秀夫 [3], 望月 伸竜 [4], 臼井 洋一 [5]
Masahiko Sato[1*], Yuhji Yamamoto[2], Takashi Nishioka[2], Kazuto KODAMA[2], Hideo Tsunakawa[3], Nobutatsu Mochizuki[4], Yoichi Usui[5]

[1] 九州大学, [2] 高知大学, [3] 東京工業大学, [4] 熊本大学, [5] 海洋研究開発機構
[1]Kyushu University, [2]Kochi University, [3]Tokyo Institute of Technology, [4]Kumamoto University, [5]JAMSTEC

Mars Global Surveyor observed the magnetic field of Mars, and revealed that there are many strong magnetic anomalies [1]. The strong magnetic anomalies suggest an active core dynamo of early Mars (about 4 billion years ago), and some mechanism of crustal formation in the dynamo field. Since magnetic properties of crustal rocks depend critically upon the mineralogical form of magnetic particles, the strong magnetic anomalies can give crucial information about the chemical composition and oxidation state prevailing in the early Martian crust. However, source of the magnetic anomalies have been poorly understood yet because of the lack of basic information concerning magnetic properties of deep crustal rocks. Here, we report laboratory magnetic experiments to interpret the source of the Martian magnetic anomaly.

According to previous analyses of the Martian anomalies [2,3,4], sources of the anomalies have to satisfy the following requirement: (1) the crustal rock on average is more intensely magnetized than terrestrial continental crust, (2) there may be a continuous non-magnetized layer at the surface (about 10 km), and (3) the magnetic layer is thick (about 30 - 40 km). Moreover, it is well known that remanent magnetization of the magnetic mineral gradually decays in a null field and at a temperature lower than the Curie point [5]. Thus, magnetic minerals of the Martian crust, probably magnetite [6], should have retained their magnetizations under high pressure and temperature for about 4 billion years.

In this study, we have conducted in-situ magnetic hysteresis measurement of magnetite under high pressure up to 1 GPa by using the high-pressure cell specially designed for a Magnetic Property Measuring System (MPMS). Based on the experimental results, systematic rock magnetic properties of multi-domain (MD), pseudo-single-domain (PSD), and single-domain (SD) magnetite were first obtained for high pressure up to 1 GPa. The results show that magnetite exhibits various pressure dependences with respect to magnetic domain states. Both MD and PSD magnetite particles, the coercivity monotonously increases with pressure at a rate of +90 %/GPa. On the other hand, the coercivity of SD magnetite is almost constant in the pressure range by 1GPa.

Taking into account new results of pressure dependences of hysteresis parameters, relaxation time of remanent magnetization in the Martian crust was calculated as a function of depth and age. As a result, remanent magnetization carried by MD and PSD magnetite would have been demagnetized within 4 billion years, except very shallow crustal part (shallower than 5 km). On the other hand, the SD magnetite could stably retain its magnetization in the entire crust. Therefore it is concluded that source of the Martin magnetic anomaly is probably elongated SD magnetite with submicron size, suggesting that chemical composition and oxygen state in the Martian crust was suited for bearing fine grains of magnetite about 4 billion years ago.

References: [1] Mitchell, D. L. et al. (2007), J. Geophys. Res. 112, E01002. [2] Krause, M. O. and Gilmore, M. S. (2000), Proc. Lunar Planet. Sci. Conf. 31th, abstract 1603. [3] Nimmo, F. and Gilmore, M. S. (2001), J. Geophys. Res. 106, 12351. [4] Voorhies, C. V. et al. (2002), J. Geophys. Res. 107, 5034. [5] Dunlop, D. J. and Ozdemir, O. (19977), Rock Magnetism, pp. 596. [6] Dunlop, D. J. and J. Arkani-Hamed (2005), J. Geophys. Res. 110, E12S04.

キーワード: Magnetite, High-Pressure, Magnetic Hysteresis, Martian Magnetic Anomaly
Keywords: Magnetite, High-Pressure, Magnetic Hysteresis, Martian Magnetic Anomaly

PPS04-08 会場:105 時間:5 月 21 日 16:45-17:00

火星表層水の水素同位体組成
A moderate hydrogen isotope composition of the surficial water reservoir on Mars

臼井 寛裕 [1]*, ALEXANDER, Conel C.M.O'D.[2], WANG, Jianhua[2], SIMON, Justin I.[3], JONES, John H.[3]
Tomohiro Usui[1]*, ALEXANDER, Conel C.M.O'D[2], WANG, Jianhua[2], SIMON, Justin I.[3], JONES, John H.[3]

[1] 東京工業大学大学院地球惑星科学専攻, [2]Carnegie Institution of Washington, [3]Johnson Space Center, NASA
[1]Department of Earth and Planetary Sciences, Tokyo Institute of Technology, [2]Carnegie Institution of Washington, [3]Johnson Space Center, NASA

Martian surface morphology implies that Mars was once warm enough to maintain persistent liquid water on its surface and that water played a significant role in the formation of weathered/altered terrains. This study characterizes Martian surficial volatile reservoirs based on in situ ion microprobe analyses of volatile abundances and H-isotopes of glassy phases (groundmass glass [GG] and impact melt [IM]) in Martian basalts (shergottites). Although these meteorites are of igneous origin, some glassy phases underwent impact-induced modification that trapped surficial and atmospheric volatile components. Analyses of these glassy phases demonstrate that surficial volatile reservoirs have distinct D/H ratios from their magmatic volatiles.

Hydrogen isotope compositions and the abundances of volatile elements (H_2O, CO_2, S, Cl, F) of IMs and GGs have been measured using an ion microprobe (Cameca ims-6f) at DTM-CIW. This study employs three olivine-phyric shergottites: Y-980459 (Y98), LAR 06319 (LAR06), and Lithology-A of EETA79001 (EETA79). These meteorites are petrographically similar, but are geochemically distinct in terms of their radiogenic isotopes and incompatible trace elements. The composition of Y98 closely approximates a Martian primary melt that was directly derived from a geochemically depleted mantle reservoir. In contrast, LAR06 represents a melt that has assimilated a geochemically enriched Martian crust. EETA79 shows an intermediate geochemical signature, which is interpreted to reflect mixing of the depleted and enriched sources represented by Y98 and LAR06, respectively.

IMs in LAR06 contain lower H_2O (~150ppm), CO_2 (~20ppm) and S (100-400ppm) but higher F (10-30ppm) and Cl (40-80ppm) than IMs in EETA79 (~300ppm H_2O, ~300ppm CO_2, 3200ppm S, $<$3ppm F, ~30ppm Cl). The major element compositions of IMs are probably derived by partial melting of primary plagioclase and pyroxene. Likewise, the halogen abundances and high-P_2O_5 contents in the LAR 06 IMs could possibly reflect the incorporation of primary phosphates. Y98 GGs contain low H_2O (20-50 ppm) contents relative to F (15-30 ppm) and Cl (30-50 ppm). The high halogen/H_2O ratios in Y98 GGs, compared to those of Y98 primary magma [1], indicates degassing of magmatic water during eruption.

In our previous study [1] based on olivine-hosted melt inclusions we showed that the primary magma of Y98 had a chondritic low-dD (delta-D) value of 275 permil, whereas that of LAR06 had a very high-dD value of 5079 permil. In contrast with such extreme dD differences, matrix phases in Y98 and LAR06 both have moderate dD values. GGs in Y98 exhibit a slightly greater dD variation of 200-1600 permil, but still much less extreme than the range exhibited by the melt inclusions. The dD values of the Y98 GGs rise with increasing water contents, implying mixing of two components: near-surface moderate-dD and magmatic low-dD components. On the other hand, IMs in LAR06 exhibit lower dD values of ~1000-3000 permil than the primary LAR06 melt (5079 permil). IMs in EETA79 also have a moderate dD value of ~1600 permil.

This study shows that the matrix phases (GG and IM) in all three shergottites have a relatively limited range of dD values regardless of the distinct dD of their magmatic sources. A dD-1/H_2O mixing diagram shows a convergence among the matrix dD values, which could be attributable to the impact-induced addition of a common near-surface water with a moderate dD value (~1500-2000 permil). The origin of this surficial water reservoir remains unresolved: (1) it may be derived from the Martian atmosphere, but its moderate dD values are distinctly lower than the widely-accepted atmospheric dD value of ~4000-5000 permil, and/or (2) it could originate from the addition of a weathered soil/dust component enriched in volatile elements.

[1] Usui, T., et al. (2012) EPSL, 357-358, 119-129.

キーワード: 火星, 表層水, 水素同位体
Keywords: Mars, surficial water, hydrogen isotope

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

PPS04-09 会場:105 時間:5 月 21 日 17:00-17:25

火星内部構造探査: InSight の紹介
An Introduction to the Exploration for the interior of Mars: InSight

Banerdt William[1*], Suzanne Smrekar[1], Philippe Lognonne[2], 小林 直樹 [3]
William Banerdt[1*], Suzanne Smrekar[1], Philippe Lognonne[2], Naoki Kobayashi[3]

[1] ジェット推進研究所, [2] パリ地球物理学研究所, [3] 宇宙科学研究所
[1]JPL, [2]IPGP, [3]ISAS/JAXA

The InSight mission (Interior Exploration Using Seismic Investigations, Geodesy, and Heat Transport) will illuminate the fundamental processes of terrestrial-planet formation and evolution by performing the first comprehensive surface-based geophysical investigation of Mars. It will provide key information on the composition and structure of an Earth-like planet that has gone through most of the evolutionary stages of the Earth up to, but not including, plate tectonics. Thus, the traces of this history are still contained in the basic parameters of the planet: the size, state and composition of the core, the composition and layering of the mantle, the thickness and layering of the crust, and the thermal flux from the interior.

InSight will delineate these parameters with a focused set of three investigations centered on seismology and supported by precision-tracking and heat-flow measurements. Rather than relying on a geophysical network to provide this information, InSight will utilize state-of-the-art analysis techniques to derive interior information from a single station on the surface carrying two scientific instruments: an ultra-sensitive, very-broad-band seismometer (SEIS); and a Heat Flow and Physical Properties Probe (HP^3) that consists of a self-penetrating mole trailing an instrumented tether. An X-band transponder (part of the communication system) to enable two-way precision Doppler tracking of the planet's rotation comprises the Rotation and Interior Structure Experiment (RISE). Monitoring surface environment is also performed by a high precision barometer, thermometer and anemometer (PTW), and magnetometer (MAG).

The launch and landing of InSight will be in Mar and Sept 2016 respectively, and the science operation period is one Mars year. The landing and deployment systems are inherited from Phoenix. A robotic arm and cameras are used to deploy the geophysical instruments to the surface. The system and instruments of InSight, and hence science objectives, are very similar to those investigated by the MELOS (Mars Exploration with Lander-Orbiter Synergy) EDL team. Thus InSight is of great interest to Japanese scientists and has many points from which they can learn. Conversely, the participation of Japanese scientists brings considerable strength to InSight as well, and we are pleased with their contributions.

The knowledge provided by the InSight mission will substantially advance understanding of the formation and evolution of terrestrial planets. This is a chance to open the door into the interior of Mars for the first time. We welcome your participation!

キーワード: 火星, 内部構造, 探査, 地震波, 地球物理学的観測, 気象観測
Keywords: Mars, internal structure, exploration, seismic wave, geophysical observation, meteorological observation

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

PPS04-10 会場:105 時間:5 月 21 日 17:25-17:45

Pre-Noachian における水の散逸：火星隕石中の水素同位体による制約
Significant Water Loss during pre-Noachian era: Constraints from Hydrogen Isotopes in Martian Meteorites

黒川 宏之 [1*], 佐藤 雅彦 [2], 潮田 雅司 [1], 松山 健志 [1], 森脇 涼太 [1], 臼井 寛裕 [1]
Hiroyuki Kurokawa[1*], Masahiko Sato[2], Masashi Usioda[1], Takeshi Matsuyama[1], Ryota Moriwaki[1], Tomohiro Usui[1]

[1] 東京工業大学, [2] 九州大学
[1]Tokyo Institute of Technology, [2]Kyushu University

Martian surface morphology implies that Mars was once warm enough to maintain liquid water on its surface (Jakosky and Philips, 2001). Although the high D/H ratio (~ 4500 per mil) of the current Martian atmosphere and hydrosphere (Owen et al., 1981; Jakosky and Philips, 2001) suggests that significant water should have been lost from the surface by the atmospheric escape during the Martian history, the timing and amount of the water loss have been poorly constrained. Whereas previous studies have focused on the water loss after the cessation of Martian dynamo (Lammer et al., 2003), studies for the pre-Noachian period (4.5 - 4.1 Ga) and the Noachian period (4.1 - 3.7 Ga) are limited.

Recent technical developments of ion-microprobe analysis have provided more accurate estimation of hydrogen isotope compositions (D/H) in Martian meteorites which inform the evolution of Martian water reservoirs (Usui et al., 2012; Boctor et al., 2003; Greenwood et al., 2008). Based on the D/H data from the meteorites, this study determines the amount of water loss during each period.

The water losses are estimated with a one-box model. The model is similar to Lammer et al. (2003). We assume that surficial water is lost in two stages: Stage-1 (4.5 - 4.1 Ga) and Stage-2 (4.1 Ga - present). Stage-1 corresponds to pre-Noachian era. The boundary (4.1 Ga) is derived from the crystallization age of ALH 84001, the only Martian meteorite formed in Noachian (Lapen et al., 2010). The D/H ratio at 4.1 Ga is 1200-3000 per mil. The values are derived from analyses of magmatic phosphate and secondary carbonate minerals in ALH 84001 (Boctor et al., 2008; Greenwood et al., 2008). The D/H ratio at 4.5 Ga is $<$ 275 per mil which is the value of melt inclusion in Yamato 980459 (Usui et al., 2012) and thought to represent the primitive D/H ratio of Mars. We use present water amount as an input parameter. The water losses in both stages are obtained as outputs.

Our results show that the water loss was more significant in Stage-1 (4.5 - 4.1 Ga) than in Stage-2 (4.1 Ga - present), indicating significant water loss during pre-Noachian era. This result is independent from the estimation of present water amount. Present water reservoirs exist mainly as polar layered deposits (PLD), which corresponds to 2-3x10^6 km^3 (Zuber et al., 1998; Plaut et al., 2007). The amount is 20-30 m of global equivalent layer (GEL). Using this value and assuming an efficient fractionation, minimum values of water losses are obtained as 35 - 85 m and 5.7-41 m (GEL) in Stage-1 and Stage-2, respectively. The sum of these values yields 82-120 m GEL for the total water reservoir at 4.5 Ga.

Our minimum estimate of the initial water reservoir are consistent with the amount of ocean (~150 m) provided by Vastitas Borealis Formation (VBF) (Carr and Head, 2003). Also, minimum estimates of the water losses in Stage-1 and Stage-2 are close to the values obtained by simulations of oxygen escape (Lammer et al., 2003; Terada et al., 2009). The significant water loss during pre-Noachian ($>$ 4.1 Ga) might have been caused by the intense atmospheric escape due to the solar wind without magnetic protection at the first ~150 Myr of the Mars history (Terada et al., 2009) before the time when Mars obtained ancient magnetic field.

キーワード: 火星, 隕石, 水素同位体, 大気散逸
Keywords: Mars, meteorite, hydrogen isotope, atmospheric escape

PPS04-11　会場:105　時間:5 月 21 日 17:45-18:00

火星大気散逸観測ミッションの検討報告
Examination of Orbiters for Martian Atmospheric Escape Study

松岡 彩子 [1*], 阿部 琢美 [1], 関 華奈子 [2], 寺田 直樹 [3], 石坂 圭吾 [4], 熊本 篤志 [5], 栗原 純一 [6], 田口 真 [7], Futaana Yoshifumi[8], 八木谷 聡 [9], 坂野井 健 [5], 中川 広務 [3], 山崎 敦 [1], 横田 勝一郎 [1]
Ayako Matsuoka[1*], Takumi Abe[1], Kanako Seki[2], Naoki Terada[3], Keigo Ishisaka[4], Atsushi Kumamoto[5], Junichi Kurihara[6], Makoto Taguchi[7], Yoshifumi Futaana[8], Satoshi Yagitani[9], Takeshi Sakanoi[5], Hiromu Nakagawa[3], Atsushi Yamazaki[1], Shoichiro Yokota[1]

[1] 宇宙航空研究開発機構　宇宙科学研究所, [2] 名古屋大学 STE 研, [3] 東北大学理学部, [4] 富山県立大学工学部, [5] 東北大学理学部惑星プラズマ大気研究センタ, [6] 北海道大学理学部, [7] 立教大学理学部, [8]IRF スウェーデン, [9] 金沢大学工学部
[1]ISAS/JAXA, [2]STEL, Nagoya Univ., [3]Dept. Geophys., Grad. Sch. Sci., Tohoku Univ., [4]Toyama Pref. Univ., [5]Planet. Plasma Atmos. Res. Cent., Tohoku Univ., [6]Cosmosciences, Hokkaido Univ., [7]Rikkyo Univ., [8]IRF, Sweden, [9]Kanazawa Univ.

火星の大気の変遷には、太陽風との相互作用が大きく影響したと考えられているが、今現在の火星においてさえ、大気と太陽風との相互作用の物理プロセスは明らかになっていない。
地球と異なり、現在の火星は惑星固有の磁場を持たない。その結果、太陽風は低い高度にまで達し、火星の大気と直接相互作用して、火星大気の一部は散逸される。この過程は、長い間には火星大気の組成を変化させるまでの作用を及ぼし、火星大気や、ひいては地上・地下の二酸化炭素（ドライアイス）や水・氷の変遷に大きく影響した可能性があると考えられている。大気散逸の様子は、太陽活動や太陽との距離によって影響を受けるため、大気の長期的な変遷を考えるためには、様々な太陽の状態について相互作用の働きを知らなければならない。
我々は、2011 年 12 月に JAXA 宇宙科学研究所理学委員会において火星大気散逸探査検討ワーキンググループを発足させた。このワーキンググループは、大気散逸に焦点を当て、２つのオービターによって散逸の全体像とプロセスを同時に観測することを検討している。１つのオービター（大気散逸その場観測衛星）によって、大気散逸が起きているその場のプラズマや中性粒子の観測を観測を行い、もう１つのオービター（リモート観測衛星）によって、散逸する大気等から発せられる光をリモートで撮像し、また同時に太陽風をモニターするというものである。大気散逸の物理プロセス、グローバルな全体像、物理プロセスを決める太陽風のモニターを同時に行うことは、複数衛星によって初めて可能となる、真に大気散逸の全容解明に迫る観測である。
現在我々は、2024 年頃の太陽活動極大期における火星観測を行う大気散逸観測オービターの実現に向けて、サイエンス・観測機器・衛星の検討を行っている。まず海外の類似ミッションに対する優位性や差別化を意識しながら、サイエンス目標の定量的・具体的な策定を行う。更に、現在の機器技術でサイエンス目標を達成できるのか、どのような技術開発が必要なのか、今後の開発計画を明らかにする。更に、この計画を実現させるための衛星構成や、軌道計画を検討する。
本講演では、これらの課題について検討を行った途中経過を報告する。

キーワード: 火星, 大気, 太陽風
Keywords: Mars, atmosphere, solar wind