Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PPS02-01 会場:418 時間:4 月 28 日 09:00-09:25

火星地下氷の水素同位体比と厚さ：マルチリザーバーモデルからの制約
Hydrogen Isotope Ratio and Thickness of Martian Ground Ice: Implication from Multi-Water-Reservoir Model

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Martian surface ice is currently observed only as polar layered deposits (PLDs), whereas Mars Odyssey Gamma Ray Spectrometer (Boynton et al., 2002; Boynton et al., 2007) and Mars Express radar sounder observations (Mouginot et al., 2012) propose the presence of much larger amount of ground ice in the mid- to high-latitudes. The total volume of PLDs is 20-30 m in Global Equivalent Depth (Zuber et al., 1998; Plaut et al., 2007). Ground-ice region is expected to spread over a few tenths of percent of the total Martian surface, yet the thickness (i.e. volume) is poorly constrained (Mouginot et al., 2012).

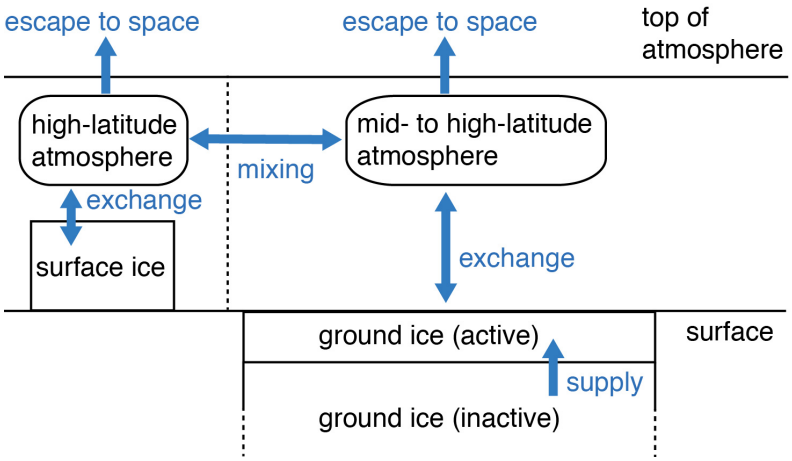
The thickness of the ground ice is related to the evolution history of the Martian water reservoirs. After ancient oceans became extinct (˜4Ga), the oceanic water would become ”surface ice”, which currently occur as PLDs, and ”ground ice” which would extend from high latitude to mid- or low-latitude. Atmospheric escape of hydrogen and oxygen through the Martian history causes decrease of the amount of the ice. The signature of the evolution history is recorded by hydrogen isotope ratio (D/H). Martin atmosphere and soil have D/H ratio of ˜6 (relative to SMOW) (Owen et al., 1988; Webster et al., 2013), which is higher than the Martian primitive D/H ratio of ˜1.3 (Usui et al., 2012).

We constrain the hydrogen isotope ratio of surface ice and ground ice, and estimate the thickness of ground ice, using a multi-water-reservoir box model (see figure shown below). The model solves the evolution of water inventories and D/H ratio of atmosphere, surface ice, and ground ice during the ice age. Atmospheric escape and sublimation are considered as D/H fractionation processes. We adapt our model to the Matian ice age (4Ga to present). The initial D/H ratio is that of ancient ocean, which is informed by D/H data of the Martian meteorite ALH84001 formed at ˜4.1Ga (Lapen et al., 2010): D/H = 2.2-4.0 (relative to SMOW) (Boctor et al., 2003,Greenwood et al., 2008).

First, we show the results from two water-reservoir box model (ice and atmosphere). The ratio of atmospheric D/H and ice D/H is in a quasi-equilibrium state of the fractionation caused by atmospheric escape and sublimation. The ratio of the present Mars is mainly determined by the fractionation caused by sublimation.

Second, we show the results from four water-reservoir box model (surface ice, ground ice, high-latitude atmosphere, and mid- to high-latitude atmosphere). Assuming the atmospheric condition of the present Mars, the mixing of two atmospheric reservoir is inefficient in D/H exchange between surface ice and ground ice, which results in the independent growth of D/H ratio of the surface ice and the ground ice. To fractionate the D/H ratio of the surface ice and the ground ice into ˜6, the thickness of active ground ice which can exchange water with atmosphere is constrained. Thin active ice causes high deuterium concentration. The required thickness is a few hundred meters, which is distinctly large value compared to the thickness that HDO diffusion works (˜10 m in 1 Gyrs). Nature of this active ground ice might be partially melted ice suggested by recent observations of recurring slope lineae (McEwen et al., 2014), hydrated clathrates in underground cryosphere, or breathing porous permafrosts.

キーワード: 地下氷, 水素同位体比, 大気散逸
Keywords: ground ice, hydrogen isotope ratio, atmospheric escape



Japan Geoscience Union Meeting 2014
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PPS02-02 会場:418 時間:4 月 28 日 09:25-09:50

火星におけるプレートテクトニクス存否の証拠：付加帯
New evidence for plate tectonism on Mars: Accreted Terrains

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Reported evidence for plate tectonism has included spatial association among magnetic anomalies, large (thousands of kilometers long) structures, and highly degraded promontories interpreted to be andesitic domes, thrust faults, folds, structurally-controlled basins, large mountain ranges, and topographic and crustal-thickness-model signatures of structural control (including plate movement) within and along the margin of the northern plains. Significant evidence for an ancient phase of plate tectonism on Mars, newly identified, is accretionary complexes, informed through Earth analogs exquisitely detailed here in Japan. This finding represents a new frontier in the geologic investigation of Mars, bringing greater attention to pre-Tharsis (~>4.0 Ga) terrains, which record Earth-like conditions. Pre-Tharsis, Earth-like conditions include an active dynamo and plate tectonism, as well as Habitable-Trinity conditions?an ocean, relatively thick atmosphere, and primordial crustal materials enriched in phosphorous, iron, among other elements important to life, all of which interact due to hydrological cycling driven by the Sun. Accreted terrains, which mark major crustal shortening through subduction of oceanic crustal materials and associated accumulation of andesites and granites, could comprise rock records on Mars dating back more than 4.2 Ga. Considering planetary evolution of Mars, largely informed through our understanding of the evolution of Earth, the accretionary complexes are likely to record environmental conditions during a time range of several hundred million years, which includes possible fossil life if initiated and evolved during the extremely ancient (>4.0 Ga) Habitable-Trinity conditions. A prime example of an extremely ancient accretionary complex is located to the west of Claritas rise, southwest margin of the Tharsis superplume. At the meeting we will present evidence of a Martian accretionary complex and discuss the implications of such a significant finding, including highlighting the next phase of geologic investigation of the evolution of Mars and its bearing on Astrobiology.

キーワード: プレートテクトニクス, 付加帯, 海洋プレート層序
Keywords: Plate tectonics, accretional complex, OPS

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PPS02-03 会場:418 時間:4 月 28 日 09:50-10:15

火星探査 MELOS 計画のためのエアロゾル・水蒸気観測用環境監視カメラの提案
Environmental monitoring camera system for the Martian aerosols and water vapor for the Japanese Mars rover, MELOS

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We propose the environmental monitoring camera system of aerosols and water vapor in the Martian atmosphere for the Japanese Mars rover, MELOS. The meteorology and the climate of Mars are strongly controlled by the aerosols, which consists of dust and clouds in the Martian atmosphere, and the better understanding of the basic parameters such as optical depth, radius distribution and composition of the aerosols enables us to describe the effect on the Martian meteorology and climate quantitatively. The water vapor also affects the Martian meteorology and climate through the infrared radiation and the generation of clouds. The MELOS aims at the search for life, and it needs the basic knowledge of the meteorology and climate at the landing site for detailed discussion. Therefore we should conduct the measurements of aerosols and water vapor at the MELOS landing site simultaneously.

To satisfy the requirement of monitoring the aerosols and water vapor in the MELOS rover mission, we propose a three-CMOS-camera system, which consists of a direct sunlight camera, a scattering light camera and a high-resolution color camera. The direct sunlight camera has four wavelength band (340 or 450nm and 550nm for aerosols and 870 and 940nm for water vapor). The scattering light camera also has the same wavelength band, but it is directed at the neighborhood of the sun and at several points along the great circle including the sun and is utilized for aerosol measurements. The arrangement proposed here basically follows the previous Mars missions, e.g., Viking lander, Mars Pathfinder and Mars Exploration Rover. The high-resolution color camera obtains pseudo color pictures around the rover and is intended to support the navigation for the life search experiment.
Keywords: MELOS rover mission, Martian atmosphere

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PPS02-04 会場:418 時間:4 月 28 日 10:15-10:30

火星大気散逸観測オービター計画の検討
Examination of Mission Scenario and Spacecraft System to Study Martian Atmospheric Escape

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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。科学目標の定量的・具体的な策定、それを達成するために必要な観測機器技術、計画を実現させるための衛星システムおよび軌道計画を検討している。 検討内容の報告と、今後の開発計画を発表する。

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Development of a dust imager for Mars landing mission
Development of a dust imager for Mars landing mission

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We report progress in developing a dust imager for future Mars landing missions. As Martian dust is a key element of its environment and a potential hazard for human exploration, it is essential to know what is Martian dust and how it works. However, little is known about the Martian dust due primarily to lack of measurements. Direct imaging would greatly increase our knowledge about the Martian dust (previously, an Atomic-Force Microscope onboard Phoenix acquired just one image).

The dust imager under development is not a microscope but a ”bare” imaging sensor of which pixels are fine pitched. After exposing the sensor to the air with dust for a while, we illuminate the sensor with a parallel beam so that shadows of particles on the sensor are directly imaged. In this way, the imager does not need a focusing mechanism and is expected to be very light-weighted and robust. Although the status is still the laboratory-experiment level, this small tool would greatly contribute to the Mars science and exploration.

Keywords: Mars, dust, imager, landing, mission

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生命探査顕微鏡：蛍光顕微鏡をもちいた火星表面での微生物探査
Life Detection Microscope: Search for Microbes on the Mars Surface with a Fluorescent Microscope

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YAMAGISHI, Akihiko[1*] ; SATOH, Takehiko[2] ; ENYA, Keigo[2] ; MIYAKAWA, Atsuo[1] ; SASAKI, Satoshi[3] ; YOSHIMURA, Yoshitaka[4] ; HONDA, Hajime[5] ; DEMURA, Hirohide[6] ; IMAI, Eiichi[5] ; USUI, Tomohiro[7] ; FUJITA, Kazuhisa[8] ; ISHIGAMI, Genya[9] ; OZAWA, Takashi[8] ; OHNO, Sohsuke[10] ; SASAKI, Sho[11] ; MIYAMOTO, Hideaki[12]

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Past trial of direct detection of life on Mars by 1970’s Viking mission reported a negative conclu-sion, whereas numbers of circumstances provided by recent Mars exploration missions in the last dec-ade indicate that there are good reasons to perform another life detection program.

Here we propose Life Detection Microscope that has much higher sensitivity than the instrument onboard Viking. Indeed Life Detection Microscope (LDM) that we propose here could detect less than 104 cells in 1 gram clay. Our life detecting instru-ment has the sensitivity that is three orders of mag-nitude higher than the one onboard Viking that issued the negative conclusion. LDM is capable of identifying what we think to be the most fundamen-tal features that a cell should possess to constitute life.

Our Investigation Goals are:

1: High-resolution characterization of regolith and dust particles.

2: Search for any type of organic compounds in Mars surface samples. The compounds include cells, other biological materials, and abiotic polycyclic aromatic hydrocarbon (PAH).

3: Identify cell-like structure in which organic compounds are enveloped by membrane, which may represent Martian life.

キーワード: 火星, 生命探査, 蛍光顕微鏡, 微生物, 有機物
Keywords: Mars, Life search, Fluorescence microscope, Microbe, Organic compounds

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火星生命探査顕微鏡を用いた生命探査のための着陸地点候補
Landing-site candidates for the Life Detection Microscope instrument

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Mars explorations of past decades indicate that ancient Mars had environment somehow similar to that of Earth. Existence of large bodies of water, chemical building blocks of life, a wide range of oxidation states, and a magnetic field indicate that Mars would have been habitable. Recent studies of microbes in extreme environments show that some terrestrial microbes have possibilities for surviving and proliferating under the current martian environment, if these are placed in some specific conditions such as with sufficient shield from UV light (attained only at more than several centimeters below the surface) and with the existence of gradients of free energy. Such environmental conditions likely exist at some specific locations even the present Mars. For this reason, we are developing a new instrument called LDM (Life Detection Microscope), which is designed to detect less than 10^4 cells in 1 gram clay, orders of magnitude higher than previous attempts performed by Viking landers. To maximize the chances of the detection of organisms, the landing sites should be carefully selected in terms of the possibility of the existence of near-surface water, as well as recent geological activities and release of volatiles. Traces of possible liquid water flow have been reported at a number of locations including those recognized as the recurring slope lineae, seasonal flows on slopes of several craters, and anastomosing slope streaks. These are proposed to be the result of small and continuous seeps of subsurface brine water, which could persist for a longer period providing a habitable environment. In this talk, we examine the morphologic characteristics of these features and discuss their origins in the line of geological contexts for selecting appropriate landing sites for the LDM instrument.

キーワード: 火星, 生命探査, 顕微鏡, 着陸地点, 水
Keywords: Mars, extraterrestrial life, life detection microscope, landing site, water