

MELOS1 火星探査検討の現状 Current status of MELOS1 Mars exploration planning

佐藤 毅彦^{1*}, 久保田 孝¹, 宮本 英昭², 今村 剛¹, 岡田 達明¹, 石原 吉明³, 山岸 明彦⁴, 藤田 和央¹, 大山 聖¹, 小松 吾郎⁵
SATO, Takehiko^{1*}, KUBOTA, Takashi¹, MIYAMOTO, Hideaki², IMAMURA, Takeshi¹, OKADA, Tatsuaki¹, ISHIHARA, Yoshiaki³, YAMAGISHI, Akihiko⁴, Kazuhisa Fujita¹, Akira Oyama¹, Goro Komatsu⁵

¹ 宇宙航空研究開発機構, ² 東京大学, ³ 国立天文台, ⁴ 東京薬科大学, ⁵ ダヌンツィオ大学

¹Japan Aerospace Exploration Agency, ²University of Tokyo, ³National Astronomical Observatory of Japan, ⁴Tokyo University of Pharmacy and Life Sciences, ⁵The G. d'Annunzio University

MELOS (an acronym of Mars Exploration with Lander-Orbiter Synergy) is Japan's new and ambitious plan for a series of Mars exploration missions. The ultimate goal of the MELOS series missions is to understand the solid planet, the surface processes, the atmosphere, and its surrounding plasma environment as one integrated system. This, of course, requires multiple missions of orbiters and landers, equipped with various instruments. The first of the MELOS series, MELOS1, is currently under planning. The mission consists of two elements: an orbiter and an entry-descent-landing (EDL) demonstrator. The scientific objective of the orbiter is the spatial and temporal variability of Martian dust, which have significant effect on the Martian climate through a variety of processes, such as heating of atmosphere by absorption of the sunlight, etc. To continuously monitor the evolution of dust storms, the orbit (near equatorial, as opposed to polar orbits in most missions) is so designed (1) that enables the orbiter nearly in synchronization with the planet's rotation when it is around the apocenter, and (2) that the apocenter's local time is always maintained near the noon. The instruments on board MELOS1 include the imaging polarimeter (visible wavelengths), the thermal-infrared camera, the sub-mm sounder, plus the ultra-stable oscillator for the radio occultation science. The EDL demonstrator will primarily perform experiments of engineering aspects, while a small portion of its payload will be available for scientific experiments. Current proposals include the interior-structure study, the astro-biological experiments, and the surface-geology study. The selection will take place in this year and the MELOS1 mission will be proposed for the launch around 2020. We welcome inputs from the world Mars science community and/or contributed instruments that require and benefit from MELOS1's unique orbit.

キーワード: 火星探査, ダスト, 気象, 火星生命, 内部構造, 表層地質

Keywords: Mars exploration, dust, meteorology, life on Mars, interior structure, surface geology

PPS03-02

会場:105

時間:5月24日 11:00-11:15

MELOS 気象オービター構想 MELOS Mars meteorological orbiter concept

今村 剛^{1*}, 小郷原 一智¹

IMAMURA, Takeshi^{1*}, OGOHARA, Kazunori¹

¹ 宇宙航空研究開発機構 宇宙科学研究所

¹Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency

火星気候システムの核心部分である大気ダストの輸送プロセスの解明を軸に、火星大気が内在する様々な変動、大気と地殻をめぐる水の循環、微量ガスの動態に迫る火星オービターを、MELOS 計画の中心ミッションとして提案する。近年の火星探査の多くが低高度の極軌道を採用してきたのと対照的に、あえて赤道周回の楕円軌道を取り、高い空間分解能かつ時間的に連続的な偏光観測、サブミリ波観測、熱赤外観測を行い、エアロゾル・微量ガス・気温場の3次元グローバル分布を得る。このことにより、これまで見ることができなかった物質循環の素過程を可視化する。

キーワード: 火星, 大気, 気象, 探査

Keywords: Mars, atmosphere, meteorology, exploration

火星大気における水同位体比の観測計画と大気大循環モデルを用いたシミュレーション Water isotopic ratio in the Mars atmosphere: observational plan and simulation using a general circulation model

黒田 剛史^{1*}, 佐川 英夫², 笠井 康子², 笠羽 康正¹

KURODA, Takeshi^{1*}, SAGAWA, Hideo², KASAI, YASUKO², KASABA, Yasumasa¹

¹ 東北大学大学院理学研究科 地球物理学専攻, ² 情報通信研究機構

¹Department of Geophysics, Tohoku University, ²National Institute of Information and Communications Technology

現在の火星地表面は非常に乾燥しているが、その一方で過去には液体の水が潤沢に存在していたことを示唆する地形が数多く観測されている。その水の一部は現在極域の氷床や地下氷(水)として存在する一方、多くの水が太陽風により宇宙空間に散逸されたと考えられている。現在火星の大気中に水蒸気や氷雲として、また氷床などの表層環境に存在する水の HDO/H₂O 比はそれらの起源を示す指標となり、火星の気候変動に伴う水循環や大気散逸を探る上で重要な情報となる。また HDO/H₂O 比の測定は地球大気においても水循環における物理プロセスの可視化に使われており、よって火星でも HDO/H₂O 比の分布を知ることによって現在の環境における水循環の様子、特に地表~大気間の水蒸気の出入りの様子が見えてくることが期待される。2020年頃の打ち上げが検討されている日本の火星探査機・MELOS 気象オービタに搭載予定のサブミリ波サウンダ FIRE (Far Infra-Red Experiment) では、世界で初めて火星周回軌道から HDO/H₂O 比の3次元分布とその時間変化を測定し、詳細なマッピングを行うことを計画している。そしてデータ同化シミュレーションを通してその観測データを理論的に解釈するツールとして、火星大気大循環モデル DRAMATIC MGCM を用いた HDO および H₂O 循環の3次元シミュレーションを行っている。本発表ではそのシミュレーションの方法と計算結果を提示し、FIRE/MELOS による観測と共同で取り組むサイエンスについて議論を行う。

キーワード: 火星, 水循環, 同位体比, サブミリ波サウンダ, 大気大循環モデル

Keywords: Mars, water cycle, isotopic ratio, sub-millimetre sounder, General circulation model

火星及び惑星の赤外線高分散分光観測の試み：東北大の現況 Trial of infrared high-spectral resolution spectroscopy for Mars and Planets: Current studies in Tohoku Univ.

笠羽 康正^{1*}, 中川 広務¹, 青木 翔平¹, 村田 功¹, 岡野 章一², 笠井 康子³, 佐川 英夫³

KASABA, Yasumasa^{1*}, NAKAGAWA, Hiromu¹, AOKI, Shohei¹, MURATA, Isao¹, OKANO, Shoichi², KASAI, YASUKO³, SAGAWA, Hideo³

¹ 東北大・理・地球物理, ² 東北大・理・惑星大気プラズマ研究センター, ³ 情報通信研究機構

¹Dep. Geophys., Tohoku Univ., ²PPARC, Tohoku Univ., ³NICT

Mid-high spectral resolution spectroscopy reveals us minor components and dynamics of planetary systems. We Tohoku University group has tried to apply this technique mainly by three methods.

The first is the space observations from orbiters (see Aoki et al., in this meeting). We have investigated the Mars Express (MEX) Planetary Fourier Spectroscopy (PFS) data for several years under the collaboration with Italian groups. In 2004, MEX/PFS team found CH₄ in the Martian atmosphere (Formisano et al., 2004). Associated with its spatial anisotropy and time variations, the loss mechanism by oxidant component becomes important. We analyzed the data and concluded that the oxidant in the atmosphere is insufficient for the support of CH₄ time and spatial variations suggested by several observations. As the next target, we just started to investigate the vertical profile of CH₄ by same instruments.

The second is the ground-based observations (see Aoki et al., in this meeting). We have investigated the SO and SO₂ abundances in the Martian atmosphere by submm observations. In all results, we could not find any signature of gas produced from the crust, which would suggest that the origin of CH₄ is not volcanic-like crust activities. In Nov 2011, Jan 2012, and Apr 2012, we also used SUBARU IRCS for the simultaneous observation of Martian CH₄ lines. This observation aims the areas where the enhancement of CH₄ was reported in past observations from ground (low-latitude region) and from MEX/PFS (polar region) in different Martian season. The preliminary result will be shown in the meeting.

The last is the instrument development (see Nakagawa et al., in this meeting). We have developed a ultra-high spectral resolution spectrometer, called MILAHI (Mid-Infrared LAsER Heterodyne Instrument), for 7-11 μ m wavelength at a resolution of up to 10^{7-8} and a bandwidth of 1GHz. In Sep 2011 and Jan 2012, the test equipment was mounted on the Higashi-Hiroshima 1.5m telescope to perform test observations with Moon, Venus, and stars. Unfortunately, the final success was prevented by bad weathers, but the observed S/N told us that we should get the Venus and Mars spectrum with this design. We just finish the development phase of this project.

Although a telescope dedicated to this instrument does not exist yet, we expect to attach it to the PLANETS telescope at the top of Mt. Haleakala, Maui island, Hawaii, which is now in development with Univ. Hawaii, Tohoku Univ., Kippenhauer Inst., National Univ. of Mexico, Univ. Turku, Harlinton Innovative Optics Co., Stan Truitt Breckenridge Astronomical Ltd, and collaborators (see Okano et al., in this meeting). Its first light is, if all things are going well, in 2014.

キーワード: Mars, infrared, spectroscopy, CH₄, velocity field, new telescope

Keywords: Mars, infrared, spectroscopy, CH₄, velocity field, new telescope

火星主成分凝結対流の二次元数値実験 –CO₂ 凍結表面上の場合– Two-dimensional simulation of Martian atmospheric convection with the major component condensation over CO₂ ice surface

山下 達也^{1*}, 小高 正嗣¹, 杉山 耕一朗², 中島 健介³, 石渡 正樹², 高橋 芳幸⁴, 西澤 誠也⁴, 林 祥介⁴
YAMASHITA, Tatsuya^{1*}, ODAKA, Masatsugu¹, SUGIYAMA, Ko-ichiro², NAKAJIMA, Kensuke³, ISHIWATARI, Masaki²,
TAKAHASHI, Yoshiyuki O.⁴, NISHIZAWA, Seiya⁴, HAYASHI, Yoshi-Yuki⁴

¹ 北海道大学, ² 北海道大学 / CPS, ³ 九州大学, ⁴ 神戸大学 / CPS
¹Hokkaido Univ., ²Hokkaido Univ. / CPS, ³Kyushu Univ., ⁴Kobe Univ. / CPS

我々は火星における主成分凝結を伴う対流の性質を調べることを目的とし、2次元雲解像モデルの開発と、それを用いた長期間の計算を行ってきた(例えば山下他, 2011年連合大会)。この様な系の低温側の一つの極限は、大気主成分の凍結物により地表が覆われた状態であるが、火星極夜はこの状態とある程度近似しており、その理解は主成分凝結大気の振る舞いの解明に寄与する。

火星の極冠上空では大気主成分であるCO₂が凝結し、氷雲を形成することが知られている(Pettengill and Ford, 2000)。氷雲の中には対流で形成されたものも存在することが示唆されている(Colaprete et al., 2003)。しかし主成分が凝結する系では、雲層の上昇域、下降域の温度分布は飽和蒸気圧曲線に拘束され等しくなり、気塊は浮力を得られず、対流性の雲は生じないことになる。それでも、臨界飽和比が1.0より大きければ、対流が生じる可能性があることが示唆されている(Colaprete et al., 2003)。さらに、ここで新たに指摘すべきこととして、凝結物が重力沈降により気相から非保存的に分離し、周囲の気相を引きずることも、対流運動を駆動する可能性がある。そこで本研究では、火星極冠環境的な境界条件、熱強制の与え方で、雲微物理の定式化を変更して行なった主成分凝結対流の予備的な数値実験について報告する。

モデルの基礎方程式として準圧縮方程式(Klemp and Wilhelmson, 1978)にCO₂固相の保存式を組み合わせたものを用い、雲粒の重力落下、引きずりの効果を考慮する。臨界飽和比は1.0、地表面気圧は7 hPaとする。放射過程は陽に解かず、放射を模した熱強制を与える。極夜では太陽放射が存在しないので、加熱は与えず、高度1 kmから15 kmに冷却率-5.0 K/dayの水平一様冷却を与える。初期温度は高度15 kmより下で飽和比が0.98となるように(Colaprete et al., 2003)、それより上で135 Kとする。極冠の表面温度はCO₂の昇華温度に拘束されると考えられるので、下部境界の温度は初期値(約150 K)に固定する。初期擾乱として、下部境界に振幅1 Kのランダムな温位偏差を与えて対流を励起する。計算領域は水平50 km、鉛直20 km、格子間隔は200 mである。積分時間は30日である。

計算開始30日目には統計的平衡状態に達している。統計的平衡状態においては、冷却層において雲層が形成され、そこでは地表面付近を除き鉛直流の大きい対流は生じない。大気最下層から高度15 km付近まで雲層が形成され、雲密度は高度2 km付近で極大となる。1.0 m/s以上の大きさを持つ鉛直流は高度2 km以下にのみ見られ、その大きさは最大で約3.0 m/sである。高度2 km以下に見られる対流は、雲粒による引きずりの効果によって駆動されている。現実の火星での臨界飽和比は約1.35となることが実験的に知られており(Glandorf et al., 2002)、発表では臨界飽和比が1.35の場合についても報告する予定である。

キーワード: 大気主成分の凝結, CO₂ 氷雲, 雲対流モデル

Keywords: condensation of major atmospheric component, carbon dioxide ice cloud, cloud resolving model

Glaciation of Mars from 10 million years ago until 10 million years into the future simulated with the model MAIC-2 Glaciation of Mars from 10 million years ago until 10 million years into the future simulated with the model MAIC-2

Ralf Greve^{1*}, Bjoern Grieger², Oliver J. Stenzel³
GREVE, Ralf^{1*}, Bjoern Grieger², Oliver J. Stenzel³

¹Hokkaido University, ²European Space Astronomy Centre (ESAC), ³Max Planck Inst. for Solar System Res.

¹Hokkaido University, ²European Space Astronomy Centre (ESAC), ³Max Planck Inst. for Solar System Res.

The Mars Atmosphere-Ice Coupler MAIC-2 is a simple, latitudinal model that consists of a set of parameterizations for the surface temperature, the atmospheric water transport and the surface mass balance (deposition minus sublimation) of water ice. It is driven directly by the orbital parameters obliquity, eccentricity and solar longitude (Ls) of perihelion. Surface temperature is described by the Local Insolation Temperature (LIT) scheme, which uses a daily and latitude-dependent radiation balance. The sublimation rate of water is calculated by an expression for free convection, driven by density differences between water vapor and ambient air, the deposition rate follows from the assumption that any water vapour which exceeds the local saturation pressure condenses instantly, and atmospheric transport of water vapour is approximated by instantaneous mixing. Glacial flow of ice deposits is neglected. Simulations from 10 million years (Ma) ago until 10 Ma into the future (with an additional spin-up from 20 to 10 Ma ago) predict a variable glaciation with two distinct stages. Stage 1, the period of high average obliquity prior to 4 Ma ago, is characterized by ice thicknesses less than 400 m and a very mobile glaciation all over the planet. During stage 2, from 4 Ma ago until today, the north and south polar ice deposits grow essentially monotonically; however, interrupted by significant sublimation events at ~3.2, 1.9 and 0.7 Ma ago (when maximum amplitudes of the main 125-ka obliquity cycle occur). The growth of the polar deposits is predicted to continue into the future.

キーワード: Mars, Planetary ice, Ice cap, Polar layered deposits, Modelling

Keywords: Mars, Planetary ice, Ice cap, Polar layered deposits, Modelling

火星北極冠にみられるスパイラルトラフの形成機構解明のためのアナログ実験：氷上に形成されるサイクリックステップ Analog experiments of formation of the spiral troughs on Mars' North Polar Layered Deposits: cyclic steps on ice

横川 美和^{1*}, 泉 典洋², 清水裕貴¹, 内藤 健介², 山田 朋人², Greve Ralf³

YOKOKAWA, Miwa^{1*}, IZUMI, Norihiro², SHIMIZU Hiroki¹, NAITO, Kensuke², Tomohito Yamada², GREVE, Ralf³

¹ 大阪工業大学, ² 北海道大学大学院工学研究院, ³ 北海道大学低温科学研究所

¹Osaka Institute of Technology, ²Faculty of Engineering, Hokkaido University, ³Institute of Low Temperature Science, Hokkaido University

The spiral troughs observed on the Mars' North Polar Layered Deposits (NPLD) show intriguing features that contain a detailed stratigraphic record of surface processes in Mars' recent polar history. SHARAD radar data showed that the troughs have migrated as much as 65 km towards the north during the accumulation of the uppermost ~ 600 m of NPLD (Smith and Holt, 2010). Though they are suspected to have some relation with katabatic wind blowing on the ice cap, it has not been known how the spiral troughs are formed in detail. Considering that the troughs are formed perpendicular to the direction of katabatic wind, they are assumed to be boundary waves rather than streak-like configurations such as rills and gullies. From features that the step length is much larger than the step height, and that internal structures show traces of upstream migration (Smith and Holt, 2010), the spiral troughs may possibly be cyclic steps formed by a density current created by cooling of the atmosphere due to ice. Cyclic steps are spatially periodic bedforms where each wavelength is delineated by an upstream and downstream hydraulic jump. They migrate upstream keeping the same wavelength. Recently cyclic steps have been reported from various environments on the Earth, such as fluvial and deep-sea settings, and in various bed materials, such as bedrock, non-cohesive sediments, and cohesive sediments (e.g., Kostic et al., 2010). Smith et al (2011) have demonstrated that numerical simulation with a cyclic step model can show reasonable consistency with an observed migration rate. In this study, we have performed a series of physical experiments analogous to the formation of cyclic steps on ice by density currents.

The experiments were conducted using the cold laboratory of the Institute of Low Temperature Science, Hokkaido University. In the case of Mars, sublimation by katabatic winds results in erosion in some places and in the other places, water included in the atmosphere blowing on ice is sublimated to become ice and deposited on the bed covered with ice. In order to model this process, we used two kinds of liquid that include water but do not freeze even below the ice point. The liquids we used were (a) ethylene glycol-water solution (17 %-83 %) whose freezing point is -6.6 degrees C, (b) mixture of silicon oil (20cS) and water (9:1) whose freezing point is -0.7 degrees C. We used a 1.4 m long, 2 cm wide, and 25 cm deep flume made by plexiglass. The flume has 8 cm high weirs at the downstream end and 1.2 m upstream from the downstream end, so that there is an 8 cm deep reservoir. We put water in the reservoir and froze it so that the flume has an 8 cm ice layer on its bottom. The flume with ice bed is tilted by 5 up to 35 degrees. The liquid is supplied from a head tank to the upstream end of the flume, flows on ice in the flume, and was dropped from the downstream end into a downstream reservoir, then pumped up to the head tank. In point of temperature, everything in the room is chilled by the air of the room. The temperatures of the liquids were (a) -6.1 to -6.6 degrees C, and (b) -1.0 to 1.5 degrees C.

As a result, cyclic steps were formed under erosional conditions in series (a) and both erosional and depositional conditions in series (b). The step length is observed to be different in each case. At this moment, steps develop almost vertically, both downward and upward, and show no prominent lateral, neither up-current nor down-current, movements.

In these experiments, we demonstrated that cyclic steps can be formed on rigid ice by the fluid flowing on the ice surface. Further experiments will be needed to examine the conditions for up-current movement of cyclic steps on ice, which should lead us to understand the migration of the spiral troughs on NPLD.

キーワード: 火星北極冠, スパイラルトラフ, サイクリックステップ, 氷, 水路実験

Keywords: North Polar Layered Deposits on Mars, spiral troughs, cyclic steps, ice, flume experiments

MELOS Lander による電磁場観測 Electro-magnetic measurements by MELOS lander

高橋 幸弘^{1*}, 清水 久芳², 石坂 圭吾³

TAKAHASHI, Yukihiro^{1*}, SHIMIZU, Hisayoshi², ISHISAKA, Keigo³

¹ 北海道大学 宇宙理学専攻, ² 東京大学 地震研究所, ³ 富山県立大学 大学院工学研究科

¹Dept. CosmoSciences, Hokkaido University, ²University of Tokyo, ³Toyama Prefectural University

No measurement of atmospheric electric field and electromagnetic waves on the ground in Mars has been made, though it could be dedicated not only to understanding of the electric current research but also to the meteorology, solid planet and space physics. DC electric field near surface is considered to play an important role in initiating dust devil. The electromagnetic wave measurement makes it possible to know the location and the quantitative strength of dust devils wind with few observation sites. Though only one observation site enables us to determine the discharging location, two or three sites improve the accuracy significantly. This measurement also contributes to the studies both on the crust and the upper atmosphere. Though Exo Mars will carry out a simple observation of electric field, most of the targets will remain unexplored. We propose a simple and promising instrumentation set for the DC and AC electromagnetic observation making use of MELOS lander. Here we also discuss the coordinated observation with atmospheric orbiter.

キーワード: 火星, ランダー, MELOS, 電磁場

Keywords: Mars, Lander, MELOS, electro-magnetic, measurement

現在の火星表層におけるダストおよび水の分布と挙動 Current distributions and behaviors of dust and water on the surface of Mars

宮本 英昭^{1*}, 小郷原 一智², 今村 剛²

MIYAMOTO, Hideaki^{1*}, OGOHARA, Kazunori², IMAMURA, Takeshi²

¹ 東京大学総合研究博物館, ² 宇宙航空研究開発機構 宇宙科学研究本部

¹University Museum, University of Tokyo, ²ISAS, JAXA

Dust and water are fundamentally important for the current status of both martian atmosphere and surface deformations. While the amount of airborne dust largely varies with seasons and the presence of dust storm, dust exists on the surface of Mars permanently through geological timescale. Theoretical studies find out that airborne dust significantly contributes to the thermodynamics of the atmosphere, which indicates that dust should play important role even in the past climatic conditions. On the other hand, the presence of dust on the surface significantly controls the condition of the martian surface in terms of such as thermal inertia, albedo, and transmittance. These are controlling factors for the formations of currently-active geological features, including as aeolian features and ice deposits, which distribute all over the surface of Mars at least as remnants. Water is a minor component for the martian atmosphere, but plays important roles for the evolutions of the regolith layer and deposits in the polar regions. The formations of water/ice-related features are resulted from the strong link between surface/subsurface reservoirs of water and atmosphere, and thus, water can be considered as an important indicator of the atmospheric transportation-mechanisms and seasonal climatic changes.

The orbiter of the MELOS mission will study martian meteorology by measuring atmospheric transportations of water and dust. The lander of the MELOS mission, which is now considered as an EDL experimental unit as a precursor of the MELOS-2 mission, may perform meteorological observation. In this talk, we will review geological aspects of dust- and water-related features to discuss the possible contribution of lander measurements for the states of airborne dust and water at the martian surface level to understand the martian meteorology and climate history.

キーワード: 火星, ミーロス, ダスト, 水, 地質, 大気

Keywords: Mars, MELOS, dust, water, geology, atmosphere

Current and future exploration of the Moon and Mars: variations of rotation, shapes, displacements of center of mass

Current and future exploration of the Moon and Mars: variations of rotation, shapes, displacements of center of mass

Yury Barkin^{1*}, Hideo Hanada², Sho Sasaki², Sander Goossens², Koji Matsumoto²

BARKIN, Yury^{1*}, HANADA, Hideo², SASAKI, Sho², SANDER GOOSSENS², MATSUMOTO, Koji²

¹Sternberg Astronomical Institute, Moscow, ²National Astronomical Observatory, Mizusawa

¹Sternberg Astronomical Institute, Moscow, ²National Astronomical Observatory, Mizusawa

Actual problems of modern selenodynamics and selenodesy, Mars rotation and inner dynamics are discussed in view of achievements by geodynamics and geodesy of last years and the possibility of re-opening prospects in modern researches of the Moon and Mars with the help of space vehicles.

Altimetry and the variation of the lunar figure and center pieces. The accuracy of satellite measurements of the Moon is now so high (Goossens S., Matsumoto K. et al., 2010; Smith et al., 2010) that it is possible to set long-term objectives for the study of temporal variations of the shape of the Moon, changing its mean radius and its mean radiuses of the northern and southern hemispheres, the eastern and western hemispheres, the displacements and oscillations of its centers of mass, the secular variations of the coefficients selenopotential etc. Altimetry method most widely used to study variations in the Earth's ocean surface, as well as some stationary geometric features of shapes and figures of celestial bodies (Mercury, Mars, Titan etc.). However, the application of this method can be significantly expanded to study the deformation of temporal variations of the solid surfaces of planets and satellites (Moon, Mars, Europa and oth.).

Tidal variations of the gravitational field of the Moon and their testing according to the lunar space missions. Due to outstanding achievements of space missions to the Moon (KAGUYA, Lunar Express etc.), there are quite real the direct determinations of cyclic (and also secular) variations of selenopotential coefficients (for low harmonics), more detailed description of tidal and non-tidal deformations of a surface, in particular researches of global planetary effects in change of opposite hemispheres of the Moon and in displacement of its centre of mass.

Eccentric positions of the shells of the Moon (and Mars) and geodynamic implications. The Moon and Mars is characterized by very significant displacements in the positions of center of the figure and the center of mass is 1.9 km from the Moon (Goossens S., Matsumoto K. et al., 2010) and the phenomenal displacement of these centers is 3.3 km for Mars (Zuber et al., 1998). These observed phenomena reflect the dynamics of shells and changes in the shells of these celestial bodies in their geoevolution. There is evidence in favor of the fact that these evolutionary changes for the Moon and Mars have place in the modern epoch. New statement of a problem about librations of the Moon with the displaced (eccentric) liquid core deserves steadfast attention and is actual. Dynamic effects caused by a eccentricity of the core can be remarkable and basically can be observed at precision laser observations with millimeter accuracy.

Mars rotation. Determination of the acceleration of axial rotation of Mars and the secular drift of the pole of its axis of rotation are the actual problems of current and future space missions to Mars. We have obtained preliminary theoretical estimates of these secular effects in the rotation of Mars, based on the assumption about existence of secular relative displacements of the core and mantle of Mars in the modern epoch and secular and directed mass redistribution of this planet (Barkin, 2009). There are some confirmations of mentioned hypothesis - secular changes in the activity of natural Martian processes, including climatic changes on Mars. Because on the Mars we observe planetary processes of a general warming, redistribution of fluids from the southern hemisphere to the northern hemisphere and secular changes in other processes, that is phenomena in nature similar to processes occurring on the Earth.

The work was supported by the Russian ? Japanese and Russian - Chinese grant RFBR N 11-02-91160 and RFBR N 11-02-92113 and Russian grant RFBR N 11-05-01134.

キーワード: Mars, Moon, rotation, shape, center of mass

Keywords: Mars, Moon, rotation, shape, center of mass

Effects of water on Martian mantle evolution induced by magmatism and solid-state convection

Effects of water on Martian mantle evolution induced by magmatism and solid-state convection

柳澤 孝寿^{1*}, 小河 正基²

YANAGISAWA, Takatoshi^{1*}, OGAWA, Masaki²

¹ 海洋研究開発機構 地球内部ダイナミクス領域, ² 東京大学大学院 総合文化研究科

¹IFREE, JAMSTEC, ²Graduate School of Arts & Sciences, Univ. Tokyo

To consider the thermo-chemical evolution of Martian mantle, we present numerical models of mantle evolution including magmatism in two-dimensional box geometry. By including magmatism, our models can reproduce compositionally layered mantle structure and surface crust spontaneously, and can treat the whole evolution process consistently. The viscosity is strongly temperature-dependent, and the lithosphere is stagnant. The effect of water is included in two aspects depending on its content; decreasing the melting temperature of mantle materials, and decreasing the viscosity of the solid mantle. At the first stage of evolution, a magma ocean develops and generates a basaltic crust, a layer of compositionally buoyant residue of the crust in the uppermost mantle, and a deep-mantle compositionally denser layer, which has a higher content of the basaltic component. The magma ocean extracts most of the water initially contained in the upper layer, but some water remains in the lower layer of the mantle. Subsequently, hot plumes ascend from the lower layer to induce magmatism. The water allows plume magmatism to continue for a long duration, up to 5 Gyr depending on the initial water content and the detail of the initial temperature distribution in the mantle, provided that the mantle is initially not too hot just after planetary formation. The plume magmatism is sufficiently active to cause significant crustal growth and dehydration of the crust and mantle in the early evolutionary stage when the internal heating is strong; the amount of extracted water is equivalent to a water layer of up to several hundred meters in depth. Water can also enhance the extraction of heat producing elements from the mantle, which makes the lithosphere thicker. Both crustal growth and dehydration eventually subside as the heat producing elements decay. By comparing these results with recent studies on crustal evolution, we gain a deeper understanding of the tectonic history of Mars.

Keywords: Martian mantle, structural evolution, magmatism, water

MELOS 生命探査提案：火星表面でのメタン酸化菌探査 MELOS LIFE SEARCH PROPOSAL: SEARCH FOR MICROBES ON THE MARS SURFACE WITH SPECIAL INTEREST IN METHANE-OXIDIZING BACTERIA

山岸 明彦^{1*}, 吉村 義隆², 本多 元³, 宮川 厚夫⁴, 長沼 毅⁵, 大野 宗祐⁶, 石丸 亮⁶, 佐々木 晶⁷, 久保田 孝⁸, 佐藤 毅彦⁸, 宮本 英昭⁹

YAMAGISHI, Akihiko^{1*}, YOSHIMURA, Yoshitaka², HONDA, Hajime³, MIYAKAWA, Atsuo⁴, NAGANUMA, Takeshi⁵, OHNO, Sohsuke⁶, ISHIMARU, Ryo⁶, SASAKI, Sho⁷, KUBOTA, Takashi⁸, SATOH, Takehiko⁸, MIYAMOTO, Hideaki⁹

¹ 東京薬科大学生命科学部, ² 玉川大学農学部生命化学科, ³ 長岡技術科学大学 生物系, ⁴ 静岡大学工学部機械工学科, ⁵ 広島大学大学院生物圏科学研究科, ⁶ 千葉工業大学惑星探査研究センター, ⁷ 国立天文台, ⁸ 宇宙航空研究開発機構, ⁹ 東京大学総合研究博物館

¹Depart. Mol. Biol., Tokyo Univ. Pharm. Life Scie., ²Tamagawa University, ³Department of Bioengineering, Nagaoka Univ. Tech., ⁴Shizuoka University, Faculty of Engineering,, ⁵Hiroshima University, ⁶Planetary Exploration Research Center, Chiba Institute of Technology, ⁷National Astronomical Observatory of Japan, ⁸ISAS/JAXA, ⁹The University Museum, The University of Tokyo

近年の探査により、火星表層には、かつて大量の液体の水が存在していたこと、温暖湿潤な気候がある程度長期間保たれていたこと、そして火星は強い磁場を保持していたことが明らかにされた。これらを端的にまとめると、生命が生まれた頃の地球と極めて類似した環境を火星が持ち合わせていたという事に他ならない。こうした理由から、我々地球生命がどこから来て、どのような位置づけを持つかという究極的な問いに答えるために、火星は最も重要な研究対象であるといえる。

火星におけるメタンの発見と、地球におけるメタン酸化鉄還元細菌の発見 (Bealら 2009) から、我々は火星表面において現在もまだメタン酸化鉄還元細菌 (化学合成微生物の一種) が生存しているのではないかと推定するに至った。この菌はメタンを生成するメタン菌とは全く別の菌であり、表層付近で生育する可能性がある。火星の様々な環境は生命が十分に生存可能な環境である。また、紫外線は様々な物質によって吸収されるので、薄い火星土壌に覆われるだけで、火星表面も十分に生育可能な環境となる。従って、メタンと酸化鉄のような酸化型物質の両者がある場所であれば、数センチメートル程度の深さでも微生物は生存している可能性がある。こうした状況から、我々は火星地下深部を掘削する必要が無いという点を世界で初めて指摘するとともに、火星において生命を直接探査することを、現在の技術レベルでも十分に実現可能な手法を用いて、世界に先駆けて提案することとした。なお計画の特性から、火星表面における有機物や地質探査も同時に行うことができると考えている。

キーワード: MELOS, 火星, 生命探査, 蛍光顕微鏡, メタン酸化菌

Keywords: MELOS, Mars, Life search, Fluorescence microscope, Methane oxidizer

地球生命進化を決めた最重要要素：初期海洋質量が3-5kmの厚さ Most essential factor of the habitable Earth: initial ocean volume 3-5km thick

丸山 茂徳^{1*}

MARUYAMA, Shigenori^{1*}

¹ 東京工業大学

¹Tokyo Institute of Technology

Considering the size of ecosystem on the Earth, one at deep-sea hydrothermal system and another on the surface, and history of life in relation to the emergence of the second system after 800-600Ma, it is concluded that the fate of life system on the Earth was determined to be initial ocean mass that was extremely tight constraint as 3-5 km thick. The planet Earth has lost water into mantle 4.0 b.y after the birth, because of cooling. Appearance of huge landmass above sea-level caused the global dispersion of nutrients by rivers and winds, driven by Sun which drives the material circulation of the system. If the value is 1km more than this limit, the metazoans have not yet appeared on the Earth. If the initial mass was smaller than 2.5km, plate tectonics did not operate to increase nutrients-enriched TTG crust on the Earth. No evolution of life is expected, even if it was born.