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

PPS02-01 Room:418 Time:April 28 09:00-09:25

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).

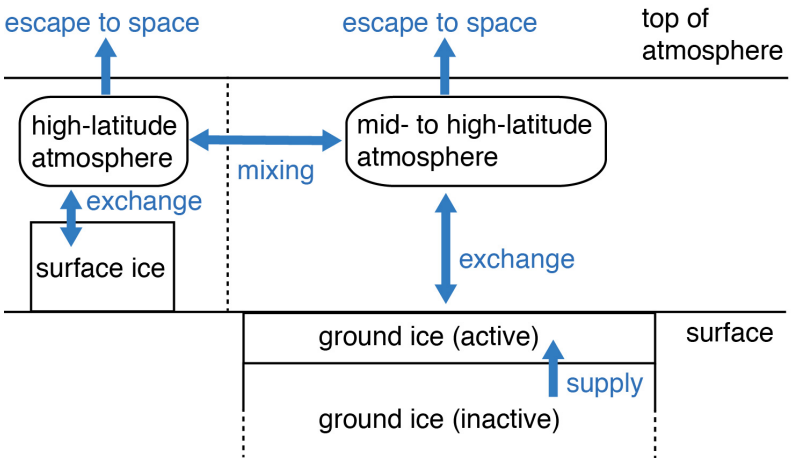
The thickness of the ground ice is related to the evolution history of the Martian water reservoirs. After ancient oceans became extinct (˜4Ga), the oceanic water would become ”surface ice”, which currently occur as PLDs, and ”ground ice” which would extend from high latitude to mid- or low-latitude. 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.

Keywords: ground ice, hydrogen isotope ratio, atmospheric escape



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

PPS02-02 Room:418 Time:April 28 09:25-09:50

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.

Keywords: Plate tectonics, accretional complex, OPS

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PPS02-03 Room:418 Time:April 28 09:50-10:15

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 Room:418 Time:April 28 10:15-10:30

Examination of Mission Scenario and Spacecraft System to Study Martian Atmospheric Escape

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The atmospheric escape from Mars is considered to be closely associated with the evolution of the Martian atmosphere as well as the existence of the water on Mars. We are now investigating a project to study the global feature and the physical process of the atmospheric escape from Mars. It is expected to consist of at least two orbiters; one of the orbiters is aimed to make in-situ observation of plasma and thin atmosphere at about 100 km altitude, and the other is for the atmospheric imaging and solar-wind monitor. We are planning to make simultaneous observation of the atmospheric escape by the interaction with the solar wind by both of in-situ measurement orbiter and remote-sensing one. Now we are examining the quantitative measurement targets to fully understand the Martian atmospheric escape. At the same time, the sorts and performance of scientific instruments on these orbiters are examined. And furthermore, the preliminary spacecraft design, orbit design and mission plan to achieve the scientific goal are investigated.

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PPS02-05 Room:418 Time:April 28 10:30-10:45

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

Japan Geoscience Union Meeting 2014
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PPS02-06 Room:418 Time:April 28 11:00-11:25

Life Detection Microscope: Search for Microbes on the Mars Surface with a Fluorescent Microscope

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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.

Keywords: Mars, Life search, Fluorescence microscope, Microbe, Organic compounds

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PPS02-07 Room:418 Time:April 28 11:25-11:40

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.

Keywords: Mars, extraterrestrial life, life detection microscope, landing site, water

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PPS02-P01 Room:Poster Time:April 28 18:15-19:30

Interannual analyses of the meridional distributions of Martian dust and clouds obtained by MRO-MCS

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[1]Nara Women's University

We investigated the interannual variability of the meridional distributions of dust and clouds in the Martian atmosphere by using Mars Reconnaissance Orbiter Mars Climate Sounder (MRO-MCS) measurements. As the previous analyses did not consider measurement errors to depict the zonal averages, we took a criterion of 10% for the measurement error. Results show that Mars Year (MY) 29, which is regarded as a standard year in the previous analyses, had an enhancement of dust in the high altitudes (above 10 Pa) in the tropical region, and such an enhancement was not found in other MYs (28, 30 and 31). On the other hand, the distribution of ice clouds in MY 29 roughly agreed with other MYs' distribution.

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PPS02-P02 Room:Poster Time:April 28 18:15-19:30

Implementing Martian dust lifting scheme into DCPAM, and a diagnosis experiment of surface dust flux

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The Martian dust cycle influences thermal states of its atmosphere, hence it plays an important role for determining states of the Martian atmosphere(Gierasch and Goody, 1968). Dust processes to be considered are dust lifting, turbulent mixing, advection, and gravitational sedimentation. Parameterizations of lifting by model resolved wind stress and by model unresolved vortices such as dust devils are considered. The Martian dust cycle has been simulated with general circulation models implemented above dust process schemes by some research groups. For example, Kahre et al.(2006) roughly simulated a seasonal variation of dust loading. The seasonal variation of dust loading has a peak in during northern autumn and winter. In contrast, DCPAM (Takahashi et al., 2012), which is a general circulation model developed by our group, has not been implemented above dust process schemes. Aims of this study are to implement dust process schemes into DCPAM, and to perform numerical experiments on the dust cycle with it. In the future, we will consider about interannual variability of the Martian dust distribution, which still has not been reproduced. In this work, we implement dust lifting scheme by model resolved wind stress into DCPAM. Addtionally, we perform an experiment with dust lifting to investigate behavior of this dust lifting scheme. And, we compare our model's results with thoses of Kahre et al.(2006).

The model utilized is DCPAM which is developed by GFD Dennou Club. DCPAM adopted three dimensions primitive equations. A radiative scheme by Takahashi et al.(2003, 2006) is used. This include the radiative effects of gaseous CO_2 and suspended dust. And, used suspended dust distribution is spatially and temporally fixed. A turbulent process is estimated by used vertical diffusivity based on Mellor and Yamada(1974). A surface process is estimated based on Louis et al.(1982). Each parameter are selected as Martian values. We use a surface distribution of thermal inertia, albedo and topography observed by Mars Grobal Surveyor. A horizontal discretization is the spectral method, and the trauncation wavenumber is 21. A vertical discretization is the finite difference method, and the number of layor is 32. We integrate 3 Mars year, and use the last 1 Mars year for analysis.

First, we implement a dust lifting scheme called by KMH scheme(Kahre et al., 2006) into DCPAM. Then, we perform a diagnosis experiment of surface dust flux with this. This result is similar to result by Kahre et al.(2006) as follows. In regions around latitude 50N degree and 30S degree, strongly dust lifting occurs during northern autumn and winter. At latitude 50N degree, it appears that eastward waves, which have zonal wavenumber 1 and period 6 Mars days, contribute to dust lifting. it is to be considered the baroclinic wave(Briggs et al., 1979). At latitude 30S degree, it appears that westward waves, which have zonal wavenumber 1 and period 1 Mars days, contribute to dust lifting. It is to be considered the diurnal thermal tidal wave(Joshi et al., 1979), and dust lifting tends to occur at 16 o'clock local time. These results qualitatively are consistent with these of Kahre et al. (2006), but are not quantitatively consistent with these of Kahre et al.(2006). For example, our model's surface dust flux is greater by a degree of magnitude then these of Kahre et al.(2006) in the northen polar cap. The reason is probably that the number of vertical levels and the method for estimating turbulent mixing are diffrent from those of Kahre et al.(2006). In this work, we implemented dust lifting scheme by model resolved wind into DCPAM. We are now implementing dust lifting scheme by dust devils into DCPAM. Then, we are going to implement advective scheme and gravitational sedimentation scheme into DCPAM in turn, and perform numerical experiments for their implementation test.

Keywords: Dust, Mars, General Circulation Model

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PPS02-P03 Room:Poster Time:April 28 18:15-19:30

Assessment of Mars surface environment for MELOS1 lander using Planetary General circulation model DCPAM

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1. Introduction

The Mars exploration program MELOS1, which is to mainly challenge life and surface environment exploration, is now planning by space engineering and planetary science community in Japan. To support designing the landing module and observation instruments and ensure safety experiments during entry, decent and landing phase, plausible range of meteorological conditions at MELOS1 landing site is required.

We try to assess the Mars surface environment from planetary to atmospheric boundary layer scale by using simulation results obtained by General Circulation Model (GCM), Regional Meteorological model, and Large Eddy Simulation (LES) model (LES). For mesoscale assessment, CReSS which is developed by HyArc Nagoya University will be used. For boundary layer scale, SCALE-LES which is developed by RIKEN AICS will be used as LES model. Both numerical model are now tuned to Mars and preliminary experiments are performed (Sugiyama et al. 2013; Nishizawa et al. 2013). For planetary scale assessment, we use a planetary atmospheric general circulation model DCPAM which is developed by GFD Dennou Club (Takahashi et al. 2012). In this study, we compare simulation results of DCPAM to observation results of Viking and Mars Path Finder (MPF) and investigate proper method for assessment of Mars surface environment by using DCPAM data. By using this method, we show some assessment results at proposed landing sites of MELOS1.

2. Data

DCPAM is a spectral GCM including physical processes appropriate for Martian atmosphere. The topography, surface albedo and thermal inertia in the model is based on observation results obtained by Mars Global Surveyor (MGS). The horizontal truncation wave number is 31, which corresponding horizontal resolution is about 200 km. The number of vertical layer is 16 and the height of lowest level is about 3 m. The seasonal variation of atmospheric dust distribution is given which is based on typical case of MGS observation. Numerical integration is performed for 7 Mars years with isothermal no motion initial condition. The data of last two years are used for analysis. The proposed landing sites are Newton Crater, Nili Fossae, and Isidis Planitia. The period of analysis is 90 sols from Ls = 331, 324, 14, and 135 which are corresponding to four mission window. In each period, diurnal variations every 15 sols are investigated.

3. Methods of analysis and results

In comparing the DCPAM results to observation results of Viking and MPF, the atmospheric temperature and wind velocity at observed altitude are estimated assuming the boundary layer similarity theory in neutral case is valid near the model surface. The surface pressure at actual altitude is estimated assuming hydrostatic balance with constant scale height which is calculated by the using model temperature. The comparison between estimated values from DCPAM results and observations show that the observed diurnal variation of atmospheric temperature is well reproduced by using 2nd level (about 12.5 m height) temperature of DCPAM, and seasonal variation of surface pressure is almost represented by using the scale hight corresponding to 10th level (about 1.35 km height) model temperature and subtracting offset value (60 Pa).

Based on above results, analysis of the DCPAM data at the three proposed landing site during four mission periods are performed. At Newton Crater, which is the first proposed site, during 90 sols from Ls = 331, the diurnal mean atmospheric temperature ranges from 190 to 220 K. The amplitude of diurnal change of atmospheric temperature is about 50 - 70 K. The air temperature is almost constant during this period and its value is about 140 K. The maximum values of direct and diffuse solar radiative flux are 480 Wm^{-2} and 40 Wm^{-2}, respectively. We will also estimate the extent of variation of meteorological variables, such as temperature and pressure, at the proposed landing sites by analyzing DCPAM data with different dust distribution.

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Keywords: Exploration of Mars, General Circulation Model, Surface environment of Mars

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PPS02-P04 Room:Poster Time:April 28 18:15-19:30

Estimation of Martian atmospheric composition change caused by CO2 condensation and its application to radio occultation

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We estimated the Martian atmospheric composition change caused by CO_2 condensation using the Ar measurements obtained by Gamma Ray Spectrometer (GRS) onboard the 2001 Mars Odyssey. We applied this estimation of the composition change to the rederivation of the radio occultation (RO) measurements of Mars Global Surveyor (MGS) obtained at polar latitudes of the winter hemisphere, because the MGS RO standard product which is available to the public did not consider the atmospheric composition change by CO_2 condensation. Using the rederived MGS RO measurements, we investigated the occurrence of CO_2 supersaturation in the Martian polar winter atmosphere and found that there were more supersaturation in the rederived data than in the original data.

Keywords: Mars, CO2, supersaturation, condensation, radio occultation

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PPS02-P05 Room:Poster Time:April 28 18:15-19:30

Equation of state of $(Fe,Ni)_3S$ phase - Implications for Mars internal structure

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The existence of lower mantle ($MgSiO_3$-perovskite layer) has an important role on Mars thermal evolution. The layer thickness of Mars lower mantle depends on the depth of the core-mantle boundary (CMB). The depth of CMB is related to the Mars core density. Although the structure model of Mars core was discussed based on the equation of state of pure iron and FeS (e.g., Urakawa et al., 2004), Fe_3S phase and also the effect of nickel on the density should be considered.

We newly established the equation of state (EoS) of $(Fe_{0.89},Ni_{0.11})_3S$ up to about 40 GPa by high pressure experiment using diamond anvil cell. Considering EoSs of γ-Fe (Tsujino et al., 2013), γ-FeNi (Tsujino, 2012), Fe_3S (Seagle et al., 2006), and $(Fe_{0.89},Ni_{0.11})_3S$, the effects of nickel and sulfur on the density was determined. Then, we determined the Mars core density corresponding to the composition model based on SNC meteorites. Our new model shows relatively thin lower mantle compare to previous one. Moreover, if Mars core contains 16 wt.%S and 7 wt.%Ni (Sanloup et al., 1999) and if Mars has an entirely liquid core (Fei and Bertka, 2005), there is a possibility of disappearance of Mars lower mantle.

Keywords: Mars core, equation of state, Mars lower mantle