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

PPS04-01 Room:105 Time:May 21 14:15-14:30

Evaluations of wind electric energy at Martian Planetia and Mons

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In planetary exploration such as a lander and a rover operating on the surface ability of electric power supply puts decisive limit on the operation. In the situation of Mars solar energy generation has been considered as a unique way to generate electricity. But sometimes martian strong surface winds cause some troubles for solar panels. MER-A(rover spirits) stopped on sol 2210 (March 22, 2010), because of its low electric power. With the increase amount of sand, the solar energy production decreases. In this presentation we report possibility of electricity generation by wind on Mars. Several lines of observation data indicate that Mars is a windy planet. Kaydash et al.,2006 estimated wind velocity up to 80[m/s] by cloud tracking. This wind velocity corresponds to the altitude above 30[km], while the surface wind was measured by the lander of Viking (Murphy et al., 1990) and Phoenix. On the surface of Mars, many eolian features are also discovered. They indicate that Mars is a windy planet (Fenton et al., 2005; Hayward et al., 2009). Fenton et al consider the surface winds over 20[m/s] as indicative of potential sand transports on the floor of Proctor Crater. On the surface of sloped ground much higher wind velocity is estimated (Toyota et al., 2011). We estimated wind electric energy at 3 different locations. Elysium Planetia, Chryse Planetia and Arsia Mons. Arsia Mons is one of the most windy place on Mars, because of ist slope wind, Elysium Planetia is one of the cadinate landing site for InSight mission and we have wind velocity data of Chryse Planetia (because Chryse Planetia was Viking Lander 1 Landing site.). These amount of energy wind turbine can generate strongly depends on the site and geography. We can generate only 3.4 [Watt hour] in a day, if we can install 1 meter square(sweep area) wind turbine on Chryse Planetia. But if we can install same turbine in Arsia Mons area, we can generate 137 [Watt hour] in a day.

We compared these results to other techniques (solar panels and nuclear batteries) with electric energy per mass. Finally, we found that wind electric is useful on Mars.

Keywords: Mars, Wind electric energy, Planetary exploration, Martian wind, Slope wind

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PPS04-02 Room:105 Time:May 21 14:30-14:50

A 2D numerical simulation of atmospheric convection with condensation of major component under early Mars condition

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In the early Martian atmosphere, it is suggested that the major component has condensed in wide area, and scattering greenhouse effect of CO_2 ice cloud contributed to the warm climate (Forget et al., 2013). The scattering greenhouse effect depends on the cloud distribution, and convective motion would play an important role in formation and distribution of the cloud. However, the structure of atmospheric convection with condensation of major component is poorly understood.

Colaprete et al.(2003) suggests that the convection due to buoyancy associated with condensation of major atmospheric component occurs if critical saturation ratio (Scr) is greater than 1 and surrounding air is kept supersaturated. However, Colaprete et al.(2003) only simulates by using 1D cloud model. It is necessary to perform 2D fluid model simulation for further investigation.

We have been developing a two-dimensional cloud resolving model including condensation of major component and performing preliminary numerical simulations under polar night condition in present Mars (e.g. Yamashita et al., JPGU 2012). In this study, we perform numerical simulation under the early Mars condition and investigate dependencies of Scr and number density of condensation nuclei ($N*$) on the flow field and cloud distribution of the convection.

The governing equations are the quasi-compressible system with condensation of major atmospheric component(Yamashita et al., 2012). Cloud particle grows only diffusion process and we assume that supersaturation is maintained if cloud density is less than the threshold (10^{-6}kg/m^3). It is physically equivalent that we consider the critical radius of cloud particle that grows diffusionally. Instead of solving atmospheric radiative transfer equation, we give horizontally uniform cooling from 0 km to 50 km height and Newtonian cooling above 50 km height. The value of cooling rate is 0.1 K/day (Kasting 1991). The surface pressure is 2.0 x 10^5 Pa and the surface temperature is fixed at 273 K. The initial temperature profile follows dry adiabat below 20 km height, and saturation vapor pressure from 20 km height to 50 km height, and isothermal above 50 km height. We set the value of Scr as 1.0 and 1.35 (Glandorf et al., 2002), and we set the value of $N*$ as 5.0 x 10^8, 5.0 x 10^6, and 5.0 x 10^4 /kg (Forget et al., 2013). The computational domain is 100 km in the horizontal direction and 80 km in the vertical direction. The spatial resolution is 500 m in the horizontal direction and 400 m in the vertical direction.

In the case for Scr = 1.0, the horizontally uniform cloud layer emerges quasi-stationarily above the condensation level. Vertical velocity in cloud layer is much smaller than those below the condensation level, and it is 0.5 m/s at a maximum. These characteristics do not depend on $N*$. In the case for Scr = 1.35, cloud distribution depends on $N*$. As $N*$ is less than 5.0 x 10^8 /kg, condensation and non-condensation periods occur alternately. In the condensation period, vertical velocity in the cloud is 2-3m/s. In the non-condensation period, horizontally uniform cloud layer forms, and the cloud density is less than the threshold for condensation (10^{-6}kg/m^3). Vertical velocity in the cloud layer is 0.5 m/s at a maximum.

We conclude that the spatial and temporal structure of cloud convection with condensation of major component vary greatly with the values of Scr and $N*$, and there are two types of solutions, which are a quasi-stationary solution that cloud distribution and flow field do not change in time drastically, and a quasi-periodic solution that condensation and non-condensation periods occur alternately.

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

PPS04-03 Room:105 Time:May 21 14:50-15:05

CO2 Snowfalls Affected by the Baroclinic Waves in the Winter Polar Atmosphere of Mars

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Using a Mars general circulation model (MGCM), we have simulated the formation of CO_2 ice clouds in the winter polar atmosphere of Mars, and showed that the occurrences of ice clouds and deposition rates on the surface are closely linked to traveling planetary waves. Given the regular and periodic nature of such waves, this study may suggest a basis for reliable forecasts of CO_2 snow storms.

The seasonal CO_2 polar cap appears to be formed from ice particles that have fallen from the atmosphere as well as those condensed directly on the surface. The possible occurrence of CO_2 snowfall in the winter polar regions have been observed, and preceding simulation studies have indicated that the longitudinal irregularities of CO_2 ice clouds in the northern polar region seemed to be linked to local weather phenomena. Especially transient planetary waves are the prominent feature during northern winters in martian atmosphere, and this study put an emphasis on revealing the mechanism how the dynamical influence of transient planetary waves affect the occurrence of CO_2 ice clouds, snowfalls and formations of seasonal CO_2 polar cap in high latitudes during northern winters.

We have implemented a simple scheme representing the formation and transport of CO_2 ice clouds into our MGCM, and investigated snowfall in high latitudes during northern winters. Our simulation showed that clouds were formed at altitudes of up to ~40 km in the north of 70 N, and their occurrence correlated to a large degree with the cold phases of transient planetary waves. Most ice particles formed above 10 km did not reach the surface in the form of snowfall, and it was likely that these particles sublimate in the lower warmer atmospheric layers. Deposition rates on the surface was shown to strongly depend on the transient planetary waves below ~10 km, as 90% of the seasonal ice cap was created by CO_2 snow while the remaining 10% were attributed to direct condensation on the surface.

Keywords: Mars, atmospheric dynamics, general circulation model, CO2 ice clouds, polar ice cap

PPS04-04 Room:105 Time:May 21 15:05-15:20

Concept of Mars meteorological orbiter

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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.

Keywords: Mars, meteorologgy, exploration, orbiter

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PPS04-05 Room:105 Time:May 21 15:20-15:45

Prime Habitable Environment of Mars: Argyre Impact Basin

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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.

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PPS04-06 Room:105 Time:May 21 15:45-16:00

Science and landing-site candidates of the MELOS 1 EDL demonstrator

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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.

Keywords: Mars, Lander, life, dust, water

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PPS04-07 Room:105 Time:May 21 16:30-16:45

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

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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.

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Keywords: Magnetite, High-Pressure, Magnetic Hysteresis, Martian Magnetic Anomaly

PPS04-08 Room:105 Time:May 21 16:45-17:00

A moderate hydrogen isotope composition of the surficial water reservoir on Mars

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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.

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Keywords: Mars, surficial water, hydrogen isotope

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PPS04-09 Room:105 Time:May 21 17:00-17:25

An Introduction to the Exploration for the interior of Mars: InSight

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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!

Keywords: Mars, internal structure, exploration, seismic wave, geophysical observation, meteorological observation

PPS04-10 Room:105 Time:May 21 17:25-17:45

Significant Water Loss during pre-Noachian era: Constraints from Hydrogen Isotopes in Martian Meteorites

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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.

Keywords: Mars, meteorite, hydrogen isotope, atmospheric escape

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PPS04-11 Room:105 Time:May 21 17:45-18:00

Examination of Orbiters for Martian Atmospheric Escape Study

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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.

Keywords: Mars, atmosphere, solar wind