Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

PPS03-01 Room:105 Time:May 24 10:45-11:00

Current status of MELOS1 Mars exploration planning

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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.

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

Japan Geoscience Union Meeting 2012
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PPS03-02 Room:105 Time:May 24 11:00-11:15

MELOS Mars meteorological orbiter concept

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A Mars mission concept MELOS (Mars Exploration with Lander and Orbiter Synergy) is now being developed in Japan. As a part of this mission, we propose a Mars orbiter dedicated to meteorological study, focusing on dust transport. Water cycle and photochemistry will also be addressed.

Keywords: Mars, atmosphere, meteorology, exploration

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PPS03-03 Room:105 Time:May 24 11:15-11:30

Water isotopic ratio in the Mars atmosphere: observational plan and simulation using a general circulation model

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Though the current Mars is a dry planet, there are many topographic evidences of past liquid water flow. Where has the surface liquid water gone? Some of the water is thought to have escaped into space, while some seems to have moved to the polar regions and underground. The detection of HDO/H_2O ratio in the atmosphere and on/under the surface of Mars should provide a good information as an index of the origin of water which shows the history of water cycle and escape processes which connents to the long-term climate change of Mars. Moreover, the mapping of HDO/H_2O ratio has been done for terrestrial atmosphere to visualize the physical processes on the water cycle, and we expect that the mapping of the ratio on Mars will also reveal the water cycle in current Mars environment, especially the moving in and out between atmosphere and surface. The sub-millimeter sounder FIRE (Far Infra-Red Experiment) onboard the MELOS meteorological orbiter (planned to be launched around 2020) plans the first observation and mapping of HDO/H_2O ratio from the Mars orbit. In addition, the 3-dimensional simulations of the HDO and H_2O cycles using a Mars general circula-tion model (DRAMATIC MGCM) are ongoing for the data assimilation of the FIRE/MELOS data. In this presentation we will show the description and numerical results of the simulations, and discuss the plan of scientific investigations together with the observation by FIRE/MELOS.

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

Japan Geoscience Union Meeting 2012
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PPS03-04 Room:105 Time:May 24 11:30-11:45

Trial of infrared high-spectral resolution spectrocopy for Mars and Planets: Current studies in Tohoku Univ.

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Mid-high spectral resolution spectroscopy revails 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 um 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, Harlingten Inovative Optics Co., Stan Truitt Breckenridge Astronomycal Ltd, and collaborators (see Okano et al., in this meeting). Its first light is, if all things are going well, in 2014.

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

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PPS03-05 Room:105 Time:May 24 13:45-14:00

Two-dimensional simulation of Martian atmospheric convection with the major component condensation over CO2 ice surface

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We have been developing a two-dimensional cloud resolving model and performing numerical simulations for the purpose of investigating characteristics of convection with condensation of the major component(e.g. Yamashita et al., JPGU 2011). In the system where the major component condenses, as a low temperature limit, a state where the surface is covered with the ice of the atmospheric major component can develop. The Martian polar night approximately corresponds to this state, therefore understanding of the Martian polar night contributes to elucidation of the behavior of the system where the major component condenses.

The observation by MOLA suggested that atmospheric major component, CO_2, condenses to form ice cloud in Martian polar region (Pettengill and Ford, 2000). Colaprete et al.(2003) proposed that some of the clouds are formed by convective motions. However, in the system that the major component condenses, the temperature profile of both an ascending air parcel and the surrounding environment follow the moist adiabat, and the air parcel cannot gain buoyancy. Therefore convection with condensation of the major component cannot occur. If the value of critical saturation ratio is greater than 1.0, there is a possibility that convective motions occur(Colaprete et al., 2003). Furthermore, falling cloud particles drag the surrounding air, and this effect can affect the convective motion. In this work, we report the preliminary numerical simulation where surface boundary condition, thermal forcing, and the formulation of cloud microphysics appropriate for the environment over the Martian polar cap are introduced.

The governing equations are based on the quasi-compressible equations(Klemp and Wilhelmson, 1978) and a conservation equation of solid CO_2. In cloud microphysics, the effects of gravitational settling and drag of cloud particles are considered. We set the initial surface pressure and the values of critical saturation ratio to be 7 hPa, 1.0, respectively. The model atmosphere is subjected to an externally-given thermal forcing that is a substitute for the radiative cooling. Because there is no solar radiation in the actual polar night, we do not give any heating, and we give horizontally uniform cooling from 1 km height to 15 km height. The cooling rate is set to be -5.0 K/day. The initial temperature profile is given such that saturation ratio is 0.98(Colaprete et al., 2003) below 15 km height, and isothermal(135 K) above 15 km height. Because the surface temperature of the actual polar cap is expected to be nearly sublimation temperature of CO_2, the air temperature at lower boundary is fixed to be initial value (about 150 K). Random potential temperature perturbations whose amplitudes are 1K are given at the lowest grid point to seed convective motion at initial time. The computational domain is 50 km in the horizontal direction and 20 km in the vertical direction. The spatial resolution is 200 m in both the horizontal and vertical directions. Time integration is 30 days.

The statistical equilibrium state has been established at 30 days. In the statistical equilibrium state, a cloud layer is formed in the uniform cooling region, and there strong convection does not occur except for near the surface. Specifically, a cloud layer is formed below 15 km height, and the density of cloud is maximum at about 2 km height. Vertical motions whose amplitudes are more than 1.0 m/s are found only below 2 km height, and the maximum value of the amplitudes is about 3.0 m/s. The convection found below 2 km height is driven by the effect of drag of cloud particles. Since laboratory experiments suggested that critical saturation ratio of 1.35 are required under the temperature and pressure in Martian polar region(Glandorf et al., 2002), we are also going to report about the case that critical saturation ratio is 1.35 in our presentation.

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

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PPS03-06 Room:105 Time:May 24 14:00-14:30

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

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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.

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

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PPS03-07 Room:105 Time:May 24 14:30-14:45

Analog experiments of formation of the spiral troughs on Mars' North Polar Layered Deposits: cyclic steps on ice

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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 Eargh, 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.

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

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PPS03-08 Room:105 Time:May 24 14:45-15:00

Electro-magnetic measurements by MELOS lander

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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 filed 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 filed, most of the targets will remained 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.

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

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PPS03-09 Room:105 Time:May 24 15:00-15:15

Current distributions and behaviors of dust and water on the surface of Mars

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Dust and water are fundamentally important for the current status of both martian atmosphere and surface deformations. While the amount of airbone 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.

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

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PPS03-10 Room:105 Time:May 24 15:30-16:00

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

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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.

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

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PPS03-11 Room:105 Time:May 24 16:00-16:15

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

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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

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PPS03-12 Room:105 Time:May 24 16:15-16:30

MELOS LIFE SEARCH PROPOSAL: SEARCH FOR MICROBES ON THE MARS SURFACE WITH SPECIAL INTEREST IN METHANE-OXDIZING BACTERIA

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Among the planets and giant satellites in our solar system, the characteristics of Mars are most similar to those of Earth. This may suggest that it may be possible for life similar to terrestrial life to arise and to survive on Mars. We propose to search for microbes on Mars, 5 to 10 cm below the surface. The first effort should be to identify locations where methane is emitted from underground. The rover will approach the methaneemitting site, where soil will be collected and analyzed. A combination of fluorescent dyes will be used to detect candidate cells using a fluorescence microscope[10]. Possibly in another mission, putative cells will be hydrolyzed and analyzed by HPLC and/or mass spectral analysis to define the characteristics of the candidate cells, which will indicate the origin of the candidate cells.

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

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PPS03-13 Room:105 Time:May 24 16:30-16:45

Most essential factor of the habitable Earth: initial ocean volume 3-5km thick

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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.