Internship project proposal for MISIP 2025

1) Project title: How much water is in the Martian mantle?
2) Supervisors (*corresponding): Takayuki Ishii*, Takashi Yoshino*, Daisuke Yamazaki
3) Number of students: 3
4) Detailed description of the project (including aim, detailed plan and expected outcome):

A long-standing question on Mars is where water has gone. Unlike Earth, the present Mars has no ocean and active plate tectonics. However, the early Mars seems to be covered with oceans. Studies of the Martian surface suggest that the planet's magnetosphere was lost during its early history, causing some of its water to escape into space. However, given the current concentration of hydrogen in the Martian atmosphere, the water escape into space is not only the mechanism to lose water from Mars. In other words, most of the water must have gone somewhere else. Therefore, water likely has gone into the Martian interior consisting of mantle silicate rocks and iron-rich core.

The Martian mantle mainly consists of iron-bearing silicate minerals like the Earth's mantle. A distinctive feature of the Martian mantle composition is enrichment in iron compared with the Earth's mantle composition, resulting in $(Mg,Fe)_2SiO_4$ iron-enriched magnesium silicates as major minerals such as olivine, wadsleyite, and ringwoodite depending on depth. The Fe/(Mg+Fe) (mol) of these minerals in the Martian mantle is in a range of 0.3-0.4, which is much higher than those in the Earth's mantle (~0.1). It is known that significant amounts of water (up to 1-2 wt%) can be stored in Earth's wadsleyite and ringwoodite. On the other hand, water contents and physical properties of these hydrous Martian mantle minerals are not well constrained, preventing possible detection of water in the Martian interior.

In this project, you will investigate phase relations and water storage capacity of hydrous Martian olivine, wadsleyite and ringwoodite by means of multi-anvil high-pressure experiments in combination with post-analyses of recovered minerals. You will also investigate physical properties such as electrical conductivity of these hydrous Martian mantle minerals. Based on these results, you will discuss water concentration in the Martian mantle.

Experimental Plan

1) Preparation of starting materials of $(Mg_x,Fe_{1-x})_2SiO_4$ (x=0.3-0.5) plus 1-15 wt% of water from using MgO, FeO, SiO_2, and $Mg(OH)_2$
2) Preparation of high-pressure experiments
3) High-pressure syntheses of olivine, wadsleyite, and ringwoodite single crystals with dimensions more than 100 microns up to 20 GPa and 1600-2000 K
4) Characterization of recovered samples using X-ray diffraction, Raman spectroscopy, Fourier Transform Infrared Spectroscopy, and electron microprobe analysis
5) In-situ electrical conductivity measurements of the above minerals by impedance analyzer under high pressure and temperature and post-analyses of recovered samples

Internship project proposal for MISIP 2025

1) Project title: Elucidating differences in light elements between chondrules, chondrule rims and matrix phases in CM2 chondrites.

2) Supervisors (*corresponding): Christian Potiszil*, Katsura Kobayashi, Ryoji Tanaka, Tak Kunihiro, Hiroshi Kitagawa, Tsutomu Ota, Masahiro Yamanaka and Chie Sakaguchi.

3) Number of students: 3

4) Detailed description of the project (including aim, detailed plan and expected outcome):

Carbonaceous chondrite meteorites represent some of the most well studied primitive meteorites in our collections on Earth. Among this group of carbonaceous chondrites, the Murchison meteorite is one of the most investigated meteorites in the world. Meanwhile Aguas Zarcas, represents a relatively new CM2 chondrite, having fallen in Costa Rica in 2019. While much has been revealed about Aguas Zarcas, the distribution of light elements remains not entirely understood. During this internship program, successful applicants will investigate the differences in the distribution of light elements such as Li, B and C between chondrules, chondrule rims and matrix phases. This work will be undertaken in order to better understand the origin and evolution of the chondrule and matrix material, as well as the different reservoirs of the early solar system and the processes responsible for shaping it.

The internship students will work together in a team to investigate the different phases using both bulk and in-situ techniques. Bulk sample analysis will involve separating chondrules from matrix and preparing these for ICP-MS analysis via wet chemistry procedures. In-situ analysis will involve using SEM-EDS, EPMA and Raman spectroscopy to characterise matrix and chondrule organic and inorganic phases. If time allows SIMS will also be used to obtain in-situ isotopic information.

The students will be exposed to an array of different analytical techniques and set-ups, as well as lab environments. Such experience will greatly contribute to the student’s scientific experience and aid them in a future career in science, whether that be in academia or industry. A large comprehensive data set will be acquired and the students will gain valuable data analysis and interpretation skills. In terms of the scientific outcomes, the students will help to determine whether the light elements in chondrules, chondrule rims and the matrix of CM2 chondrites originated from different reservoirs, and if so, what processes were responsible for the differences. Overall, such information will improve our understanding of the formation and evolution of solar system.

Internship project proposal for MISIP 2025

1) Project title: **Advancing Hyperspectral Imaging Techniques and Remote Sensing for Future Exploration**
2) Supervisors (*corresponding): ***RUJ Trishit, *KAMEDA Jun, IZAWA Matthew, OHTAKE Makiko (will join IPM in April, 2025) and ONODERA Keisuke.**
3) Number of students: **2**
4) Detailed description of the project (including aim, detailed plan, and expected outcome):
(4-1) **Aim**

The objective is to provide students with a solid understanding of remote sensing and hyperspectral data, emphasizing their applications in interpreting planetary surface processes. By integrating mission datasets with laboratory measurements, students will gain practical, real-world skills essential for planetary exploration.

(4-2) **Detailed plan**

(P1) One student will focus on utilizing a newly developed hyperspectral camera (Nakauchi et al., LPSC 2025; laboratory model) to capture and analyze high-resolution hyperspectral imaging data from a variety of natural rock samples. The rock samples will include diverse materials (including Lunar and Mars stimulants, Olivine-Pyroxene bearing rocks, laboratory synthesized minerals, meteorites, and clay minerals) providing an opportunity to investigate their mineralogical and textural properties in detail. The project will try to document and cross-verify the capability of the camera.

(P2) Another student will focus on the detailed analysis of remote sensing data (already available at the Planetary Data System), with a particular emphasis on landing site assessment and characterization (Golombek et al, 2020; Qian et al., 2021). This involves identifying and evaluating potential sites and creating the landing ellipse based on various geological, topographical, and environmental parameters critical to mission objectives. Given Japan's ambitious plans for multiple landings on the surfaces of Mars (with a target of subsurface Ice, present-day activity of water, recent volcano-tectonically active zones), the Moon (water and investigating the feldspathic crust, KREEP terrane, and lower crustal materials), and potentially Venus (volcano-tectonic activity, internal dynamics) soon. Selecting optimal landing sites requires a thorough understanding of surface conditions, including terrain stability, resource availability, and scientific value, as well as accessibility for planned mission operations. The analysis will directly support mission planning by providing data-driven insights to ensure the success and safety of future exploration endeavors.

(4-3) **Expected outcome**

(P1) This project will evaluate the performance of a hyperspectral camera using natural rock samples, including lunar meteorites and Mars analogs. It will analyze parameters like signal-to-noise ratio and flat field correction while examining how surface flatness affects texture and mineralogy, advancing hyperspectral imaging techniques for planetary exploration applications.

(P2) Comprehensive database of potential landing sites on Mars, the Moon, and possibly Venus, characterized by their geological attributes. The student will produce detailed assessments of site suitability based on mission-specific requirements, such as terrain stability, resource availability, scientific potential, and operational accessibility. This work will provide actionable recommendations to support Japan's future planetary exploration missions, ensuring the selection of safe and scientifically valuable landing locations. Additionally, the project will contribute to advancing methodologies for remote sensing analysis and landing site evaluation, aiding in the success of upcoming missions.

References
[1] Nakauchi et al., 2025 LPSC.
[2] Golombek, Matthew, et al. "Geology of the InSight landing site on Mars." *Nature communications* 11.1 (2020): 1014.
[3] Qian, Yuqi, et al. "China's Chang'e-5 landing site: Geology, stratigraphy, and provenance of materials." *Earth and Planetary Science Letters* 561 (2021): 116855.