Martian Moons eXploration (MMX): connecting small bodies with habitable planets

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Martian Moons eXploration, MMX, is a mission under pre-phase A study in ISAS/JAXA to be launched in 2020s. The basic question that MMX is going to answer is how water was delivered to rocky planets and enabled to produce the habitability of rocky planets in the solar system. Planet formation theories suggest that delivery of water, organic compounds and other volatiles from outside the snow line entitles the rocky planet region to be habitable. Small bodies like comets and asteroids play the role of delivery capsules. Then, dynamics of small bodies around the snow line in the early solar system is important issue to be understood. Mars was at the gateway position to witness the process, which naturally leads us to explore two Martian moons, Phobos and Deimos, to answer to the basic question.

On the origin of Martian moons, there are two leading hypotheses, “Captured volatile-rich primordial asteroid” and “Giant impact”. Current observational facts such as orbital properties and surface reflectance spectra are individually supportive of either hypothesis but insufficient to judge which is true. MMX project aims to collect samples from a Martian moon to conclude this discussion through in-depth sample analyses in combination with close-up observations of the moons. Depending on the conclusion, we will further extract information and constraints on material distributions and transports at the outer edge of the early inner solar system as well as on planetary formations.

If the capture hypothesis is true, the Martian moons may serve as an anchor to estimate chemical properties of primitive asteroids and their original formation environments possibly near the Jovian orbit. The dynamics of transportation across the snow line to the circum-Martian orbits would also be constrained, which improves our understanding of building blocks and circum-planetary environments of Mars and the other terrestrial planets during accretion. Acquisition of constraints on the delivery of water and other volatile to Mars is particularly important because these are difficult to be deduced from observations of Mars alone that has experienced differentiation and volatile escape.

Recent numerical simulations of Martian moon accretion from giant impact ejecta suggest that the moons may be constituted from a mixture of nearly equal proportion of impactor and proto-Mars materials. Ejected materials may experience weak impact-induced heating, avoiding severe homogenization due to melting and vaporization before agglomeration. It would therefore be possible to estimate the material properties of impactor and proto-Mars, separately, from returned regolith samples if the giant impact hypothesis is true. This would provide unique constraints for the physico-chemical state of proto-Mars as well as for the material supply to Mars. These constraints are clues to understand the surface environment of Mars where chemical evolution toward life expectedly proceeded under the presence of liquid water.

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