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The Gulliver Mission: Sample Return from Deimos

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Abstract

The Gulliver Mission is designed to collect a kilogram of Deimos regolith and return it to Earth. Deimos is an attractive sample return target because: (1) Its spectral D-type material is probably primitive carbonaceous material that is poorly represented in the meteorite collection; (2) Deimos one of the smoothest small bodies know making it much easier to find a safe sampling site; (3) Deimos is much small and farther from Mars making proximity maneuvering and orbital determination much easier than at Phobos; (4) Deimos is high in the Martian gravity well reducing the energy requirements for rendezvous and return.

1. Introduction

The Martian moon Deimos presents a unique opportunity for a sample return mission. Deimos is spectrally analogous to type D asteroids, which are thought to be composed of highly primitive carbonaceous material that originated in the outer asteroid belt. It also is in orbit around Mars and has been accumulating material ejected from the Martian surface ever since the earliest periods of Martian history, over 4.4 Gyrs ago [1].

Deimos's position in the Martian gravity well makes it likely to accumulate and retain material. Much of the ejecta from Deimos will not have the velocity to escape the Martian system and will eventually reaccrete to the moon [2]. Deimos is also probably a low-density rubble-pile and that structure strongly dissipates impact energy, further limiting ejection velocities and material escape [3]. Because of stochastic processes of regolith mixing over 4.4 Gyrs, the rock fragments, grains, and pebble-sized materials will likely sample the diversity of the Martian ancient surface and as well as thoroughly mixing the original primitive material of Deimos. Modeling suggests that between 1-10% of the surface material could be Martian ejecta.

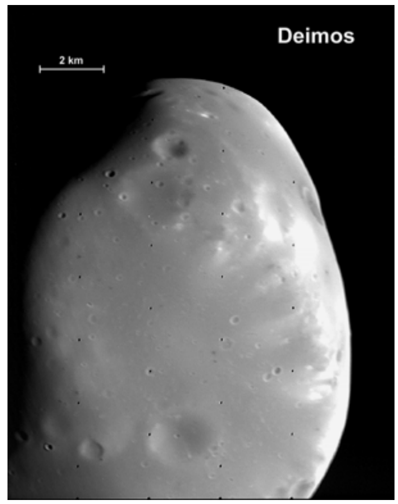

Figure 1: The Martian moon Deimos

2. Gulliver Mission Plan

The Gulliver Mission has been proposed as a Discovery/Mars Scout Class probe to directly collect a kilogram of Deimos regolith and return it to Earth. The spacecraft instrument suite is tightly focused to the requirements of finding a safe and scientifically interesting sampling location, collecting a sample, and returning to Earth safely. They include a high-resolution imaging camera for navigation and sampling site selection, a radar altimeter for closed-loop approach manoeuvring, and a wide-angle descent imager to record the sampling site and the actual sampling process.

Deimos is also by far the safest small body for sample return yet imaged. Shown in Figure 2 is a comparison of the surfaces of Deimos and 433 Eros. The NEAR-Shoemaker mission succeeded in landing on Eros with a spacecraft not designed for landing and proximity manoeuvring. As can be seen in Figure 2, Deimos is significantly less rough at 5-10 meter scales than Eros.

Compared to Phobos, Deimos has a number of advantages as a sample return target. Phobos is significantly rougher surface than Deimos with an order of magnitude more blocks, much higher local slopes, numerous impact and fracture scars. Operationally, Phobos will be much harder to find a safe, level sampling site. Higher local gravity and a much greater tidal acceleration from Mars complicates proximity operations and orbital maneuvers. These challenges imply larger fuel requirements for orbit and sampling at Phobos. In addition Phobos is much farther inside the Mars gravity well: The trip down to Phobos adds an additional 440 m/s to ΔV requirements compared to a mission to Deimos.

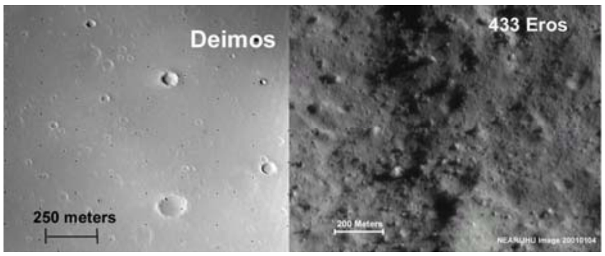

Figure 2: A comparison of the surface roughness of Deimos and 433 Eros.

The inherent robustness of Earth-based cosmochemical laboratory analysis, along with the diversity of the sample, allows the mission scientific goals to be both ambitious and comprehensive: (1) Determine the geochemistry of the accretion zones for the primitive D-type asteroids found in the outer asteroid belt and near Jupiter. (2) Study pre-biotic materials in primitive asteroids for their implications on the chemistry and astrobiology of outer solar system objects. (3) Determine the composition, diversity, and crystallization history of the Martian crust. (4) Date and characterize the era of Martian heavy bombardment After initial processing these samples will be made available as soon as possible to the international cosmochemistry community for detailed analysis.

References

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