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Phobos and Deimos: Science Goals for Human Exploration

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Abstract

The nature and origin of the two moons of Mars, Phobos and Deimos, are outstanding unknowns. Solving this mystery is considered the single most important science goal to be addressed in their exploration [1]. When considered in the broader and longer-term context of the human exploration of Mars, human missions to Phobos and Deimos offer exciting intermediate opportunities for science. Four key science objectives can be met by humans, that would be difficult to achieve well by robotic means alone: i) Collect samples representative of the *bulk* of Phobos and Deimos; ii) Image in detail the subsurface and interior of Phobos and Deimos via seismic tomography; iii) Drill deep (>5m) into Phobos and Deimos to investigate their interior and extract subsurface samples; iv) Search for accreted materials in the regolith of Phobos and Deimos that might have originated in the asteroid belt or on Mars.

1. Introduction

After four decades of Mars exploration by spacecraft, the nature and origin of Phobos and Deimos remain enigmatic [1, 2]. Meanwhile, on 15 April 2010, President Obama declared: "By the mid-2030s, I believe we can send humans to orbit Mars and return them safely to Earth." In this context, Phobos and Deimos are emerging as exciting new targets for human exploration in Mars orbit that could be visited well before the surface of Mars itself is reached [3-6] (Fig. 1). We examine here what science opportunities Phobos and Deimos offer to human explorers [7, 8].

2. Science Objectives

Four key science objectives have been identified that will likely be met more effectively by human explorers than by robotic systems:

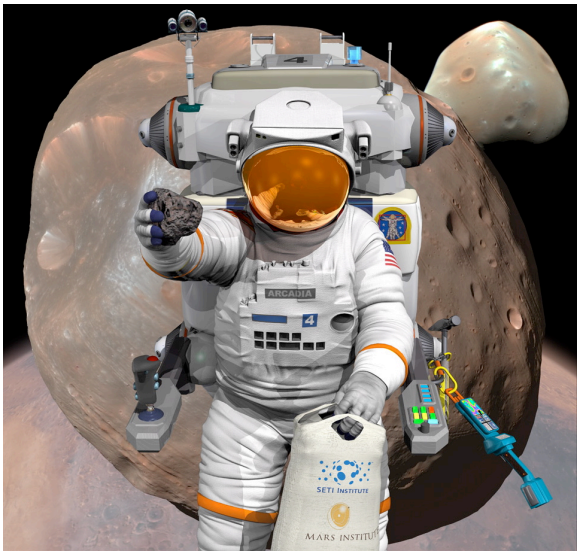

Figure 1: Artist concept of human exploration tools for Phobos and Deimos (Mars Inst./W. Myers, 2011).

1) Targeted collection of samples representative of Phobos and Deimos's bulk. This objective stems from the growing realization that understanding the nature and origin of Phobos and Deimos will likely require that samples from large impact ejecta blocks, which are the only materials in their regolith whose provenance is almost certainly local and whose composition is likely to reflect the bulk composition of the moons, be collected and analyzed [2,7].

2) Detailed 3-D imaging of the subsurface and interior of Phobos and Deimos via seismic tomography. Detailed visualization of the subsurface structure of Phobos and Deimos requires a combination of geophysical methods, namely sounding radar and seismology. Ensuring good ground coupling of geophones is essential for seismic imaging, and is difficult to achieve robotically, particularly in regolith in a microgravity environment.

3) Deep drilling (> 5m) on Phobos and Deimos to investigate their interior and extract subsurface samples. Deep drilling will provide direct access to subsurface materials and the internal structure of Phobos and Deimos. Because deep drilling is inherently a complex, mass and mobility-intensive exploration activity, it is difficult to implement via autonomous robotics.

4) Search for accreted materials in the regolith of Phobos and Deimos that might have originated in the asteroid belt or on Mars. The regolith of Phobos and Deimos likely harbors accreted particulate materials from asteroids, comets, and Mars. Large impact ejecta fragments from Mars are, in general, unlikely to be intercepted by either Phobos or Deimos, and those that are, impact the martian moons at too high a velocity (typically 1–2 km s^{-1}) to survive impact [3]. However, Phobos and Deimos may be effective collectors of martian dust ejected by impacts on Mars and mobilized by electromagnetic forces. The moons might have collected martian material from many parts of Mars throughout their history in Mars orbit. Some of this material might be even better preserved on Phobos and Deimos than on Mars today. Humans will have the important and challenging task of sampling Mars on Phobos and Deimos, and possibly also of retrieving Mars samples cached robotically and quarantined in advance on the moon(s) [9].

6. Summary and Conclusions

While the scientific exploration of Phobos and Deimos will and should continue to advance through robotic missions in the short-term, some important objectives will likely remain more effectively met via an eventual human mission. There is general consensus that the human exploration of Phobos and Deimos, given its substantial requirements in resources, cannot be justified on the basis of advancing our scientific understanding of Phobos and Deimos alone [2]. However, if human missions to Mars orbit are part of a logical, stepwise strategy to achieve an eventual human landing on Mars in the longer term, then Phobos and Deimos may be viewed as exciting targets of opportunity for human exploration and science in Mars orbit in the medium term. It is in this broader context of human Mars exploration that the proposed science objectives for humans at Phobos and Deimos should be considered.

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References

[1] Lee, P.: First Int'l Conf. on the Exploration of Phobos & Deimos, 5-7 Nov 2007: Summary & Recommendations. Mars Inst. Tech. Pub. MITP-2009-001, Mars Institute, 57 pp, 2009.

[2] Lee, P. & Jaroux, B.: 2nd Int'l Conf. on the Exploration of Phobos & Deimos, 14-16 Mar 2011: Summary & Recommendations. Mars Inst. Tech. Pub. MITP-2011-002, Mars Institute, 2011.

[3] Lee, P., Braham, S., Gladman, B., Mungas, G., Silver, M., Thomas, P., & West, M.: Mars Indirect: Phobos as a Critical Step in Human Mars Exploration. Int'l. Space Dev. Conf., 19-21 May 2005, Washington, D.C., Abstract 96, 2005.

[4] Lee, P., Braham, S., Mungas, G., Silver, M., Thomas, P., & West, M: Phobos: A Critical Link Between Moon and Mars Exploration. Report of the Space Resources Rountable VII: LEAG Conference on Lunar Exploration, 25-28 Oct 2005, League City, TX, USA, LPI Contrib. 1318, p. 72, 2005.

[5] Lee, P.: Phobos ASAP. Phobos as a stepping stone between the Moon and Mars. ISDC-2007, 25-27 May 2007, Dallas, TX, USA, 2007.

[6] Lee, P.: Phobos-Deimos ASAP: A Case for the Human Exploration of the Moons of Mars. First Int'l Conf. on the Exploration of Phobos & Deimos. NASA Research Park, Moffett Field, CA, USA, 5-7 Nov 2007. LPI Contrib. 1377, p. 25 [7044], 2007.

[7] Lee, P.: Phobos and Deimos Sample Return: Importance, Challenges, and Strategy 2011. Solar System Sample Return Mission Workshop, 5-6 March 2011, The Woodlands, TX. USA, [5044], 2011.

[8] Lee, P., & Martin, G. L.: Human Missions to Phobos and Deimos: What Science? In Abstracts of the 2nd Int'l Conf. on the Exploration of Phobos & Deimos. Mars Inst. Tech. Pub. MITP-2011-001, Mars Institute, Moffett Field, CA, USA, p. 20 [11-001], 2011.

[9] Lorber, K., and Lee, P.: Phobos, Deimos, and Planetary Protection: A Review. In Abstracts of the 2nd Int'l Conf. on the Exploration of Phobos & Deimos. SETI Inst. Tech. Pub. SITP-2011-001, SETI Institute, Mountain View, CA, USA p. 22 [11-020], 2011.