***ALADDIN*: EXPLORATION AND SAMPLE RETURN OF PHOBOS AND DEIMOS.** C. Pieters[1], W. Calvin[2], A. Cheng[3], B. Clark[4], S. Clemett[5], R. Gold[3], D. McKay[6], S. Murchie[3], J. Mustard[1], J. Papike[7], P. Schultz[1], P. Thomas[8], A. Tuzzolino[9], D. Yeomans[10], C. Yoder[10], M. Zolensky[6], O. Barnouin-Jha[3], D. Domingue[3], [1]Brown Univ., Providence, RI 02912; [2]USGS, Flagstaff, AZ; [3]Johns Hopkins Univ. Applied Physics Lab., Laurel, MD; [4]Lockeed Martin Astronautics, Denver, CO; [5]MVA Inc. Norcross, GA; [6]NASA Johnson Space Center, Houston, TX; [7]Univ. New Mexico, Albuquerque, NM; [8]Cornell Univ., Ithaca, NY; [9]Univ. Chicago, Chicago, IL; [10]JPL, Pasadena, CA

Mission Overview: The Aladdin mission has been selected as a finalist in the 1999 Discovery competition based on the high quality of science provided to the science community. Aladdin addresses two of NASA's highest priority science objectives: the composition and nature of small bodies (the building blocks of the solar system), and the origin and evolution of the Martian system. Aladdin is a remote sensing and sample return mission to explore the two small moons of Mars, Phobos and Deimos. The mission's primary objective is to acquire well-documented, representative samples from both moons and return them to Earth for detailed analyses. Launch is in May 2003 and samples are returned to Earth within three years (see Figure 1).

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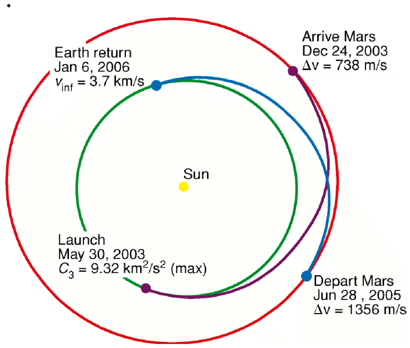

Fig. 1. Aladdin Mission Trajectory.

Aladdin uses an innovative flyby sample acquisition method described below which has been experimentally validated and does not require soft landing or anchoring. An initial thirteen-month phasing orbit at Mars reduces propulsion requirements, enabling Aladdin to use proven, low-risk chemical propulsion with good mass margin. This phasing orbit is followed by a five month prime mission which provides redundant opportunities for remote sensing and five independent sampling sequences.

The Aladdin mission will be implemented as a partnership between Brown University, the Johns Hopkins University Applied Physics Laboratory, Lockheed Martin Astronautics, the Jet Propulsion Laboratory, and NASA Johnson Space Center. Co-Investigator's affiliations are listed above.

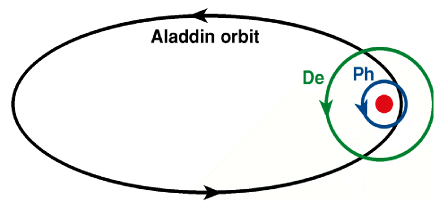

Fig 2. Aladdin's orbit at Mars has repeated encounters with Phobos and Deimos.

Science Background: Phobos and Deimos are postulated to be related to primitive outer solar system objects [1, 2], but their proximity to Mars make them far more accessible with low-cost spacecraft. The geology of each satellite is distinctive and complex [3,4]. Both satellites have low densities and optical properties resembling primitive asteroids, which may be the remnants of bodies that delivered organics and volatiles to the inner solar system. These primitive bodies are not well represented in meteorite collections. Alternatively, because Phobos and Deimos exhibit spectra with some resemblance to those of the Moon and Mercury, their surface properties might be explained by space-weathered silicates [4].

Resolution of the origins and histories of the two enigmatic Martian satellites requires detailed evaluation and comparison of the mineralogy and chemistry of regolith samples that can only be performed using the advanced analytical capabilities of Earth-based facilities. Analysis of Aladdin's samples will determine whether either moon co-accreted with Mars, is a captured more primitive asteroid/comet, or is derived from Martian basin ejecta. With current analytical technology and expanding experience with IDPs, the amount of sample required to achieve these science objectives can be as small as 3 µg (5). Aladdin is, of course, designed to collect substantially more than this limit, and the availability of Aladdin samples in terrestrial laboratories are a priceless resource for the planetary community since they also enable questions not yet even conceived to be addressed in the future. For example, Aladdin returns orders of magnitude more material than the cumulative amount of IDPs analyzed to date.

Sample Collection. Aladdin derives its name from its "flying carpet" sample collector, a flexible fiber maze trap. The spacecraft flies through a plume of debris released by small artificial impactors targeted at specific geologic formations on the satellites (two for Phobos, two for Deimos, plus a spare). Regolith particles from the surface are preserved during capture by the exposed carpet collector since both impact and collection velocities are relatively low (~1 km/s). Segments of the carpet are reeled into the sample return capsule after each "launch and catch" event so that each sample can be analyzed separately when returned to Earth. Onboard particle detectors confirm successful collection of each regolith sample. The Aladdin payload dedicated to sample collection thus includes 5 sample mobilizers (projectile launchers), sample collectors (spooled carpet), return capsule, and dust detectors

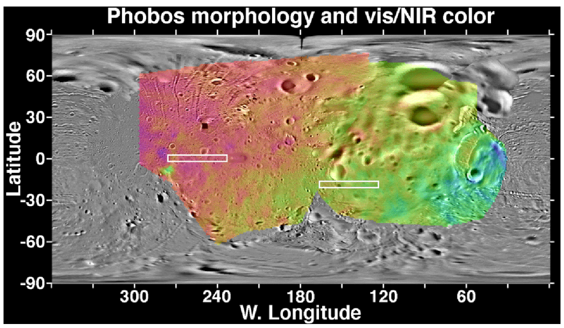

Fig 3. Location of high resolution imaging (1m/pixel) across Aladdin's two prime targets on Phobos. Each of the known geologic units is sampled [Basemap is Phobos 2 vis-NIR color superimposed on Viking image mosaic (4)]

Remote Sensing: Aladdin's high resolution color imager (CCAM) and visible and near-infrared imaging spectrometer at 0.45 - 3.6 µm (ISPEC) are used to characterize the moons' surfaces and map geologic units and compositional parameters. A specialized monochromatic camera records the artificial impact plumes of regolith (PCAM). A monochromatic navigation camera (NAVCAM) provides precision targeting information. The coordinated series of remote sensing observations, obtained before, during, and after sample acquisition, place the sample sites in geologic context, allowing inference of global properties from the detailed sample analyses.

Radio science experiments will provide significant improvements for the mass estimates, and hence derived density measurements, of Phobos and Deimos. Knowledge of the density for these two bodies is expected to be determined to within ~10%.

As a bonus, Aladdin's remote sensing instruments will acquire unique compositional data for Mars' surface, with no additional spacecraft or payload capability requirements (see related abstract by Mustard et al.). Extensive regions of great scientific interest will be mapped at high spatial resolution under high sun lighting conditions using visible and *near*-infrared spectroscopy, which is particularly sensitive to minerals indicative of past liquid water environments. Aladdin data provide exceptionally valuable information on Mars' mineralogy that is complementary to, but independent and distinctly different from data obtained by the Mars Surveyor Program at longer wavelengths.

Products and Participation. The role of the Aladdin Science Team and associates (above co-authors) is to assure the highest quality of science results from the Aladdin mission. When Aladdin is selected for implementation, broad input from the science community will also be sought for two key aspects of the mission: Mars remote sensing and sample analysis planning. Advisory committees of knowledgeable scientists in these fields will be formed to assure optimum Mars science data and to prepare the science community for data and samples returned by Aladdin. Remote sensing optical data of Phobos and Deimos will be calibrated and released by the time samples are returned to Earth (6 months after finishing activities in Mars orbit). This will allow the context of the samples to be studied while the samples themselves are being allocated to the community. It is expected that ~10% of returned samples will be set aside for preliminary analysis; the rest will be curated and available for allocation.

The breadth of Aladdin science involves many disciplines: small bodies, planetary materials, remote sensing, satellite systems, planet formation and origins, mineralogy of Mars. The mission as a whole provides an enormous wealth of information and long-term resources reminiscent of the first return of lunar soil.

References: [1] Burns J. (1992) in *Mars* (Kieffer et al), 1283. [2] Bell J et al., (1993) in *Resoures of Near-Earth Space*, U AZ, 887. [3] Thomas P. et al. (1992) in *Mars* (Kieffer et al.) 1257. [4] Murchie S. and Erard S (1996) *Icarus*, 123, 63. [5] Zolensky et al. (1998) LPS29, 1716; Zolensky et al., (1999) submitted to *MAPS*.