MARS PATHFINDER IMAGING RESULTS AT PHOBOS AND DEIMOS: CONSISTENCY WITH PREVIOUS DATA.

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The Imager for Mars Pathfinder (IMP) acquired reflectance spectra of both Phobos and Deimos, simultaneously with spectra of two standard stars. The IMP spectrum of Deimos is highly consistent with previous ground-based and HST measurements. From the results of the multispectral imager on Phobos 2, the covered region of Phobos is expected to be a mixture of spectrally bluer and redder regions. The measured IMP spectrum of Phobos is intermediate to composite Phobos 2 spectra of the two color units, and it is consistent with Mariner 9 UVS and HST spectra of an overlapping region. Both Martian moons are redder than most asteroids and very different spectrally than C-types. There is no definitive evidence on either moon for a strong absorption due to Fe minerals. Spectrally, the moons most closely resemble two very dissimilar analog materials, putatively clay- and organic-rich D-like asteroids and highly space-weathered, mafic-rich assemblages such as lunar mare soils. Further measurements at infrared wavelengths may distinguish between these possibilities.

Background. The C asteroid-like spectra of Phobos and Deimos assembled from different Mariner 9 and Viking Lander observations have been considered important evidence for the composition and origin of the two Martian moons [1,2]. More recent observations from ground-based spectroscopy [3], HST [4], and Phobos 2 [5,6] have yielded a very different picture of the two moons. Both are redder spectrally than most asteroids, and Phobos exhibits two spectrally dissimilar units with relatively redder and bluer spectral properties. Murchie and Erard [6] showed that the C-like spectrum of Phobos can be explained as an artifact of mixing of measurements covering these dissimilar regions at different wavelength ranges. Analog materials having as red a spectrum as Phobos or Deimos include D-like asteroids and space-weathered mafic silicates. These would would imply drastically different satellite compositions.

Each of the two hypotheses for the moons' composition makes predictions about occurrence of Fe mineral absorptions and about relationships between albedo and spectral properties. IMP observations were designed: to observe independently the two moons' spectral properties, to validate previous measurements; to assess the presence of an Fe mineral absorption feature near 1 mm; and to determine the relationhip, if any, between albedo and spectral properties of the two moons.

Procedures. Each IMP satellite observation consisted of three multispectral image sets, averaged to improve uniformity in CCD response. The sub-Mars leading hemispheres of both satellites were measured, during Martian early morning. The data were calibrated against standard stars in nearby parts of the sky, to minimize affects of atmospheric opacity, and were converted to geometric albedo using a photometric model. For comparison with IMP data, previous observations were selected for coverage of the same geographic regions. Where the data were in units of relative reflectance, they were converted to estimated albedo using Viking clear-filter albedos of the observed regions [7,8].

Results. Phobos 2 multispectral imaging results suggest that the region of Phobos measured by IMP is predominantly the spectrally bluer unit, with some fraction of the redder unit. The IMP spectrum is intermediate to composite, multi-instrument Phobos 2 spectra of the two units, as expected (Fig. 1). It is also consistent with Mariner 9 UVS data and HST data, which cover larger regions that overlap spatially the area covered by IMP (Fig. 2). For the leading hemisphere of Deimos, there is excellent consistency between spatially overlapping data sets (Fig. 3). These results validate the recent view of the Martian satellites as dissimilar to C-type asteroids and spectrally very red.

The measured region of Phobos does not exhibit a 1-mm absorption greater than several percent in depth. This excludes a freshly exposed, highly mafic-rich composition, but excludes neither (a) an organic-rich composition nor (b) a mafic but highly optically altered composition. The measured region of Deimos may exhibit a shoulder approaching 1 mm, but scatter in the data rules out a definitive identification of an absorption. There is enough scatter between adjacent IMP filters that interpration of narrower, single-filter "spectral features" is likely problematic.

Comparison to Analogs. The spectra of both moons are grossly similar, but differ in albedo and spectral character near 1 mm. Deimos is both higher in albedo and exhibits more of a shoulder near 1 mm. A similar relationship between albedo and depth of a 1-mm absorption is seen in mafic assemblages space-weathered to different degrees [9], but the small number of IMP spectra, scatter in the data, and lack of wavelength coverage beond 1 mm preclude definitive statements about an analgous trend. The moons are redder than most asteroids, and are most similar to red, putatively clay- and organic-rich D-like asteroids including D- and T-types. Alternatively, the satellites compare equally well with highly space-weathered mafic mineral rich materials such as lunar mare soils. Drastically different compositional implications of these analog materials may be resolved by further spectral measurements, covering infrared wavelengths diagnostic of the presence of mafic silicates or organics and clays.

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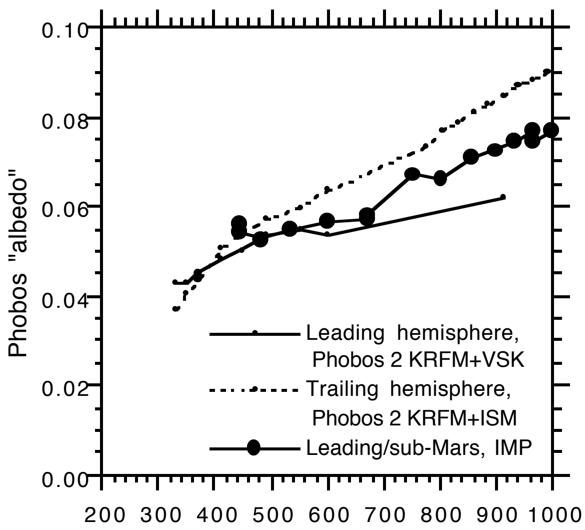

Fig. 1

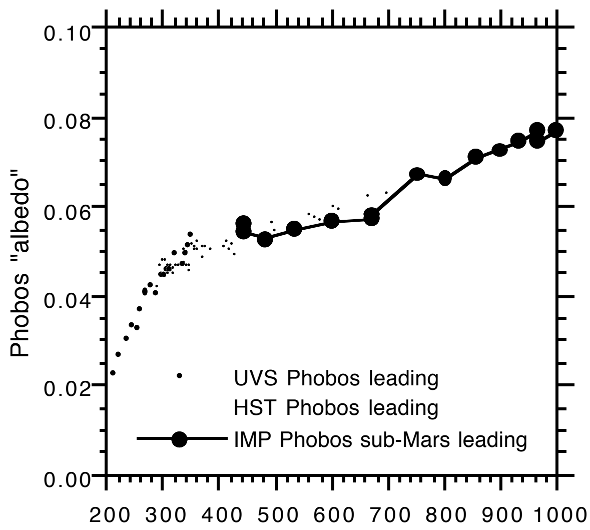

Fig. 2

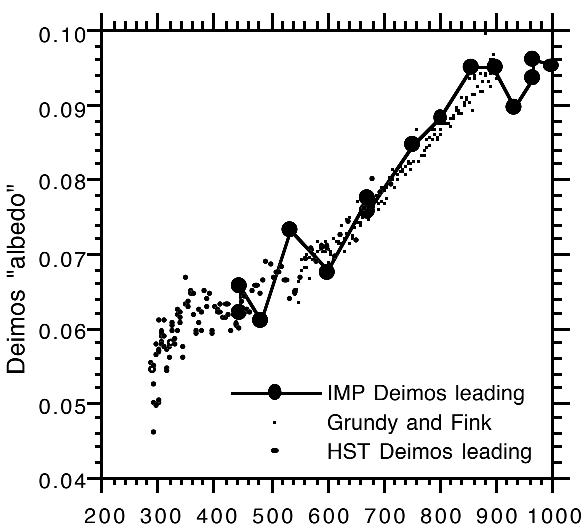

Fig. 3

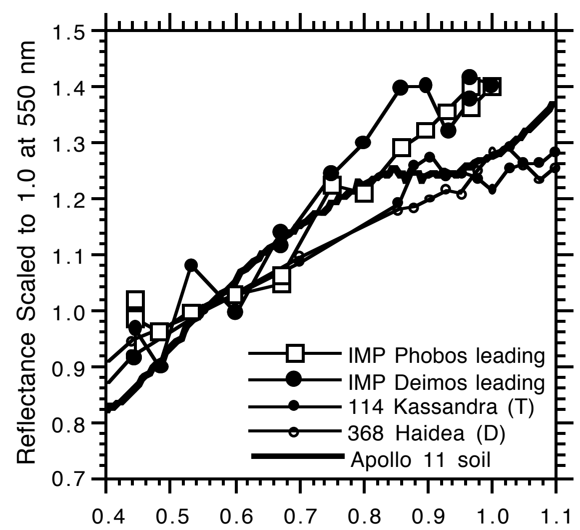

Fig. 4