

DEIMOS: HYDRATION STATE FROM INFRARED SPECTROSCOPY

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In the fall of 1988 Mars came to the most favorable opposition for Earth-based observations in the remainder of this century, providing a rare opportunity for ground-based studies of the Mars satellites. We conducted spectral observations in the 1.2- to 3.2- μm wavelength region intended to detect (or place an upper limit on the abundance of) bound/adsorbed water on Phobos and Deimos in order to support the Soviet Phobos mission and to evaluate their utility as fueling bases for future Mars exploration.

Background: Telescopic data obtained during the last favorable oppositions in 1971-73 and data from Mariner 9 and Viking indicate that the visible spectral reflectance of both satellites is essentially identical to the spectrum of the asteroid Ceres (1,2). Ceres and many similar asteroids possess an absorption band near 3 microns due to bound water in the mineral structure of clays (3,4,5); the depth of this band appears to be correlated with the depth of the absorption below 0.4 microns (6). Thus the similarity of Phobos and Deimos to Ceres in the 0.2-0.9 micron range suggests a composition dominated by hydrated clay minerals, and probably analogous to the CI and CM meteorites. Direct detection of the 3-micron band would provide unambiguous evidence of water.

Measurements: 1.2-3.2 μm reflection spectra of Deimos were obtained on 7 October 1988 with the 3-meter NASA Infrared Telescope Facility at Mauna Kea, Hawaii. The InSb detector system "RC2" was used with the standard JHK filters and the circular variable filter "MCVF". The star HD1160 was used for extinction corrections. Several special measures were taken to properly subtract the scattered light from Mars, since it is known to possess a very deep bound-water absorption band very similar in wavelength and shape to that we were searching for in Deimos (7). A black baffle tube was installed in the center of the primary mirror, and the throw direction of the chopping secondary mirror adjusted in order to sample the sky at an equal distance from Mars as Deimos (8). Residual offsets due to scattered light from Mars (never more than 10% of the Deimos signal) were corrected by measuring sky intensity inside and outside Deimos.

Results: Preliminary analysis of the data was carried out by constructing models of the total flux (Fig. 1) assuming the "standard thermal model" long used for asteroids, and the spectral reflectance of various meteorites. The top figure assumes that Deimos has the spectrum of Orgueil, one of the most hydrated carbonaceous chondrites. It is clear that Deimos is much drier than Orgueil. The model curve in the lower figure was generated with the reflectance of Karoonda, a totally anhydrous chondrite. This comparison suggests a weak bound-water band in Deimos of about 5-10% relative depth. More sophisticated thermal models incorporating the thermal inertia of the regolith (not shown) tend to reduce the apparent band depth, but do not properly match the spectral slope. It is not possible at present to rule out a completely anhydrous surface on Deimos, given the uncertainties in the thermal models and possible residual scattered light from Mars; on the other hand it is certain that Deimos is much less hydrated than the "average" main-belt C-type asteroid. The short-wavelength data points fall well below the model curves, implying a red reflectance curve in the 1.2-2.2 micron region. Combined with the flat reflectance in the 0.35-0.7 micron range (9), this implies that Deimos spectrally resembles the anhydrous Class P asteroid 65 Cybele. P asteroids like Cybele are found just inside the gap between the main asteroid belt and the Trojan asteroids (10), suggesting that the Phobos/Deimos parent body was delivered to Mars during the cleaning out of this region.

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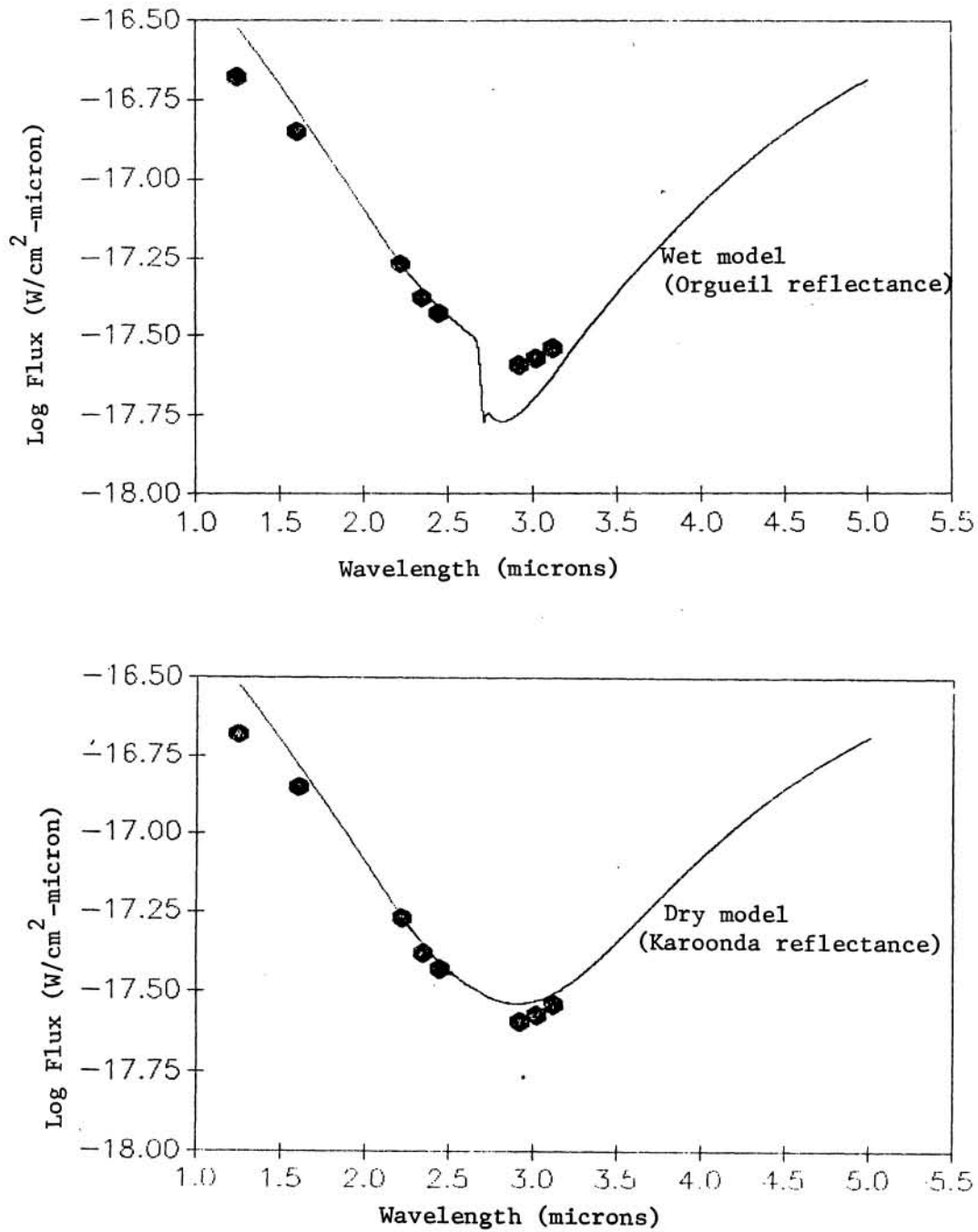


FIGURE 1: Deimos telescopic observations (symbols) compared with flux models assuming standard asteroid thermal model and spectral reflectance of hydrous and anhydrous carbonaceous chondrites (lines). Telescope data scaled to models at 2.2 μ m.