A COMPARISON OF TELESCOPIC AND PHOBOS-2 ISM SPECTRA OF MARS IN THE SHORT-WAVE NEAR-INFRARED (0.76-1.02 μm) James F. Bell III (NRC/NASA Ames, Space Sciences 245-3, Moffett Field, CA 94035) and John F. Mustard (Brown University, Dept. of Geological Sciences, Providence RI 02912).

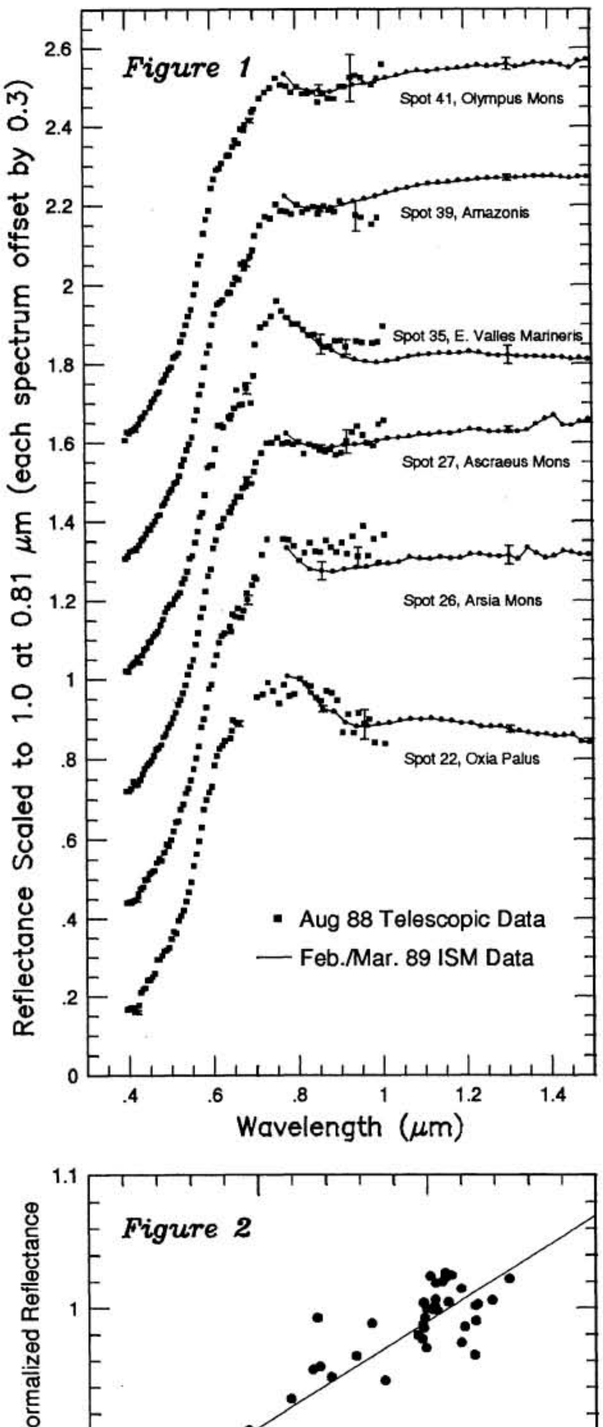
The Problem: Recent analyses of near-IR (0.76-3.16 μm) Mars surface reflectance spectra obtained by the Phobos-2 ISM instrument during early 1989 have revealed the presence of substantial variability in surface spectral properties [1-3]. Strong absorption features seen in the 0.85-1.05 μm region are up to 10-15% deep relative to the local continuum [2,3] and have been interpreted as evidence of Fe^{2+} and Fe^{3+}-bearing minerals (pyroxenes and iron oxides, respectively). Though these observed band depths are comparable to those seen in laboratory reflectance spectra [*e.g.*, 4-6], they are up to three times larger than most previously reported band depths for Mars spectra at these wavelengths. Thus, we have posed the following questions: (1) Do the ISM data accurately represent the spectral behavior of the Martian surface in the near-IR? If so, are the differences between the ISM spectra and decades of previous groundbased observations a result of (a) differences in spatial resolution, or (b) changes in the spectral character of the martian surface and/or atmosphere with time? If not, are the differences due to calibration errors in the groundbased data, the ISM spectra, or both?; and (2) If these large band depths are indeed real, what are the implications for Mars surface mineralogy and past/present weathering environments?

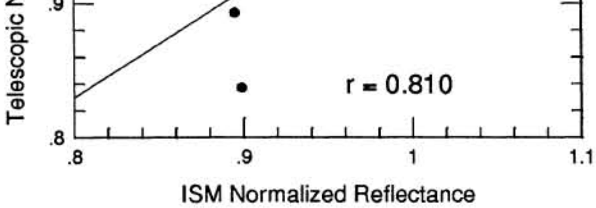
The Data: Groundbased telescopic observations of Mars in the visible to near-IR (0.4-1.0 μm) were obtained from Mauna Kea Observatory during the 1988 opposition by Bell *et al.* [7]. Earlier measurements in the near-IR have been summarized by Singer *et al.* [8], McCord *et al.* [9], and Bell and McCord [10]. The spatial resolution of these data ranges from 150-2000 km, and calibration is relative to standard stars and/or returned lunar samples. Near-IR (0.76-3.14 μm) imaging spectrometer data of Mars were acquired from orbit by the ISM instrument onboard the Phobos-2 spacecraft in February and March 1989, approximately 6 months after the 1988 telescopic observations. Data were acquired with a spatial resolution of 22 km/pixel over 11 regions, focusing on Tharsis, Valles Marineris, Arabia, and Syrtis Major-Isidis. Data were calibrated in two steps: 1) using pre- and in-flight calibrations to account for known instrumental. and atmospheric effects, and 2) relative to a spectral model for Mars [1,2].

Comparison Procedure: Six regions of variable albedo and geologic setting were identified where ISM and 1988 opposition telescopic coverage either overlapped physically or sampled the same surface geologic unit [11]. The areal sizes and positions of the regions measured telescopically were compiled by Bell *et al.* [7]. ISM pixels falling within these spots were averaged to produce a spatially convolved spectrum that simulates what would have been seen telescopically (neglecting the effects of the Earth's atmosphere). To facilitate comparisons of absorption band positions and relative strengths, the convolved ISM data and the 1988 telescopic spectra were scaled to unity at 0.81 μm and are presented in Fig. 1. The data have also been convolved to equivalent band pass normalized reflectances in the region of spectral overlap (0.76-1.02 μm). A scatter diagram of telescopic vs ISM reflectances is shown in Fig. 2.

Results: Of the six regions compared (Fig. 1), four exhibit remarkably good agreement between the telescopic and ISM data (Spots 22, 27, 35, 41). Another shows differences within acceptable bounds of the noise (Spot 26). The final spot exhibits differences associated with the 0.85-0.95 μm band (Spot 39). However, it should be noted that telescopic data from 0.93-0.98 μm are occasionally contaminated by a telluric water vapor feature. Overall, the impression is that, when properly convolved to simulate telescopic spatial resolution, the ISM data are consistent with groundbased telescopic measurements of the same regions taken only a few Mars months earlier. The depth of the absorption features seen in the 0.8-1.0 μm region are qualitatively consistent between the two data sets. However, quantitative comparisons can be complicated when using multiplicatively scaled data. Nevertheless, a correlation coefficient of 0.81, as a simple statistical measure of similarity, was computed for the data shown in Figure 2.

Discussion and Implications: Our simple study indicates that, at coarse spatial resolution, both ISM and groundbased telescopic spectra of Mars are in general agreement, despite being calibrated independently. This provides assurance that the observations of the Martian surface spectral properties at finer spatial scales with the ISM data are accurate. It also confirms that there is significant and meaningful spectral heterogeneity on Mars at fine spatial scales, even in regions that appear to be mantled by the global dust on larger spatial scales [3,10]. Differences between the convolved ISM data and the telescopic measurements for local areas may be related to changing surface and/or atmospheric conditions between the





time the two data sets were acquired. Specifically, the ISM convolved spectrum for Spot 39 shows a ≈5% absorption feature centered near 0.85-0.90 µm while the telescopic spectrum does not. This could be due to transient surface or atmospheric phenomena such as the presence of poorly-crystalline airborne or surface-mantling dust in this region during August 1988 that had cleared by the time the region was measured by ISM in 1989. We believe that the deep (10-15%) absorption features reported in the ISM spectra for regions like Syrtis Major [2] and subtle but spatially coherent differences in weak spectral features observed in high albedo regions [3] are a manifestation of the order of magnitude increase in spatial resolution of the ISM data over the telescopic measurements. This finding has important implications. First, it demonstrates that high spatial resolution spectral observations can detect mineralogic variability over all ranges of Mars albedo and surface geology. Further increases in spatial resolution can be expected to provide greater information on the compositional diversity of the Martian surface. Second, Mustard *et al.* [2,12] have interpreted the band near 0.95 µm and related band near 2.1 µm to indicate the presence of calcic pyroxene. Based on morphologic associations, this implies that relatively unaltered pyroxene-bearing volcanic materials occur on the Martian surface and must occupy a large percentage of each pixel's 400 km^2 field of view where detected. Given the paradigm that the surface of Mars is highly altered, the presence of relatively pristine volcanic material is surprising and also exciting. If relatively fresh volcanic materials (secondary crust) are exposed on the surface, perhaps unaltered primary crust is also exposed in the ancient cratered terrains and could be sensed by remote means. If not, then the fresh volcanics seen on current Mars may be in a metastable weathering environment, effectively "frozen in time" by the currently low temperature, humidity, and oxygen partial pressure. The problem of how and when oxidative weathering occured may therefore be tractable by carefully targeted data collection with high spatial and spectral resolution.

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