Interpretation of Spectral Units of Isidis-Syrtis Major from ISM-Phobos-2 Observations. John F. Mustard[1], J-P. Bibring[2], S. Erard[2], E. M. Fischer[1], J. W. Head[1], S. Hurtrez[3], Y. Langevin[2], C. M. Pieters[1], C. J. Sotin[3] (1) Dept. Geol. Sci, Box 1846, Brown Univeristy, Providence RI (2) Institut d'Astrophysique Spatiale, 91405, Orsay France (3) Labratoire de Geodynamique Interne, 91405 Orsay, France

Introduction: During the encounter of Phobos-2 at Mars between January and March of 1989, imaging spectrometer data were obtained by the ISM instrument for several areas on Mars. These are the first high spectral and spatial resolution data for Mars and provide important information for identifying the composition of the atmosphere and surface (1). Data obtained for the Isidis-Syrtis Major region are examined here to determine and interpret the spectral features which characterize surface units defined in a companion abstract by (2). The area of the Martian surface covered by these data is shown in outline on the Viking orbiter photomosaic in Figure 1. A diverse range of geologic and geomorphic terrains are contained in this window and it is anticipated that careful analysis of these data will provide information on the composition of the Syrtis Major volcanic materials, basin rim materials of Isidis, and the cratered terrains of Arabia and Amenthes.

Unit Definition: Surface spectral units shown in the schematic map in Figure 2 were defined by (2) on the basis of spectral variation using the first 51 even channels. In this approach, each pixel in the image data is modelled as a linear combination of 2 endmembers chosen from within the window. One endmember is selected from the bright materials in the Isidis basin and one from the dark materials on the eastern part of Syrtis Major indicated by E1 and E2 in Figure 1. Pixels most accurately modelled by these endmembers (low total variance, random error as a function of wavelength) comprise the Isidis and Syrtis East units. The other units have high variance and/or show non-random variations in error as a function of wavelength (residual spectra). Careful examination of the residual spectra and the magnitude of the variance led (2) to define the other 3 units shown in Figure 2.

The correlation of the spectral units with the broad scale surficial geologic and geomorphic features is discussed in in detail by (2). Briefly, the Isidis unit is associated with bright deposits in the Isidis basin, the Cratered unit is associated with the rim of the Isidis basin, and the Arabia unit in the extreme north-west corner of the window corresponds with the edge of the cratered highlands. Two distinct units are recognized on the Syrtis Major plateau; an eastern and a western unit. Although the residual spectra are used to define these units, all spectral features identified are relative to the endmember spectra and direct compositional interpretations are difficult.

Calibration of ISM Spectra: The ISM data are initially calibrated using pre and inflight engineering data, an assumed average spectral response of Phobos and applying a preliminary atmospheric correction based on the strength of the 2.0 µm CO_2 absorption band (3). An additional calibration was applied to these data by assuming regions of homogeneous bright surface material have the same spectral properties as average bright terrain measured telescopically (4). Average telescopic data for bright regions were smoothed and resampled to ISM wavelengths. The region of the ISM data selected for this calibration is indicated by STD in Figure 1. This calibration approach is not an absolute measure of reflectance and subject to possible errors in the choice of reference spectra and the spectral properties of the surface calibrated to. This procedure surpresses features common to all surfaces but not in the reference spectrum.

Interpretation of Spectra Units: Typical spectra from each of the spectral surface units shown in Figure 2 are presented in Figure 3. The primary spectral features which distinguish these units are albedo, slope and the nature of the absorption band between 0.8 and 1.2 µm. The character of the absorption band is particularly important because it provides information regarding the composition of the surface. In the spectra of the bright terrain units, the band shape and position (near 0.9 µm) is relatively constant and is characteristic of Fe^{3+} absorptions observed in predominantly dust covered regions (4, 5). The primary spectral differences between the bright terrain units are the slope of the spectrum and slight variations in the position and shape of the 0.9 µm ferric absorption band. Whether the sources of the observed spectral variations are compositional, textural, or otherwise is unclear, however they do define spatially coherent units which are associated with morphologic and geologic features (2).

The shape and position of the absorption centered near 1.0 µm in the spectra of the Syrtis Major units is indicative of Fe^{2+} crystal field absorptions in mafic minerals. To de-emphasize albedo relationships and visually enhance absorption features, the spectral segments for the Syrtis Major units and the Isidis unit are divided by a simple straight line continua and are presented in Figure 4. The shape of the 1.0 µm band for the Syrtis units, and in particular the width of the bands, suggest that multiple mafic minerals contribute to the measured reflectance. In addition to the 1.0 µm band, there is a broad band centered near 2.1 µm. The presence of this feature together with the 1.0 µm band is strong evidence that high calcium pyroxene is present in the volcanic materials of Syrtis Major, the presence of which was previously proposed by (6) based on the shape of the 1.0 µm band alone. A principal distinguishing feature of the Syrtis Major units is the slope of the spectra towards long wavelengths; Syrtis East has

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a decrease in reflectance towards longer wavelengths while Syrtis West is relatively flat. It is unknown at this time whether this is a weathering or surface coating phenomenon, or a fundamental mineralogic difference.

A significant degree of spectral variation exists in these data which was used to define units by (2). The principal distinguishing spectral characteristics between units are albedo, slope, and nature of the 1.0 μm band. In the units of Syrtis Major, the presence of clino pyroxene is clearly indicated as well as additional unresolved mafic mineral. We are currently in the processes of refining the calibration and also incorporating odd channels into the analysis to increase the spectral resolution and help resolve some of the remaining compositional ambiguities.

References: (1) Bibring et al, *Nature 341*, 1989. (2) Erard et al, *LPSC XXI* (this volume) 1990. (3) Erard et al, *Bull. Am. Astron. Soc. 21*, 1989 (4) McCord et al, *JGR 87*, 1982 (5) Singer, *JGR 87*, 1982 (6) Singer, *LPSC XI*, 1980.

Figure 1. Area covered by the ISM data for the Isidis-Syrtis Major window. The actual image is 26 by 116 pixels and a typical pixel to scale is indicated by the white arrow. The location for the reference spectra (E1 and E2) and the standard area (STD) are also indicated.

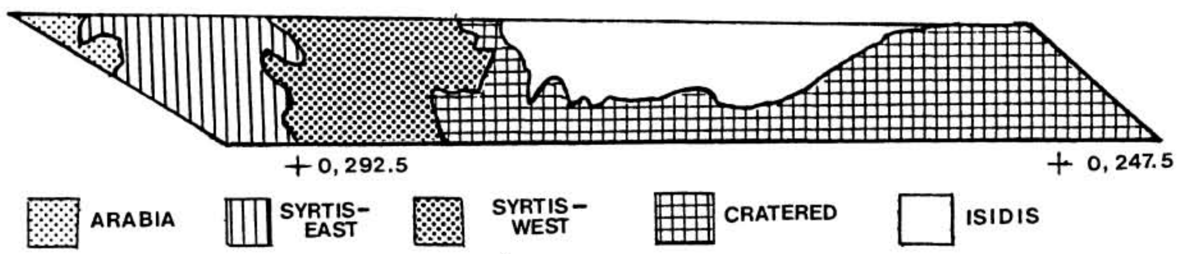
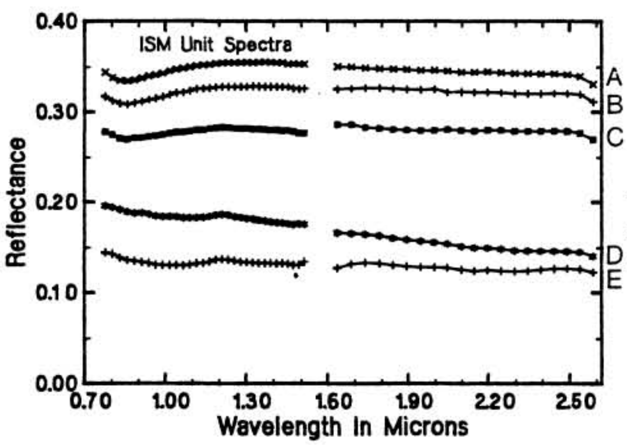


Figure 2. Schematic map for the above window of spectral units defined by (2) using the spectral characteristics of the first 51 channels of the ISM data.



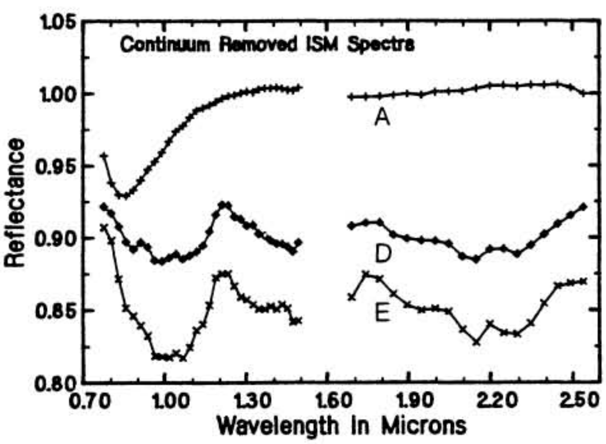


Figure 3. Calibrated ISM spectra typical of the units shown in Figure 2. A) Isidis B) Cratered Highlands C) Arabia D) Syrtis East E) Syrtis West.

Figure 4. Spectra of the units Isidis (A), Syrtis East (B) and Syrtis West (C) after removing a simple straight line continuum for each segment. These spectra are offset 5% relative to each other for clarity.