

MARS SURFACE MINERALOGY FROM HUBBLE SPACE TELESCOPE MULTISPECTRAL IMAGING: 1994 PRE-OPPOSITION DATA; J.F. Bell III (NASA Ames Research Center, Moffett Field CA), P.B. James (University of Toledo, Toledo OH), L.J. Martin (Lowell Observatory, Flagstaff AZ), R.T. Clancy and S.W. Lee (LASP/University of Colorado, Boulder CO), and D. Crisp (JPL/Caltech, Pasadena CA).

As part of a long-term program of Hubble Space Telescope (HST) monitoring of Mars atmospheric phenomena [e.g., 1, 2], multispectral images of Mars are being obtained during the 1994-1995 apparition using the newly-installed WF/PC-2 camera and its corrective optics. Imaging began in August 1994 ($L_S = 335^\circ$, late northern winter) when Mars exceeded the 50° solar elongation limit required by HST. Sequences of images are being acquired approximately once per month through five specific filters (wavelength in nm): f255w, f336w, f410m, f502n, and f673n. Because of severe limitations in the amount of HST time granted for this project, we have been forced to concentrate on only one hemisphere of Mars, centered approximately on the Syrtis Major region. The spatial resolution of the images ranges from 65 km/pixel at the sub-Earth point in August 1994 to 24 km/pixel at closest approach in February 1995. This resolution exceeds by far the capabilities of groundbased observatories, especially during this rather poor opposition. Thus, in many ways, this data set is comparable to the images obtained during the Mariner and Viking far-encounter mission phases, and has a maximum resolution that is almost identical to that of the Phobos-2 ISM data. In addition, the data can be accurately calibrated to flux units without the usual interference of H_2O , O_2 , and other gases in the terrestrial atmosphere (Fig. 1).

This abstract reports initial results from one aspect of this Mars monitoring program; specifically, the attempt to glean as much mineralogic information as possible from this predominantly meteorology-oriented data set. There are a number of rocks and minerals that have previously been detected or can reasonably be expected to occur on Mars and which have diagnostic absorption features in the long-wave UV to visible (≈ 250 -700 nm) [e.g., 3, 4]. Most of these materials are ferric (Fe^{3+}) oxides or oxyhydroxides, because the most spectrally active cation at these

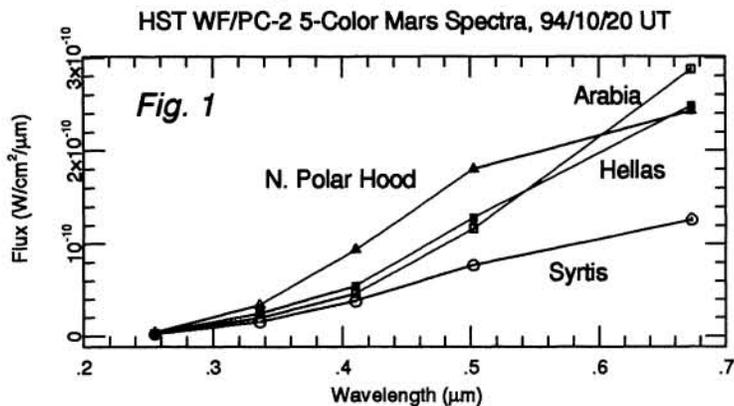


Fig. 1: Calibrated Mars spot spectra extracted from the registered October 1994 HST imaging sequence.

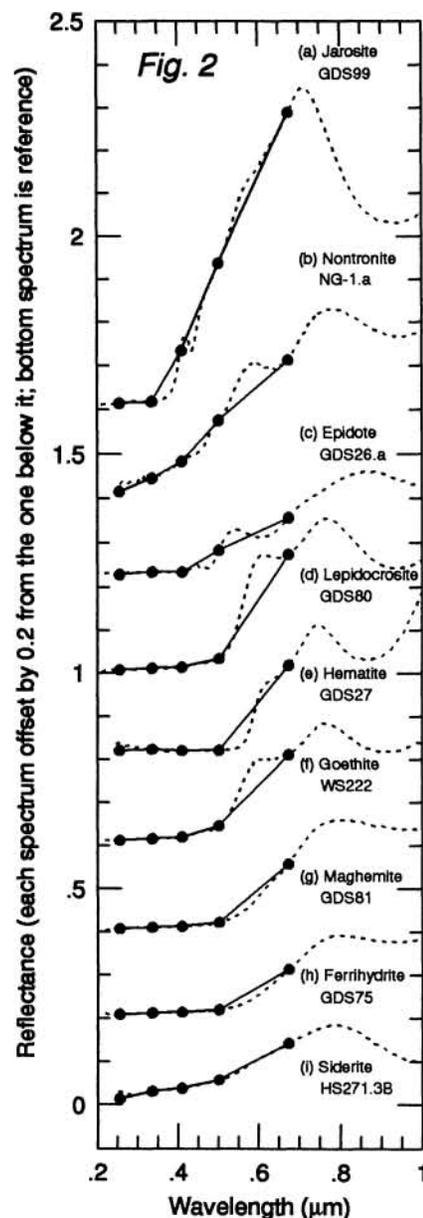


Fig. 2: 5-color spectra of ferric materials convolved over our HST filter set (solid lines and points); The full-resolution spectra from [6] are also shown (dashed lines).

wavelengths is iron. However, several sulfur- and carbonate-bearing species and clays or Fe^{3+} -bearing silicates could also be detected [5]. Unfortunately, our current image sets do not go to long enough wavelength to allow unique detection of ferrous (Fe^{2+}) silicates like pyroxene or olivine. Attempts to detect and spatially map those and other minerals will be conducted at opposition in February 1995 and during HST Cycle 5. A subset of laboratory mineral spectra representing the types of materials that can be detected in our pre-opposition data is shown in Figure 2, where the spectra [6] are shown at full spectral resolution and also convolved over the bandpasses of the HST filters listed above. The convolution demonstrates that although the 5 filters being used are not optimized for mineralogic detection, several could still yield diagnostic information on certain mineralogic absorption features. Specifically: (a) the 410/336 nm ratio appears to be able to discriminate minerals like jarosite, nontronite, and siderite (ratio > 1) from most of the iron oxides/oxyhydroxides (ratio \leq 1); (b) the 410 nm and 502 nm continuum-removed band depth values [7] should be a sensitive indicator of the presence of well-crystallized ferric-iron-bearing phases; and (c) for those areas exhibiting higher crystallinity, the 502/410 nm ratio may be able to distinguish between anhydrous iron oxides (hematite, maghemite; ratio \approx 1) and the hydrated oxyhydroxides (goethite, lepidocrocite; ratio > 1). We have conducted several preliminary tests to search for evidence of variability in these spectral parameters that could possibly be caused by specific surface mineralogies.

Results: (a) We see no clear evidence in the October 1994 data (the highest spatial resolution available as of late 1994; \approx 51 km/pixel) of surface regions in the Syrtis hemisphere exhibiting anomalously low 410/336 nm ratios that could be uniquely indicative of large deposits of pure, well-crystallized ferric oxides or oxyhydroxides (Fig. 3). The north polar hood and cap regions do show anomalous spectral behavior, but this is most likely due to Rayleigh scattering by atmospheric CO_2 and/or the spectral character of water and/or CO_2 ice and clouds, rather than to surface minerals. (b) Both the 410 and 502 nm band depth maps (Figs. 4, 5) show a high correlation with albedo (increasing albedo \Rightarrow deeper band depth). Bright regions have distinctly concave spectra near 410 and 502 nm, dark region spectra are distinctly convex (Fig. 1). Two-dimensional histograms show that there is substantial mixing between bright and dark materials, but there is little evidence for anomalous (non-polar) units.

Additional analyses of these images, using these methods and others like spectral mixing and principal components, are ongoing. Higher spatial resolution data will be obtained in 1995 at more mineralogically-appropriate wavelengths, yielding more useful data for quantifying the distribution and specific mineralogies of ferric-iron-bearing (and other) minerals on Mars.



Fig. 3: 410/336 nm ratio image. Oct. 20, 1994 1200UT data. Black = 1.9, White = 2.7. The north pole is at 11:00; sub-earth lat = 18° , lon = 285° .



Fig. 4: 410 nm band depth map. Black = 0%, White = 35%. Band depth was defined relative to a linear continuum between 336 and 502 nm.

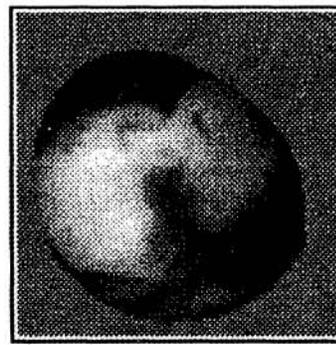


Fig. 5: 502 nm band depth map. Black = -25%, White = +25%. Band depth was defined relative to a linear continuum between 410 and 673 nm.

References: [1] James, P.B. *et al.*, *Icarus*, 109, 79-101, 1994. [2] Clancy, R.T. *et al.*, *B.A.A.S.* 24, 1007. [3] Bell III, J.F. *et al.*, *J. Geophys. Res.*, 95, 14447-14461, 1990. [4] Soderblom L.A. In *Mars*, ed. H. Kieffer *et al.*, pp. 557-593. Tucson: Univ. Arizona Press, 1992. [5] Bell III, J.F., *Icarus*, 100, 575-597, 1992. [6] Clark R.N. *et al.*, The U.S.G.S. Digital Spectral Library: Version 1: 0.2 to 3.0 μm . U.S. Geol. Surv. Open File Report 93-592, 1993. [7] Bell III, J.F. and D. Crisp, *Icarus*, 104, 2-19, 1993.