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HIGH RESOLUTION VISIBLE TO SHORT-WAVE NEAR-INFRARED CCD SPECTRA OF MARS DURING 1990; James F. Bell III (NRC/NASA Ames, Moffett Field CA), Karl Bornhoeft (PGD/SOEST, Univ. of Hawaii), and Paul G. Lucey (PGD/SOEST, Univ. of Hawaii)

The 0.4 to 1.0 μm spectrum of Mars is dominated by a steep red, relatively featureless spectral slope. Earlier lower spectral resolution observations [*e.g.*, 1-3] interpreted the red color and the lack of absorption features in the spectra as evidence of poorly crystalline ferric oxide minerals. More recent higher spectral resolution observations and re-interpretations of older data sets have revealed measurable spectral structure, however [4-7]. For example, absorption features near 0.65 and 0.86 μm were detected and spatially mapped in data obtained during the 1988 opposition. These absorptions were interpreted as evidence for crystalline hematite on Mars, occurring as an accessory phase in abundances of 3-6% in the soil. We are attempting to verify the existence of these subtle crystalline Fe^{3+} absorption features and to map their spatial distribution in regions of the planet not imaged in 1988.

During the 1990 opposition, we obtained imaging spectroscopic data of Mars from the University of Hawaii 2.24 m telescope at Mauna Kea Observatory [8]. The data were obtained with the Wide Field Grism Spectrograph (WFGS), a facility instrument operated by the Institute for Astronomy at the University of Hawaii. WFGS uses an 800×800 CCD and a transmission grating ruled on a prism. We used a grating blazed at 4800 Å in first order to obtain data from 0.50 to 0.94 μm at a spectral resolution of R = 200 to 350. WFGS is a field widened spectrograph that can accommodate a variety of user-designed slits. Our Moon/Mars slit design had projected dimensions of 0.29" × 153", allowing for high spectral resolution and adequate cross-slit spatial sampling of the Martian disk. A typical Mars image cube consists of approximately 20×30 spatial pixels at ≈ 160 useful wavelengths.

On 9-10 November 1990 UT we obtained 11 image cubes of all or parts of the Martian disk centered near 100-140° W longitude. Mars subtended 17.8" during this time, was at a phase angle of 17°, and the season was late northern winter (L_s = 330°). We also obtained 10 scans of the standard star κ Cetus (Type G5V, M_V = +4.82) and numerous bias and flatfield calibration frames. As an aid in reconstruction of the slit-scan images, we also obtained a number of red filter CCD images of Mars with the grism out of the path. Wavelength calibration was performed using Hg-Cd-Zn and Ne calibration lamps.

Data reduction procedures are similar to those used for 1988 WFGS data described previously [9, 10]. These procedures include bias and dark current removal, flatfield (pixel-to-pixel non-uniformity) corrections, assembly of the individual slit positions into image cubes, and spatial reconstruction of the imaging data.

Table 1. 1990 Mars MKO/WFGS Imaging Spectroscopic Observations

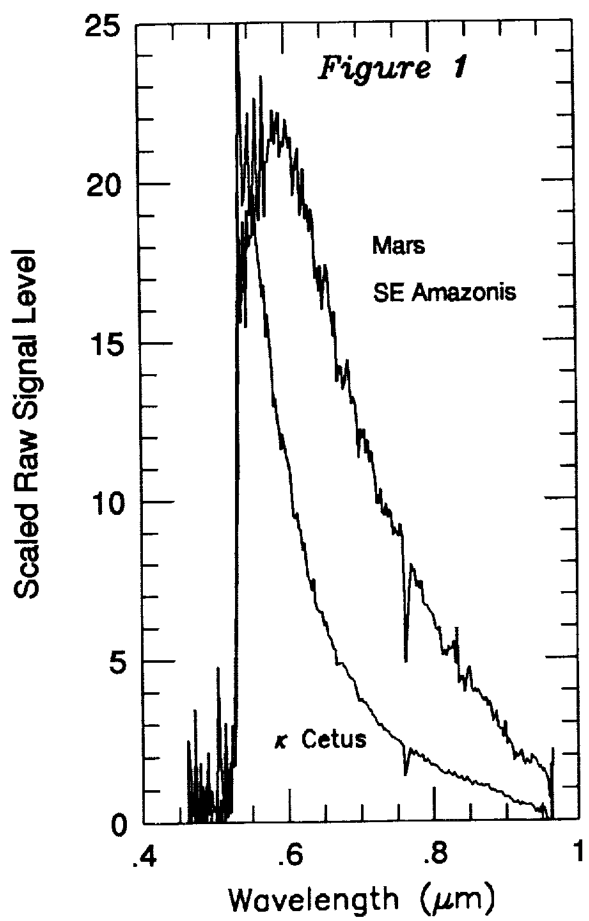
Date (UT)	Ls	Phase	# Mars Cubes	# Spectra	# Star Cubes	# Spectra
9 Nov. 1990	330°	17°	5	≈4000	4	≈30
10 Nov. 1990	330°	16°	6	≈6000	5	≈35

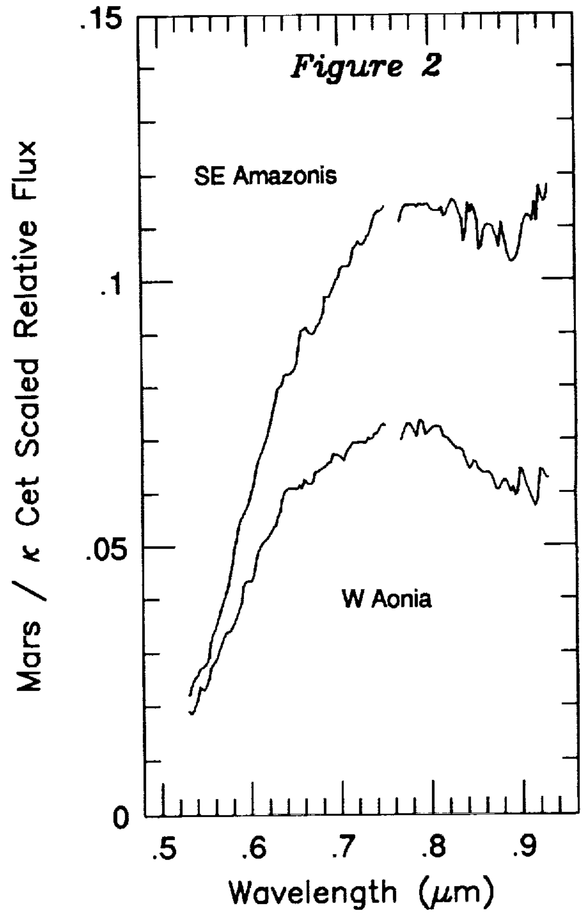
Figure 1 shows an example of the raw data obtained on 11/9/90 UT for a Mars bright region in southeast Amazonis and for the standard star κ Cetus. These data have had bias and flatfield corrections applied. A number of high frequency features can be seen in the spectra, some of which are associated with poor signal to noise at the shortest wavelengths and some of which are due to absorptions in the Earth's atmosphere or in the Solar or κ Cet spectra [*e.g.*, 11].

Figure 2 shows some representative bright and dark region spectra extracted from the same image cube as Figure 1. The spectra are (Mars / κ Cet), which is a good approximation of (Mars /

Sun) as κ Cet is a G class main sequence star with a spectrum described as "very close to solar" by Hardorp [12]. The spectra have been smoothed slightly using a gaussian convolution program in order to eliminate some of the high frequency noise.

Several interesting features are immediately apparent in the spectra of Figure 2. First, both bright and dark regions exhibit the characteristic red slope typical of Mars. Second, absorption features are evident near 0.6 to 0.7 μm and 0.8 to 0.9 μm in both spectra. The longer wavelength band is centered near 0.867 μm (derived using a 2nd order polynomial fit) in the bright region and near 0.893 μm in the dark region. And finally, the dark region spectrum exhibits a more negative spectral slope in the 0.75 to 0.94 μm region than the bright region. These observations are consistent with the interpretations that (a) the bright regions exhibit a ferric spectral signature due to a small amount of crystalline hematite (having bands near 0.65 and 0.86 μm) in a matrix of a much more poorly crystalline ferric phase that primarily accounts for the color [*e.g.*, 4,5] and (b) this particular dark region also exhibit much of this ferric character but also shows evidence of absorption at slightly longer wavelengths that would be expected for more ferrous-bearing compositions. Evidence will be sought in the data for additional compositional heterogeneity among and between bright and dark regions.





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