Earth-Based Telescopic Observations of Mars in the 4.4 μm to 5.1 μm Region. **Diana L. Blaney and Thomas B. McCord. Planetary Geosciences Division, Hawaii Institute of Geophysics, 2525 Correa Rd. Honolulu, HI 96822.**

Measurements. The telescopic measurements of Mars reported here were made on August 19, 1988 UT at the NASA IRTF facility. Spectra were obtained with the Cooled Grating Array Spectrometer (CGAS) which utilizes a thirty-two element InSb line array with a resolution of R=300. Measurements were made by taking data at two different grating positions, with an eleven channel overlap between positions. Segment 1 covered 4.405 μm - 4.86 μm, and segment 2 covered 4.67 μm - 5.13 μm. Spectra were normalized to unity at 4.71 μm and were reduced using the star BS437 as a standard. A 2.7 arc-second aperture was used, producing a spot size 900 km in diameter at the sub-earth point. The measurements were taken as part of a sequence of measurements which also covered the wavelength region between 3.2 μm and 4.2 μm using three grating positions discussed(1).

The Martian atmosphere has a large number of atmospheric absorptions from both CO and CO2 in the wavelength region between 4.4 μm and 5.1 μm in addition to significant thermal components. These complications must be considered in the interpretation of the spectra.

Detection of an Absorption Feature at ~4.5 μm--Indication of Sulfates. A modeled atmospheric spectra (PCO2 =7 mbar, T=240K, CO/CO2=0.002, Airmass = 2.0) based on atmospheric models by Encrenaz is plotted over the spectra from the Argyre region (Figure 1). Note that all the atmospheric absorption features (shown with arrows) are clearly present in the telescopic data and that most features appear to be weaker than predicted by the model. The exception to this is the rise out of the 4.2 μm - 4.4 μm CO2 absorption which has a much shallower slope in the telescopic data than in the model atmosphere spectra. In addition to this gradual slope, an inflection at 4.5 μm is present in all the spectra and is extremely well defined in the Eastern Solis Planum and Argyre spectra (Figure 2). These measurements indicate that a surface absorption, centered near 4.5 μm, is present on the Martian surface.

The wavelength region between 4.4 μm and 5.1 μm contains sulfate absorptions, shown in figure 3a, for anhydrite, gypsum, and MgSO4, with the the 2v3 vibrational overtone of the SO4-2 anion being centered at 4.5 μm.

The multiband structure seen in the sulfate spectra is produced by the metal cation complexing with the SO4 -2 lowering the symmetry of the sulfate. The lower symmetry causes degeneracy in the v3 and v4 modes, and the appearance of the v1 and v2 modes which are not infrared active under the tetrahedral symmetry that the SO4 -2 anion occupies. Unfortunately the Mars atmosphere cuts off the short wavelength portion of the absorption. The sulfates shown in figure 3a are shown in figure 3b at the resolution and wavelength of the telescopic data. Note that there does not appear to be any of the structure associated with the sulfates shown above in figures 3 a and b present in the telescopic data.

The location of this feature at 4.5 μm, the 2v3 SO4 overtone, is especially exciting as the Viking lander sites detected large quantities of sulfur (~7 wt% SO3) in the Martian soils. The sulfur content was highly variable even at a local level. Sulfur abundance ranged from 5.9 wt% to 9 wt% SO3 at Chryse and from 7.6 wt% to 8.5 wt% SO3 at Utopia (2).

Spatial Variation in the 4.5 μm band depth -- Implications for sulfate distribution. In order to isolate atmospheric effects from surface absorptions we compared spectra which had the same 3.81 μm band depth. The 3.81 μm band is caused by CO2 with 16O and 17O (1). The isotopically heavy CO2 absorption provides an indicator, independent of possible sulfate absorption, of the similarity of atmospheric conditions of the various spectra. The spectra for the regions Valles Marineris, Argyre Basin, Eastern Solis Planum and Eastern Tharsis (figure 2) all have 3.81 μm band depth between 3.1% and 3.3%.

In comparing the Valles Marineris, Argyre Basin, Eastern Solis Planum and Eastern Tharsis spectra, the 4.5 μm inflection discussed above is probably the strongest indicator of sulfate abundance. In order of strength of deepest absorption to weakest the regions are ordered 1. Eastern Solis Planum, 2. Argyre Basin, 3. Eastern Tharsis, and 4. Valles Marineris, although in no spectrum does the rise out of the carbon dioxide band match the atmospheric model. A note of caution must be offered in taking this approach to estimating relative sulfate abundance as the strength of the 4.5 μm band could indicate not only the abundance but changes in mineralogy and degree of crystallization. However, the four regions do follow a progression due to either sulfate abundance or chemistry and there is significant variation between regions shown in figure 2.

Conclusions. The rise out of the 4.2 μm - 4.4 μm CO2 band cannot be matched by solely atmospheric constituents. A surface absorption must be added at roughly 4.5 μm in order to decrease the reflectance rise and produce the 4.5 μm inflection which is present in the data. The known presence of sulfates on the Martian surface and the location of this feature at the 2v3 overtone of the SO4 -2 anion indicate that the surface absorption is probably caused by sulfates on the Martian surface. An exact match to a terrestrial sulfate mineral has not been made but it is suggested that the mineral has very weak structure and thus a high degree of symmetry . Significant variation exists between the spectra at 4.5 μm. In order of strength of deepest absorption to weakest the regions are ordered Eastern Solis Planum, Argyre Basin, Eastern Tharsis, and Valles Marineris for the four regions measured at similar Mars atmospheric conditions.

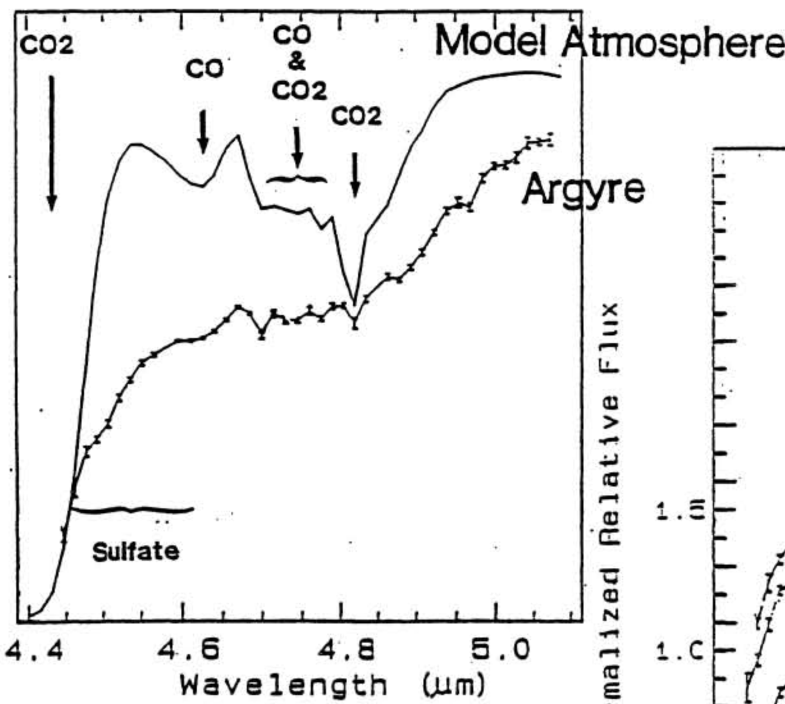

Figure 1. Representative spectra (Argyre region) and Mars model atmosphere of 7 mbar, 2 airmass, 240K, and CO / CO2 with atmospheric and surface absorptions labeled.

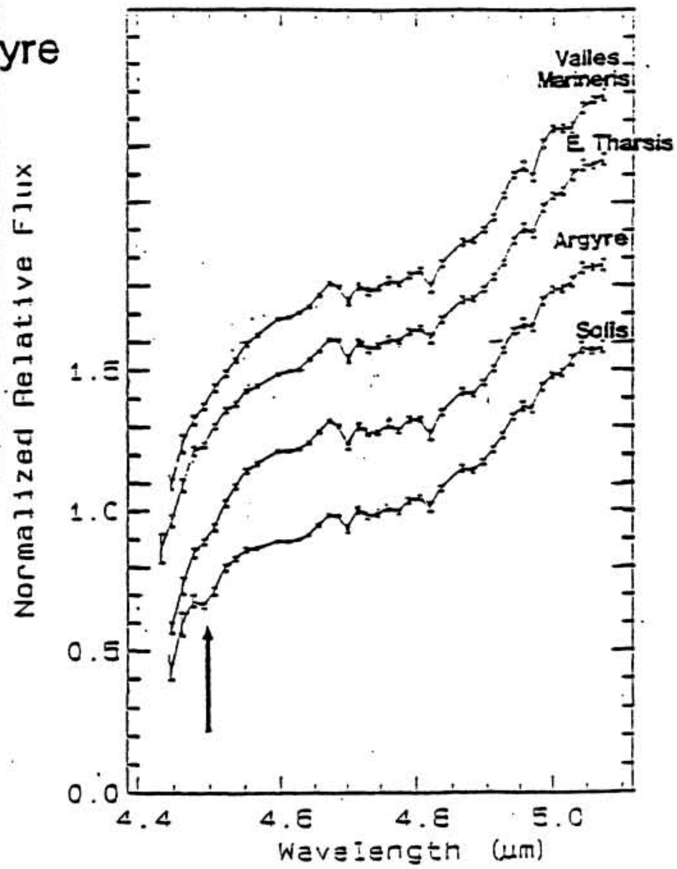

Figure 2. Spectra for four regions with similar 3.81 µm band depths. Regions are Eastern Solis Planum, Ridged Plains, Heavily Cratered Terrain; Argyre Basin; Eastern Tharsis; and Valles Marineris. Spectra are arranged in order of 4.5 µm band depth.

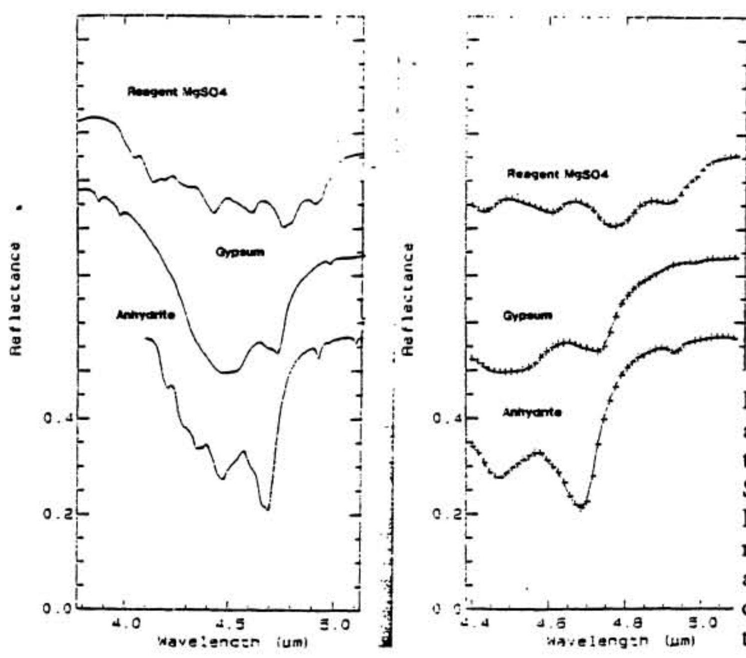

Figure 3 a. Reagent MgSO4, gypsum, and anhydrite reflectance spectra. Spectra are relative to sulfur and have a grain size of <34 µm. Spectra measured at 2 cm^{-1} resolution. b. Reagent MgSO4, gypsum, and anhydrite reflectance spectra. Spectra are relative to sulfur and have a grain size of <34 µm. Spectra convolved and interpolated to wavelengths of the telescopic observations.

References: 1. Blaney D.L. and T.B. McCord submitted to *J. Geophys. Res.* 1990. 2. Clark, B.C. et al. *J. Geophys. Res.* 87, 10,059-10,068, 1982.