

CAN IRON OXIDE/OXYHYDROXIDE MINERALS BE IDENTIFIED ON THE MARTIAN SURFACE FROM GROUND-BASED VIS-NIR SPECTRA? Jim Bell and Tom McCord, Planetary Geosciences, Univ. Hawaii, Honolulu 96822; BITNET: jimbo@uhpgvax.pgdl.hawaii.edu

Visible to Near-Infrared (VIS-NIR) reflectance data of numerous regions on Mars were obtained during the 1988 opposition at Mauna Kea Observatory. A Circular Variable Filter (CVF) spectrometer was used to acquire data of 41 regions on the planet from 0.4-1.0 μm . The spatial resolution of these observations was approximately 500-600 km, the spectral resolution was $R = \lambda/\Delta\lambda \approx 80$, and the spectral sampling was $S \approx 125$ channels/ μm [Bell *et al.*, 1989].

The new CVF data show abundant evidence (some previously observed, some not) of the existence of the Fe^{3+} cation on Mars. First, there is the strong and diagnostic $\text{O}^{2-} \rightarrow \text{Fe}^{3+}$ near-UV charge transfer absorption edge which is typical of ferric-bearing minerals [*e.g.*, Sherman *et al.*, 1982]. This deep blue absorption is primarily responsible for the red color of Mars and also led numerous early workers to speculate on the existence of iron oxides on the martian surface. Second, there is a weaker though clearly discernible absorption band from 0.78-0.94 μm , centered at ≈ 0.85 μm in many of the spectra. This band has been interpreted by several groups as being due to the ${}^6\text{A}_1 \rightarrow {}^4\text{T}_1({}^4\text{G})$ ligand field transition of Fe^{3+} [Singer, 1982; Morris *et al.*, 1989; Bell *et al.*, 1989], indicating the presence of some crystalline iron oxide component in the Mars soil. This contention is further supported by the third piece of evidence, a heretofore undetected weak band or "cusp" at 0.61-0.72 μm that is interpreted as being due to the ${}^6\text{A}_1 \rightarrow {}^4\text{T}_2({}^4\text{G})$ electronic transition of Fe^{3+} . This weak feature is typically deepest in spectra of brighter regions on the planet. Thus these new data indicate unambiguous evidence of Fe^{3+} absorption; the question as posed above is whether or not the positions and strengths of these absorptions can be used to identify surface Fe^{3+} mineralogy.

Some of these new data are compared directly to laboratory Fe^{3+} -bearing mineral spectra in Figures 1-3. It can be immediately seen that the position and strength of the near-UV charge transfer absorption edge places severe constraints on the abundances of several of these *pure* iron oxides in certain particle size ranges. For example, the hematite powder in Figure 1 exhibits a steep, saturated near-UV absorption with the band edge near 0.55 μm , typical of most bulk crystalline hematites and a poor match to the martian spectral data. It can be seen that none of the other common iron oxides/oxyhydroxides in Figure 1 reproduce the shape and position of the near-UV absorption either. The less common and also more poorly crystallized Fe^{3+} phases in Figure 2 come closer to matching the absorption edge position and shape, yet there are still discrepancies except for the spectrum of synthetic iron-silica gel which provides a fair match. The similarly poorly crystalline "amorphous" palagonites in Figure 3 also provide a good fit to the absorption edge. Based on this simple examination of these particular lab data, it appears that poorly crystalline (*not* amorphous) materials exhibit the best match to the VIS-NIR martian data based solely on the highly diagnostic near-UV charge transfer absorption.

As mentioned above, however, two *crystalline* Fe^{3+} absorption bands are evident in the new Mars data. Figure 3 clearly shows that most "amorphous Hawaiian soils" such as those examined by Singer (1982) do not exhibit Fe^{3+} bands as deep as those in the Mars data, suggesting then that although poorly crystalline materials constitute an important part of the Mars soils, some component of well crystallized, bulk Fe^{3+} -bearing mineral(s) exist and produce those features. A more quantitative estimate of the partitioning of crystalline vs. poorly crystalline Fe^{3+} phases is in progress.

A quick look at the variation in band strengths and positions of the two VIS-NIR Fe^{3+} electronic transition bands in the lab data of Figures 1 and 2 suggests that the answer to the question posed in the title is "yes." The increased spectral sampling of these new data combined with ongoing lab analog studies and refined data calibration suggest that at least hematite, and possibly also goethite, existing in a wide range of particle sizes down to nanometer scales, may be important constituents of the Mars soil. Other possibilities which must not be overlooked without further study include Fe^{3+} -bearing sulfates, palagonite-like secondary weathering products, and some of the more exotic, poorly crystalline iron oxides/oxyhydroxides.

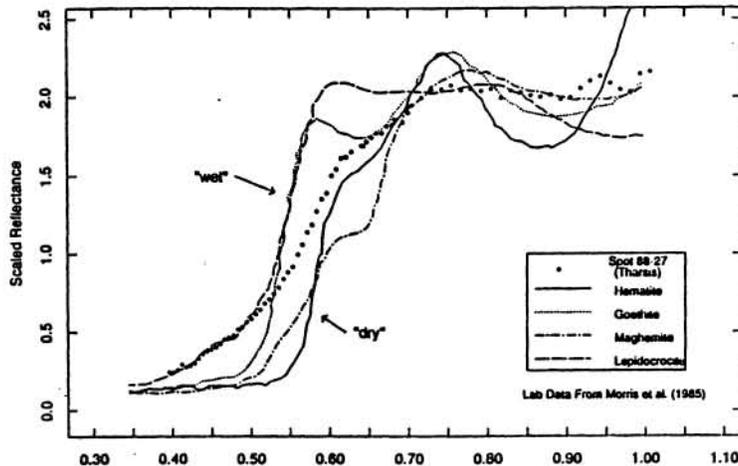
MARS Fe^{3+} MINERALS: Bell, Jim and McCord, T.B.

Figure 1: Mars CVF spectrum 88-27 (Tharsis region) from Bell *et al.* (1989) compared to four common iron oxides/oxyhydroxides. The lab data are from powdered samples of Morris *et al.*, 1985. The wet/dry distinction simply refers to the presence or lack of OH^- radicals in the mineral structure. Note the poor fit of the Mars data to the lab near-UV charge transfer absorptions and the variation of position of the two Fe^{3+} electronic transitions at $0.65 \mu\text{m}$ and $0.86 \mu\text{m}$ in the lab data. Data scaled for display purposes.

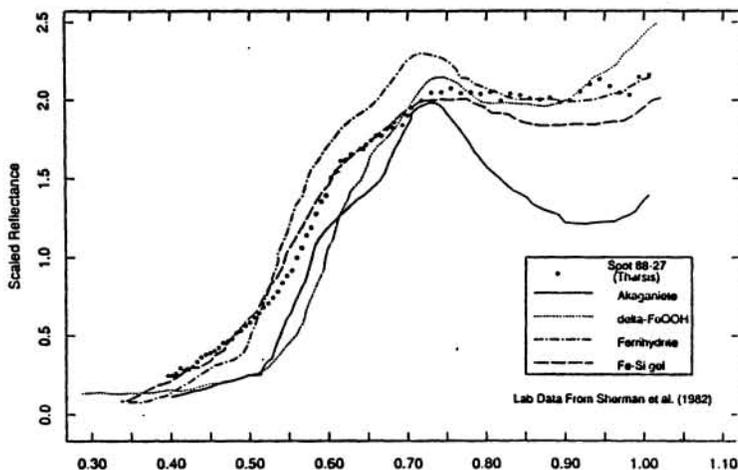


Figure 2: Same Mars data as Figure 1 compared to some less common and poorly crystalline iron oxides/oxyhydroxides from Sherman *et al.*, 1982. The near-UV charge transfer edge is more closely matched in these data although there are still discrepancies. Data digitized and scaled for display purposes.

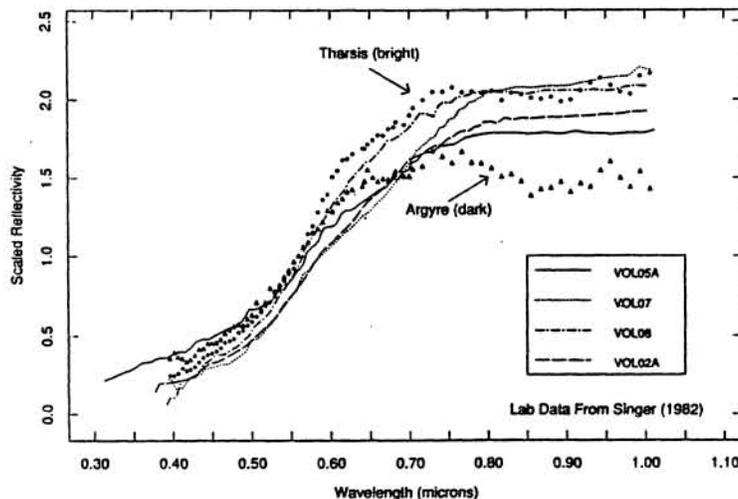


Figure 3: Mars CVF data from bright (Tharsis) and dark (Argyre) albedo regions compared to hawaiian palagonite spectra of Singer (1982). The position of the near-UV charge transfer edge is matched nicely, however the palagonites show little evidence of the crystalline Fe^{3+} absorption bands seen in the Mars data. Data digitized and scaled for display.

References:

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