THERMALLY ALTERED PALAGONITIC TEPHRA AS A MARTIAN SOIL ANALOG?; James F. Bell III, (Planetary Geosciences Division, Univ. Hawaii, Honolulu), Richard V. Morris (SN2, NASA/JSC, Houston), and John B. Adams (Dept. of Geology, Univ. Washington, Seattle).

Introduction: The visible to near-infrared (VIS-NIR, 0.4-1.0 µm) spectrum of Mars has been measured extensively over the past 30 years at moderate spectral resolution ($R = \lambda/\Delta\lambda$ = 5-20) but has been measured at relatively high resolution ($R \approx$ 80-350) only recently [1,2]. These new high resolution data show evidence of crystalline hematite (αFe_2O_3) in both classical bright and dark regions on Mars, with a good correlation between albedo and hematite band depth. However, the Fe^{3+} electronic transition bands at 0.66 µm and 0.86 µm that have been detected are weak compared to those found in pure mineral phases, and the near-UV O^{2-}->Fe^{3+} charge transfer edge has a more shallow slope. This argues that a significant part of the ferric iron mineralogy must also be in the form of poorly crystalline or amorphous materials that have spectral properties similar to terrestrial palagonites [1,3-7]. We have studied a suite of thermally altered palagonitic tephra from Hawaii that exhibit the dual behavior seen in the new Mars data: a smooth, unsaturated charge transfer band in the 0.4-0.6 µm region and distinct though weak crystalline absorption bands near 0.66 µm and 0.86 µm.

The materials studied here were obtained in 1987 from the Puu Huluhulu cinder cone on the Big Island of Hawaii (2040 m level, just SW of the 27 mile marker on the Saddle Road). The south side of the cone has been partially quarried, exposing a steeply dipping lava dike which has intruded and baked the surrounding cinders. The altered tephra grades from bright reddish-orange within 0.5 m of the dike to dark tan-brown at 2 m away. Samples were obtained at approximately 30 cm intervals perpendicular to the dike. The samples were wet seived in freon into 9 size fractions ranging from > 2 mm to < 20 µm. Analyses performed included water determinations, saturation magnetization (J_s), and Mossbauer and reflectance spectroscopy.

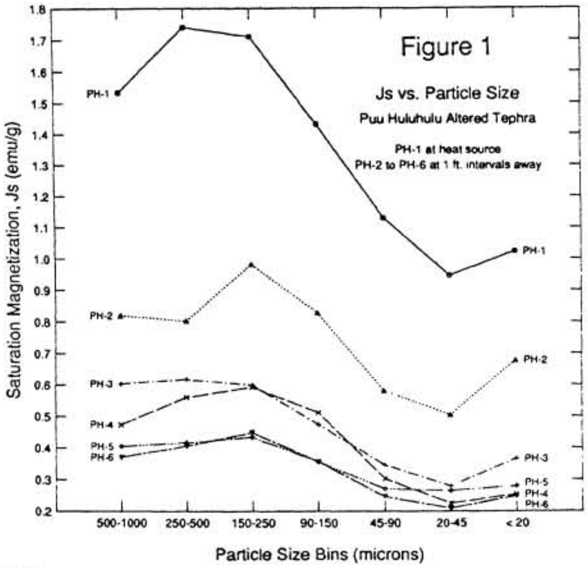
Physical Measurements: The samples closest to the lava dike heat source were found to have a much higher percentage of fine particles than the samples from farther away, consistent with the brightness gradient and the fact that the particles closest to the dike have undergone the most alteration. Water analysis revealed that both bound (H_2O^+) and adsorbed (H_2O^-) water is depleted by 8-10% in the samples closest to the dike, and that this depletion is mostly confined to a sharp zone within the first 30 cm from the dike.

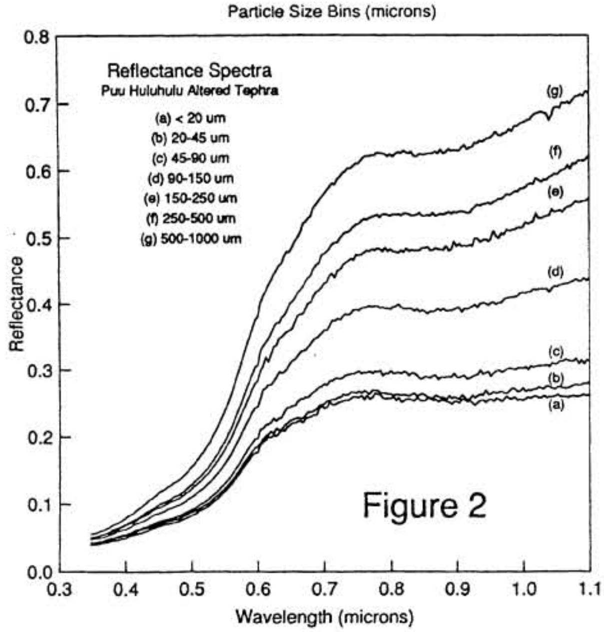
Magnetic Measurements: The saturation magnetizations (J_s) for all size fractions were determined using a vibrating sample magnetometer in fields up to 21 kG. Figure 1 shows the variation in J_s with particle size for each of the tephra samples. There is a definite gradient of increasing J_s approaching the dike, which implies that the increase is associated with the thermal event at the dike. However, the mineralogy of the magnetic phase responsible for this increase in J_s is unknown at this time.

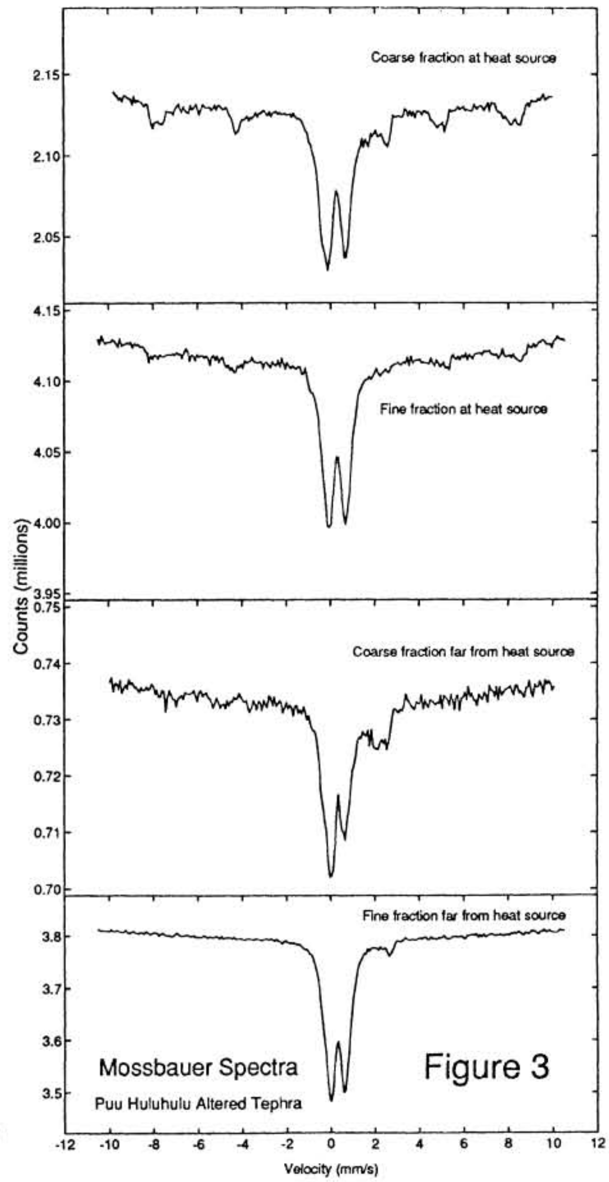
Mossbauer Spectroscopy: Mossbauer spectra were obtained using Ranger Scientific spectrometers. Figure 3 shows spectra from coarse and fine size fractions from samples close to and far from the lava dike. The coarse fraction at the heat source shows a relatively strong hematite sextet, and there is a weak indication of a sextet in the fine fraction. The spectra from the unaltered sample 2 m from the heat source show little or no evidence of a hematite sextet.

Reflectance Spectroscopy: Reflectance data (0.35-2.2 µm) were obtained using a Cary-14 ratio recording spectrophotometer with Halon as the standard. Figure 2 shows the 0.35-1.10 µm reflectivity of the sample closest to the heat source. All size fractions show a deep near-UV O^{2-}->Fe^{3+} absorption and 0.8-1.0 µm and 0.6-0.7 µm crystalline Fe^{3+} absorption features (the 0.6-0.7 µm feature is most obvious in the lower contrast, coarse size fractions). These spectra are very similar to the new, comparable resolution Mars data from the 1988 opposition [1,2]. The band positions in these spectra are consistent with the presence of crystalline hematite in the samples near the lava heat source. Samples farther from the heat source do not show crystalline absorption bands of this magnitude.

Conclusions: These initial results show that the Hawaiian Puu Huluhulu palagonitic tephra studied here has been substantially thermally altered by a lava dike intruding into the cinder cone, resulting in the production of hematite adjacent to the heat source. These samples and many bright regions on Mars have remarkably similar spectral properties, suggesting that a thermal alteration mechanism involving volcanism and/or impact [9-11] may be important in the genesis of crystalline iron oxides on Mars.







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