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REFLECTANCE SPECTROSCOPY OF PALAGONITE AND IRON-RICH MONTMORILLONITE CLAY MIXTURES: IMPLICATIONS FOR THE SURFACE COMPOSITION OF MARS

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Because of the power of remote sensing reflectance spectroscopy in determining mineralogy, it has been used as the major method of identifying possible mineral analogs of the martian surface. A summary of proposed martian surface compositions from reflectance spectroscopy before 1979 was presented by Singer et al. (1979, 1985). Since that time, iron-rich montmorillonite clay (Banin and Rishpon,1979; Banin et al., 1988), nanocrystalline or nanophase hematite (Morris et al.,1989), and palagonite (Evans and Adams, 1979; Allen et al., 1981; and Singer, 1982) have been suggested as Mars soil analog materials.

Palagonite in petrological terms is best described, perhaps, as an amorphous, hydrated, ferric iron, silica gel. Montmorillonite is a member of the smectite clay group and its structure is characterized by an octahedral sheet in coordination with two tetrahedral sheets in which oxygen atoms are shared. The crystallinity of montmorillonite is well defined in contrast to palagonite where it is considered amorphous or poorly crystalline at best.

Because of the absence of the diagnostic, strong 2.2 μm reflectance band characteristic of clays in the near infrared (NIR) spectrum of Mars and palagonite, and based upon a consideration of wide wavelength coverage (0.3-50 μm), Roush et al. (1989) concluded that palagonite is a more likely Mars surface analog. In spite of the spectral agreement of palagonite and the Mars reflectance spectrum in the 2.2 μm region, palagonite shows poor correspondence with the results of the Viking LR experiment (Banin et al., 1983, 1988). In contrast, iron-rich montmorillonite clays show relatively good agreement with the results of the Viking LR experiment (Banin et al., 1979, 1983, 1988).

This spectral study was undertaken to evaluate the spectral properties of mixtures of palagonite and Mars analog iron-rich montmorillonite clay (16-18 wt % Fe as Fe_2O_3) as a Mars surface mineralogical model. Mixtures of minerals as Mars surface analog materials have been studied before (Singer, 1982; Singer et al., 1985), but the mixtures were restricted to crystalline clays and iron oxides

Reflectance spectra from 0.3 to 2.5 μm were recorded on a Perkin Elmer Lambda 9 spectrophotometer (Norwalk, CT) using a Labsphere DRTA-9A Diffuse Reflectance and Transmittance Accessory (North Sutton, NH). Reflectance data presented below thus represent hemispherical reflectance. The spectral bandpass was set between 1/5 and 1/10 of the widths at half height of the spectral features of interest by setting the slits to 2.0 nm in the UV/VIS. This allowed for a constant spectral resolution (±10%) in the UV/VIS. In the NIR , an automatic slit program was used to maintain a constant energy level during spectral scanning (120 nm/min).

Mixtures (% by wt) of palagonite with the iron-rich Mars analog montmorillonite (15.8 ± 0.8 wt % Fe as Fe_2O_3 - a full Mars iron analog) are shown in the figures. In the very important 2.2 μm region, the band due to clay lattice structure becomes noticeable in mixtures at the 10 - 20 wt % Fe-montmorillonite level. In order to evaluate this observation more quantitatively, a rigorous band depth analysis was carried out (Clark and Roush, 1984). The results indicated that band depth at 2.2 μm is insensitive to the presence of up to 15 wt % Fe-montmorillonte. Above these concentrations, there is an increase in band depth with increasing wt % Fe-montmorillonite (decreasing palagonite) which is attributable to the 2.20 μm absorption feature characteristic of smectite clays. If one accepts the premise that palagonite is a "good" spectral analog of the Mars surface material, up to 15 wt % of Fe-montmorillonite can be present on the surface of Mars and remain undetected. In spite of the fact that the most recent telescopic observations of Mars do not show evidence of a 2.20 μm band (Clark et al., 1990), the absence of the 2.20 μm band cannot be used to eliminate less than 15 wt % iron enriched montmorillonite. The conclusion follows that a Mars analog, iron rich, montmorillonite clay can be present on the surface of Mars as a major component (up to 15wt %) of the Mars soil even if the 2.20 μm band is absent from remotely sensed spectra.

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A comparison of the diffuse reflectance spectra of different wt % mixtures of palagonite and Fe-montmorillonite (15.8 ±.8 wt % Fe as Fe_2O_3). All spectra are scaled to unity at 1.02 μm.