MID-INFRARED SPECTROSCOPY OF PALAGONITE; Joy Crisp and Mary Jane Bartholomew, Earth and Space Sciences Division, Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, 91109.

Palagonite is a good spectral analog for Martian dust in the visible and near infrared [1,2]. Little is known, however, about the spectral characteristics of palagonite in the mid-infrared. We ran some preliminary experiments to study the reflectance, absorption, and transmission of a sample of palagonite. The results apply to spectroscopic observations, within the 7 to 20 μm wavelength range, where silicate rocks have distinctive spectral features that would facilitate their identification in remote sensing observations of Mars.

The palagonite we studied is a sample of Pahala ash collected near the beach at South Point, Hawaii. X-ray diffraction indicates that most of the sample probably consists of poorly crystalline alteration products of basalt, and/or basaltic glass. Near-IR reflectance of pressed palagonite powder was measured with a Beckman 5240 spectrometer to further check the mineralogy. The resulting spectrum exhibits Fe absorption at 0.4-0.6 μm, but lacks the features at 0.6 and 0.9 μm, which commonly occur in well-crystallized Fe-bearing phases. The palagonite has moderate OH absorption features at 1.45 and 1.95 μm attributable to water-bearing phase(s) and a broad, weak feature at 2.2 μm, which could be due to a poorly crystalline clay.

In reflection, palagonite is spectrally flat with extremely low reflectance (1-2%) at wavelengths between 7 and 20 μm (Figure 1). Even for a pressed pellet of pure palagonite, the reflectance is less than 1.5% in this wavelength region. This low reflectance indicates that the real part of the index of refraction, n, is nearly equal to 1. The low reflectance of palagonite in the mid-infrared could be due, in part, to the presence of Fe-oxides which have extremely low reflectance in the mid-infrared and, in part, to the poorly crystalline nature of the palagonite.

A transmission spectrum was obtained for a pressed disk with 1.6 wt% palagonite imbedded in KBr. The resulting effective thickness of palagonite dispersed in the KBr disk was 11 μm. The transmission spectrum shows two broad absorption features (Figure 1). Because the palagonite reflection is so low ($R \approx 0$), scattering is relatively unimportant (scattering coefficient $k_s \approx 0$) and k, the imaginary part of the index of refraction, can be estimated from Beer's Law

$$I / I_o = \exp [-4 \pi t k / \lambda] \quad . \qquad (1)$$

At $\lambda = 7\mu$m, we have $k \approx 0.04$; at 8.5 μm, $k \approx 0.1$; at 10μm, $k \approx 0.4$; at 13μm, $k \approx 0.1$; and at 19-20μm, $k \approx 0.4$. These are order-of magnitude estimates of k because of our assumptions that the palagonite was evenly dispersed in the KBr, $k_s \approx 0$, and $R \approx 0$. These calculations clearly show that palagonite is a strong absorber from 8.5 to 10.5 μm and 18 to 20μm. These absorption features are probably due to the presence of poorly crystalline silicate phases(s) in the palagonite.

These spectral regions where palagonite has high absorption are precisely where quartzite and basalt have their strongest reflectance features (Figure 1). The combination of high absorption and low reflectance result in a nearly opaque behavior for palagonite in these wavelength ranges where silicate rock identification is critical.

Equation (1) can also be used to estimate the degree of transmission through coverings of various thicknesses of palagonite on rock substrate.

The single-pass transmittance through 5 μm of palagonite would be 50-70% in weakly absorbing regions (λ = 7 or 13μm) and 10-40% in those regions where it is more strongly absorbing. The predicted reflectance of a basalt completely covered with an even thickness of 5μm palagonite would be less than 1% across the mid-infrared, and for quartzite, it would be less than about 6%.

For greater thicknesses of palagonite, the reflectance would be even further reduced. However, the absorption coefficients do indicate that nearly opaque behavior (absorption optical depth of unity) should be expected for thicknesses of palagonite greater than 5μm in the 8.5-10.5 and 18-20 μm wavelength regions. In the weakly absorbing regions, it would take about 10-15 μm thickness of palagonite to achieve optical depth unity and mask an underlying substrate reflectance.

The spectral properties of palagonite dictate that a small amount of palagonite dust can result in a substantial reduction in the reflectance of an underlying rock, making it difficult to identify and discriminate rock types when there is a covering of palagonite dust. As a consequence, some means of obtaining clean rock surfaces (hammer, drill, crusher, etc.) on a Mars rover equipped with a mid-infrared spectrometer would certainly improve the scientific return of the mission.

References: [1] Adams J.B., Smith M.O., and Johnson P.E., J. Geophys. Res., 91, 8098-8112, 1986. [2] Singer R.B., J. Geophys. Res., 87, 10159-10168, 1982.

Figure 1. Reflectance spectra for sawed surfaces of solid quartzite (Q-R) and basalt (B-R) and palagonite dust (P-R), all measured with an Analect FX6200 FTIR biconical spectrometer. Transmission spectra for palagonite dispersed in a pressed KBr disk (P-Tr) was measured with an FX6160 Analect spectrometer.