

INITIAL ESTIMATES OF OPTICAL CONSTANTS OF MARS CANDIDATE MATERIALS. T.L. Roush¹, A. Brown^{2,1}, J. Bishop^{2,1}, D. Blake¹, and T. Bristow^{3,1}, ¹NASA Ames Research Center, Moffett Field, CA 94035, (ted.l.roush@nasa.gov), ²SETI Institute, Mountain View, CA 94043, NASA Post-Doctoral Program, Oak Ridge Assoc. Univ., Oak Ridge, TN 37831.

Introduction: Data obtained at visible and near-infrared wavelengths by OMEGA on MarsExpress and CRISM on MRO provide definitive evidence for the presence of phyllosilicates and other hydrated phases on Mars. A diverse range of both Fe/Mg-OH and Al-OH-bearing phyllosilicates were identified including the smectites, nontronite, saponite, and montmorillonite. To constrain the abundances of these phyllosilicates, spectral analyses of mixtures are needed.

We report on our effort to enable the quantitative evaluation of the abundance of hydrated-hydroxylated silicates when they are contained in mixtures. We include two component mixtures of hydrated/hydroxylated silicates with each other and with two analogs for other Martian materials; pyroxene (enstatite) and palagonitic soil (an alteration product of basaltic glass, hereafter referred to as palagonite). For the hydrated-hydroxylated silicates we include saponite and montmorillonite (Mg- and Al-rich smectites). We prepared three size separates of each end-member for study: 20-45, 63-90, and 125-150 μm .

Sample Preparation and Characterization:

Sample Preparation. The samples were prepared by grinding bulk materials, except the palagonite, in an alumina mortar and pestle. After grinding, the powders were passed through a series of sieves. The smectites were dry sieved. The palagonite was both dry and wet sieved, and the enstatite was wet sieved. Methanol was used for wet sieving.

Sample Characterization. Characterization of each sample particle size includes scanning electron microscopy (SEM) to document particle size, X-ray diffraction (XRD) to document structure, and reflectance spectroscopy to relate the laboratory measurements to observational data from Mars [1,2]. Here we focus upon the reflectance spectroscopy.

Reflectance spectra in the 0.35-100 μm wavelength range were obtained at the RELAB [3] and data from two instruments were combined by scaling the longer wavelength data to agree with the shorter wavelength range. The shorter wavelength data were obtained with incidence and emission angles of 0° and 30°, respectively. The results for each of the three grain size separates of the samples are shown in Fig. 1 over the wavelength range approximately applicable to CRISM. From the data shown in Fig. 1a it appears that the en-

statite is not pure and contains some OH-bearing contaminant. This is consistent with the independent XRD data that indicates an augitic component in this sample.

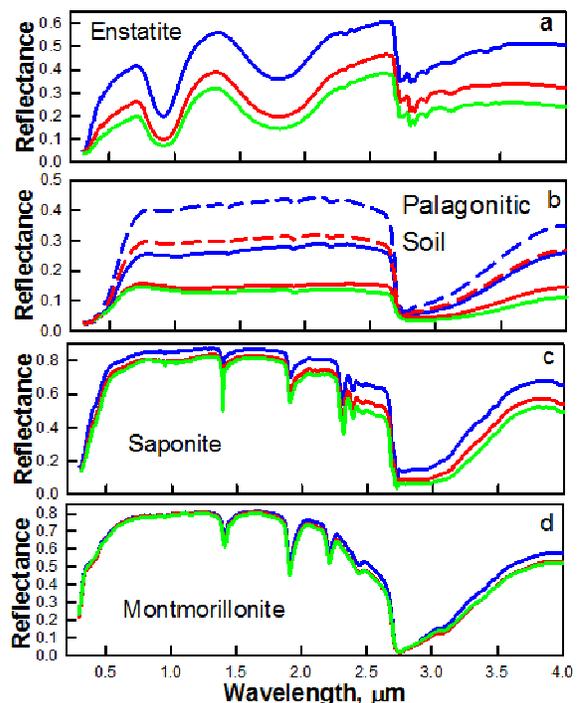


Figure 1. Reflectance spectra of samples studied. The blue, red, and green curves are for the 20-45, 63-90, and 125-150 μm size fractions, respectively. The dashed lines are for the dry sieved palagonite.

Analytical Approach: The basic approach to retrieving the optical constants is to use multiple grain sizes of the same sample and assume all grain sizes are compositionally equivalent. Unless independently known as a function of wavelength, an additional assumption must be made regarding real index of refraction, n . For all samples, except the palagonitic soil, we use the average n provided in the literature, and for the palagonitic soil we assumed n was 1.5077 [4]. The Hapke model of the interaction of light with particulate surfaces [5,6] is used to determine the imaginary index of refraction, k , at each wavelength by iteratively calculating the reflectance and comparing the result to the measured reflectance using a χ^2 -criterion. The interested reader is referred to [7] for more details regarding the precise equations and assumptions. The results, assuming the sieve fraction median size and a constant

n , are shown for each grain size in Fig. 2 to wavelengths of $\sim 4 \mu\text{m}$; the range most applicable to the CRISM data analysis.

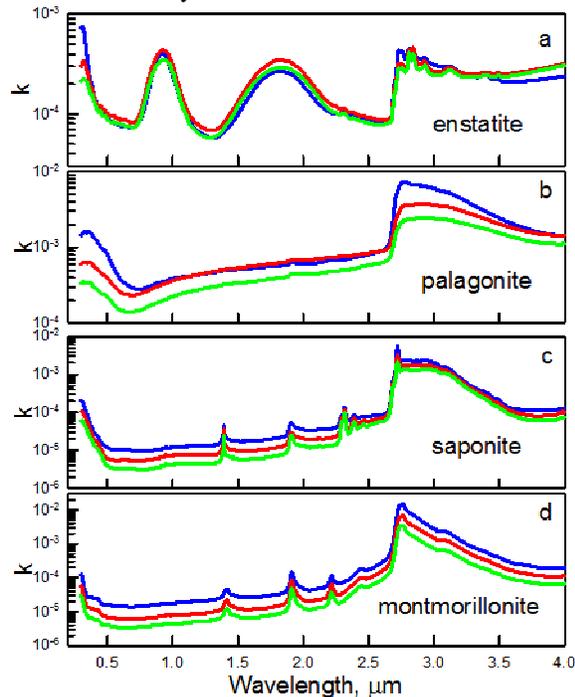


Figure 2. Initial estimates of the optical constants of samples in this study using the reflectance data shown in Fig. 1. The blue, red, and green curves refer to the 20-45, 63-90, and 125-150 μm grain size samples, respectively. The palagonite values were determined for the wet sieved samples.

The k -values of the small and large size fractions were ratioed to the medium size fraction in order to illustrate variations in k with grain size. These data are shown in the Fig. 3 for all for samples. The largest variance in k is observed between the small and medium grains of the phyllosilicates.

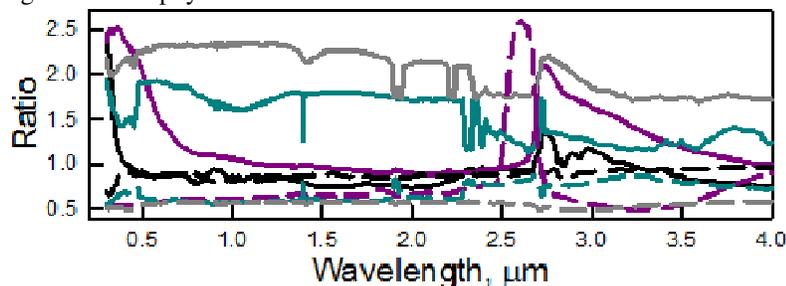


Figure 3. Ratio of the k -values derived from the small (solid lines) and large (dashed lines) grain sizes to the k -values of the medium grain size. Black, purple, green, and gray lines are for enstatite, palagonite, saponite, and montmorillonite, respectively.

Discussion and Future Efforts:

Discussion. Fig. 3 shows that the initial k -values extracted from the large range of grain sizes are consistent with each other to within a factor of 5, or better.

Future Efforts. An independent analysis of the sample particle size distribution was obtained via SEM imaging [1,2]. These distributions will be used to refine these initial estimates of k -values.

In the future we will estimate the wavelength dependence of n , using a subtractive Kramers-König (SKK) analysis. Ideally the SKK analysis requires data at all wavelengths. In our efforts we restrict the analysis to the k -values extracted from the reflectance measurements up to $\sim 7 \mu\text{m}$, except when data is available at longer wavelengths from the literature. As in [7], we will iteratively apply the Hapke and SKK analyses until the k and n do not change significantly.

Mixtures of saponite and montmorillonite with enstatite and palagonite were prepared for the 63-90 μm sieve fraction [2]. Another future effort will be to use the derived n 's and k 's to model these mixture data and evaluate the accuracy of predicting the known abundances.

References: [1] Brown, A., et al., 2012, 43rd LPSC, abstract 1747. [2] Roush, T., et al., 2012, AGU poster P13C-1905. [3] Pieters, C. and T. Hiroi, 2004, 35th LPSC, abstract 1720. [4] Roush, T., et al., 1991, *Icarus*, 94, 191-208. [5] Hapke, B., 1981, *JGR*, 86, 3039-3054. [6] Hapke, B., 1993, Cambridge Univ. Press, New York, NY, 455pp. [7] Roush, T., et al., 2007, *JGR-Planets*, 112, doi: 10.1029/2007JE002920.

Acknowledgements: We gratefully thank NASA's Mars Fundamental Research Program for supporting this research.