

THE SPECTRAL REFLECTANCE, 0.6 TO 4.3 μ m, OF PARTICULATE MINERAL-WATER ICE MIXTURES Ted L. Roush, Robert B. Singer, and Thomas B. McCord, Planetary Geosciences Div., Hawaii Inst. Geophysics, University of Hawaii, 2525 Correa Rd., Honolulu, HI 96822.

INTRODUCTION The importance of spectral reflectance data for the interpretation of planetary surface mineralogy has been discussed elsewhere (1). Since water ice has been identified on the surface of the outer planets satellites (2,3,4,5,6,7,8) it is important to understand its reflectance behavior. Laboratory studies, in the 0.3 to 2.5 μ m wavelength range, of the spectral reflectance of water ice-silicate mineral mixtures have included particulate minerals frozen in solid blocks of water ice (9), frost grown on particulate minerals (10), and particulate minerals deposited on water frost (10). There have been a number of laboratory studies concerning the reflectance behavior of water ice in the 2.5 to 4.3 μ m wavelength region, but they did not include particulate samples or mixtures of silicates and water ice (11,12,13,14).

The mapping spectrometers on future spacecraft missions, such as Galileo and the Mars Orbiter, are designed to return spectral reflectance data from 0.7 to 5.2 μ m. Thus, it is important for interpretation of such data to expand laboratory reflectance measurements to include the longer wavelength region. The study presented here provides empirical laboratory data concerning the spectral reflectance of particulate water ice mixed with particulate silicate minerals in the 0.6 to 4.3 μ m wavelength region.

EXPERIMENTAL METHOD The instrumentation and data collection techniques used in this study were discussed previously (1). All samples were prepared by weighing the appropriate weight percentages of the end-members at room temperature, then the two were mixed thoroughly. The samples were flash frozen when the mixtures were placed into a mortar and pestle which is in a dry nitrogen atmosphere and sitting in liquid nitrogen. The samples were subsequently ground which resulted in a thoroughly mixed, particulate sample with an approximate grain size of 100 μ m. The sample was transferred to an environment chamber which had been pre-cooled to liquid nitrogen temperature and purged with dry nitrogen gas. The chamber was subsequently evacuated to remove any atmospheric contamination accumulated during the transfer process. The samples reached equilibrium temperature before the spectral data was collected. Mixtures of 0, 1, 5, 10, 25, 50, 75, 90, and 100 weight percent silicates to water ice were prepared and spectral data collected for each sample.

BACKGROUND Initial room temperature spectral reflectance measurements of phyllosilicate samples, before and after heating to 200°C, exhibit three types of characteristic spectral signatures (15). The silicate samples used in this study were chosen to represent each of these different spectral types. The pyrophyllite represents type I spectral behavior, the montmorillonite represents type II spectral behavior, and the palagonite represents type III spectral behavior (15).

The absorptions due to the presence of OH⁻ and liquid H₂O found in the phyllosilicates and the palagonite has been discussed elsewhere (15). H₂O ice has strong absorption features located very near the same wavelengths as liquid H₂O (16). There are overtone and/or combination of these ice absorptions which occur throughout the visible and near-infrared (.7-2.5 μ m) wavelength region (10).

DISCUSSION The reflectance spectra of selected mixtures of pyrophyllite with water ice are shown in figure 1. These spectra illustrate the changes seen for all samples when mixed with water ice. Except for the very near-infrared (0.6 - 1.3 μ m), the spectra of mixtures with less than 50 weight percent silicate are dominated by water ice absorptions. The differences in the reflectance of these mixtures could be explained solely in terms of different grain sizes of water ice without the presence of any contaminant required. At about 50 weight percent silicate the reflectance spectra of those mixtures which contain OH bearing silicates begin to exhibit absorptions, located near 1.4 and 2.75 μ m, which are due to the presence of OH⁻ and the spectra of all mixtures exhibit an increase of reflectance between 2.3 and 2.9 μ m. By a concentration of 75 weight percent silicate, the OH⁻ absorptions are more pronounced, the reflectance between 2.3 and 2.9 μ m continues to increase, and additionally the reflectance beyond 3.4 μ m begins to increase.

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CONCLUSIONS This study has provided valuable spectral reflectance information concerning particulate mixtures of minerals and water ice in the 0.6 to 4.3 μ m wavelength region. The reflectance spectra of the resulting mixtures are dominated by a pure ice spectral signature beyond 1.3 μ m until relatively high concentrations of silicates are present in the mixture. The reflectance of these mixtures beyond 3.4 μ m does not significantly increase until approximately 75 weight percent silicate is present in the mixture.

At shorter wavelengths, except for the 0.6 to 1.3 μ m region, the detection of a contaminate, based solely on the reflectance spectra, requires about 50 weight percent of the silicates used in this study to be mixed with water ice. The identification of the presence and type of OH⁻ bearing minerals, based on the reflectance spectra, is greatly enhanced for mixtures with greater than 50 weight percent silicate.

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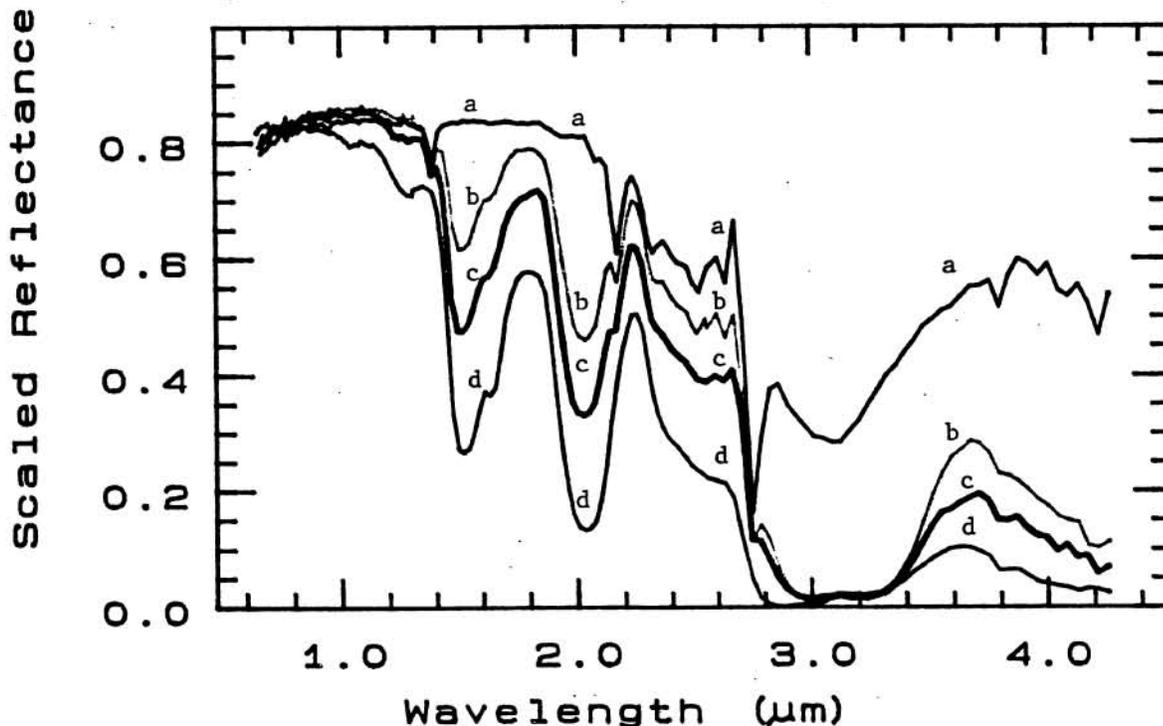


Figure 1. Reflectance spectra of various mixtures of pyrophyllite and water ice, a) pure pyrophyllite, b) 9 weight percent water ice-91 weight percent pyrophyllite, c) 25 weight percent water ice-75 weight percent pyrophyllite, d) pure water ice.