

DERIVATION OF MID-INFRARED (5-25 μ m) OPTICAL CONSTANTS OF SOME SILICATES AND PALAGONITE; T. Roush (NASA Ames/San Francisco State Univ.), J. Pollack (NASA Ames), and J. Orenberg (San Francisco State Univ.)

Recent reports concerning the mid-infrared reflectance properties of silicates [1,2,3] coupled with recent observations of Mars in the mid-infrared [4] and the planned Thermal Emission Spectrometer scheduled as an instrument on the Mars Geosciences Orbiter all illustrate the increasing interest in the optical properties of materials in the mid-infrared and their direct application to remote sensing observations of other planetary surfaces. As the observational data increase, the desire for quantitative analysis will require knowledge of the optical constants (real (n) and imaginary (k) indices of refraction) of pertinent materials. Here we describe methods for deriving optical constants of a variety of silicates and assess some of the associated errors.

We wish to derive n and k at each wavelength of a material from a measurement obtained in the laboratory. One technique commonly used is dispersion analysis [5,6,7,8,9] which describes n and k as the contributions due to a sum of classical oscillators and relates them via Fresnel's equations for non-normal incidence, to the measured near-normal reflectivity. Non-linear least squares techniques can be used to minimize the differences between the observed and calculated reflectivities.

Since most of the silicates included in this study were clays, which are not amenable to standard polishing techniques, we prepared pellets of pure samples for the reflectivity measurements. This technique consisted of using a standard KBr pellet die, commonly employed in preparation of samples for IR transmission measurements, and powders of the pure sample. The powders were previously separated by sieving and the finest grain size fraction placed in the KBr die. The die was placed in a hydraulic press and the pressure increased to 50 tons on the 12mm die and held there for 5 minutes. For all clays and the palagonite this produced a pellet with highly reflective surfaces at visible wavelengths. In contrast, the sole pyroxene (from Bamble, Norway) prepared by this technique exhibited a matte-like surface. In order to semi-quantitatively assess the variation of derived optical constants as a function of surface roughness a sample of the pyroxene was prepared by polishing a large slab of pyroxene to produce a mirror-like surface. The reflectivities of all samples were determined by placing them at the focus of a standard near-normal reflectance attachment located in a Nicolet 7199 Fourier transform spectrometer. The signal measured from each sample was ratioed to that from a first surface aluminum mirror which was conservatively assumed to have a reflectance of 0.96 at all wavelengths. Data was collected from 4000 to 400 cm^{-1} (2.5-25 μ m) with a constant spectral resolution of 4 cm^{-1} . At frequencies higher than 2000 cm^{-1} ($< 5\mu$ m) the assumption that Fresnel reflectivity is the dominant source of reflected light becomes invalid due to the increasing contribution of multiply scattered light. As a result, optical constants were derived for only the 2000-400 cm^{-1} (5-25 μ m) region.

Figure 1 illustrates the difference between the measured reflectivities of the polished slab and powdered pellet of the pyroxene. Figure 2 illustrates the difference between the derived optical constants of the pyroxene samples. The imaginary index (k) of the slab is generally a factor of 2 to 4, but occasionally in the more intense features a factor of 10, than that derived from the powdered pellet. The derived real index (n) of both samples generally agree to within a factor of 2, but again occasionally deviate by slightly more than 2. These results imply that pellets which have a matte finish are not ideally suited for derivation of the materials optical constants. Using pressed pellets of pure samples and the techniques described above we have derived the optical constants for pyrophyllite, palagonite, montmorillonite, kaolinite, serpentine, and saponite in the 2000-400 cm^{-1} (5-25 μ m) range. The values derived here are in close agreement with values previously reported for montmorillonite [7], serpentine [9], and palagonite [10]. Discrep-

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ancies between the derived values are easily explained by the slight compositional variability of the actual samples measured.

We conclude: 1) that if a polished slab can be prepared, then n and k can be derived for a sample; and 2) if the sample is too crumbly to make a polished slab, then it will make a fine pellet and this implies that n and k can be derived in this manner.

REFERENCES: [1] Salisbury *et al.* (1987) *JGR*, **97**, 702; [2] Salisbury and Walter (1989) *JGR*, **94**, 9192; [3] Walter and Salisbury (1989) *JGR*, **94**, 9213; [4] Pollack *et al.* (1990) submitted to *JGR*; [5] Pollack *et al.* (1973) *Icarus*, **19**, 372; [6] Aronson and Strong (1975) *Appl. Opt.*, **14**, 2914; [7] Toon *et al.* (1976) *JGR*, **81**, 5733; [8] Querry *et al.* (1978) *Appl. Opt.*, **17**, 353; [9] Mooney and Knacke (1985) *Icarus*, **64**, 493; [10] Crisp and Bartholomew (1989) pers. comm.

Figure 1. Measured reflectance of pyroxene relative to a mirror. Line with error bars is the average of two measurements of the polished slab. Line without error bars is the measurement of the pressed pellet.

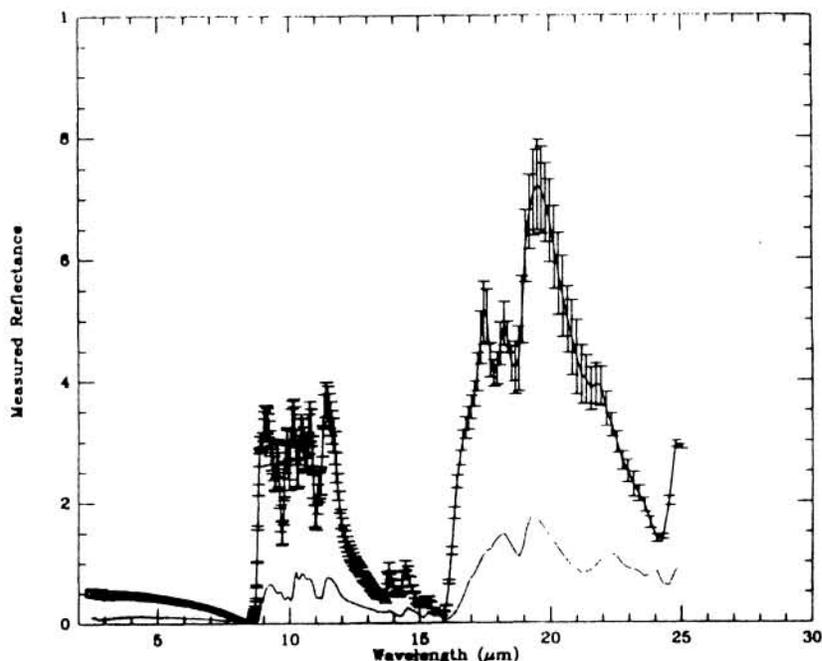


Figure 2. Ratio of the imaginary (A) and real (B) indices of refraction derived for the pyroxene using measurements of the polished slab to those derived using measurements of the pressed pellet.

