

REFLECTANCE SPECTRA OF SELECTED MAFIC SILICATES FROM .6 TO 4.6 μ m; Ted L. Roush, Robert B. Singer, and Thomas B. McCord, Univ. Hawaii, Planetary Geosciences Div., Hawaii Inst. Geophysics, 2525 Correa Rd., Honolulu, HI 96822

INTRODUCTION Spectral reflectance, obtained by spacecraft and earth-based telescopic observations, is the dominant method of collecting mineralogical information concerning the surface properties of solar system objects. Our ability to interpret these data, in terms of the identity and abundance of minerals present on a surface, is important for addressing more general questions concerning the origin and evolution of that body as well as the solar system as a whole. The reflectance of geologically important materials in the 0.3 to 2.5 μ m wavelength region has been the subject of intense laboratory research for many years(1,2,3,4,5). However, there has been a paucity of research concerning the reflectance behavior of geologic materials in the 2.5 to 4.6 μ m wavelength region.

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 reflectance behavior of important geological rock forming minerals in the 2.5 to 4.6 μ m wavelength region.

EXPERIMENTAL METHOD For this study two infrared, cooled, circular variable filter (CVF) spectrometers with InSb detectors were used and the combined wavelength coverage spanned the .65 to 4.5 μ m wavelength region. In both instruments the detector, filter, and other internal components are operated at liquid nitrogen temperature (77 K). The spectral resolution ($\Delta\lambda/\lambda$) of both CVF's is about 1.5%.

The mafic mineral samples studied here were chosen to represent minerals which result in mafic to ultramafic assemblages. All samples were dry sieved to the <38 μ m grain size. All samples were placed in a furnace prior to being situated in an environment chamber. The environment chamber was flushed with inert nitrogen gas during the entire data collection and heating sequence. The samples were allowed to equilibrate in the nitrogen environment for thirty minutes before room temperature spectral data were collected. The samples were then heated at 200°C for thirty minutes and subsequently allowed to cool to room temperature before additional data were collected.

BACKGROUND Electronic transitions of the first transition element series, especially the petrologically significant cations Fe²⁺ and Ti³⁺, result in absorptions in the visible and near-infrared (0.3 to 2.5 μ m) region of the electromagnetic spectrum(6), and are due to ions located within specific crystallographic sites. Hence, from the spectra direct information is obtained concerning the chemistry and crystal structure of the material.

For this study, the most important species which have vibrationally induced absorptions are the H₂O molecule and the OH⁻ ion. The H₂O molecule has strong absorption features located near 2.9 μ m (O-H asymmetric stretch), 3.0 μ m (H-O-H bend overtone), and 3.1 μ m (O-H symmetric stretch)(7). Overtones and/or combinations of these bands can occur near 0.94, 1.135, 1.38, 1.45, and 1.88 μ m(7). There is a fundamental of the OH⁻ group located near 2.75 μ m and the first overtone of this fundamental is located near 1.4 μ m(7).

DISCUSSION The results of the spectral measurements for the mafic silicates are presented in Figures 1 to 3. All spectra, except the plagioclase, exhibit electronic absorptions located near 1 and/or 2 μ m which are due to Fe²⁺ located in octahedral crystallographic sites. These absorptions remain unchanged after heating. Additionally, all spectra have an absorption centered near 3 μ m which is due to H₂O. This absorption changes in intensity, and in some cases shape, after heating. We believe these changes represent the removal of physically adsorbed H₂O from the sample. The continued presence of the 3 μ m band in the spectra of all samples after heating implies that H₂O bearing contaminants are present, or alternatively, the samples contain fluid inclusions.

CONCLUSIONS This study provides valuable spectral reflectance information about mafic silicates in the 2.5 to 4.6 μ m wavelength region. In this wavelength region we have shown that the reflectance of these materials is strongly affected by the presence of H₂O and OH⁻. Therefore, the identification of these absorbing species is greatly enhanced.

The reflectance behavior of mafic silicates beyond 2.5 μ m can provide additional information about the chemical composition of the pyroxenes by revealing the long wavelength edge of the clinopyroxene absorption band located near 2 μ m. For Mercury, the Moon, Earth, Mars, and the asteroids this additional information enhances our ability to map mineralogical composition and abundance changes across the surface of a planetary body.

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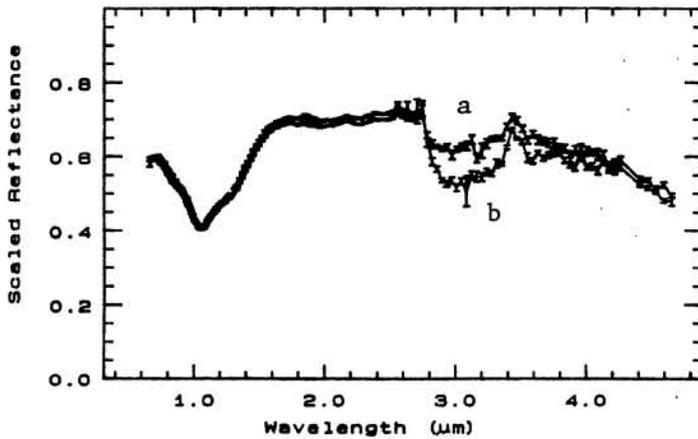


Figure 1. Reflectance spectra of olivine (Fe_{80}) before (b) and after (a) heating. The absorption centered near 1μ m is due to the presence of Fe^{2+} and is unaffected by heating. The decrease of the absorption located near 3μ m upon heating is due to the loss of physically adsorbed H_2O .

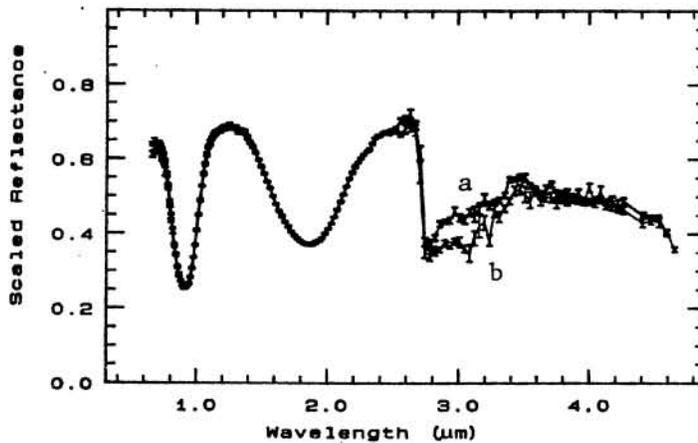


Figure 2. Reflectance spectra of orthopyroxene (En_{86}) before (b) and after (a) heating. The absorptions located near 1 and 2μ m are due to the presence of Fe^{2+} and are not affected by heating. Because this sample contains tremolite as a contaminant, after heating the 3μ m band depth decreases, due to the loss of physically adsorbed H_2O , and the relatively narrow absorption located near 2.75μ m, due to OH^- , is more pronounced.

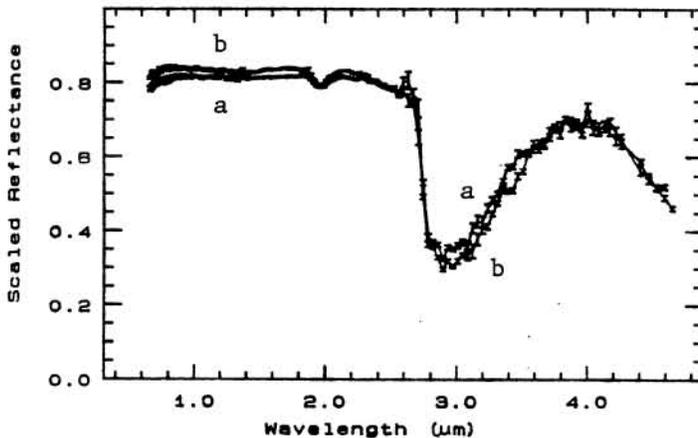


Figure 3. Reflectance spectra of plagioclase (An_{55}) before (b) and after (a) heating. The spectra of this mineral exhibit the strongest 3μ m of all the mafic silicates due to the presence of fluid inclusions in the sample. Since the H_2O in the fluid inclusions is not easily lost upon heating, the minor spectral changes indicate solely the loss of physically adsorbed H_2O .