

THERMAL INFRARED (8- to 14- μm) SPECTROSCOPIC REMOTE SENSING OF ROCK TYPE ON PARTICULATE PLANETARY SURFACES; John W. Salisbury, U.S. Geological Survey, and Louis S. Walter, NASA Goddard Space Flight Center

Silicate minerals display their strongest fundamental molecular vibration bands in the 8- to 14- μm atmospheric window. These spectral features are peaks in reflectance and troughs in emittance.^{1/} These "reststrahlen bands," which have long been recognized as characteristic of the compositions of minerals and rocks, become attenuated and difficult to detect in reflectance or emittance from fine particulate materials.^{2/} It is the purpose of this paper to show that other features associated with the principal Christiansen frequency and a region of transparency between the stretching and bending vibration bands can be used to determine the composition of fine particulate regoliths, with specific reference to igneous rocks.

The wavelength variation of the Christiansen frequency for particulate silicate minerals was first shown by Conel;^{3/} similar variations were described for igneous rocks by Logan et al.^{4/} In contrast, the transparency feature between the Si-O stretching and the bending modes only recently has been documented for silicate minerals.^{5/} This feature occurs because the absorption coefficient between the bending and the stretching vibration bands is low enough that significant volume scattering takes place as particle size is reduced and a reflectance peak results. As the reststrahlen peaks become less intense in the reflectance spectrum of a fine powder (in our experiment, <74- μm particle size), the transparency peak may become the most prominent feature in the 8- to 14- μm spectral region. Confusion of this peak with a reststrahlen band would result in an erroneous identification. However, the transparency peak, if recognized, can be used to determine composition; that is, as the stretching and bending vibration bands change in wavelength with composition, the transparency peak that lies between them changes also.

Thus, infrared reflectance spectra of fine particulate rocks typically display two spectral features that have compositional significance. To determine the extent of their significance, we plotted the product of the wavelengths of these two features against a recently proposed^{6/} chemical index of igneous rock types (Figure 1). This SCFM index is the ratio of silica to the sum of silica plus the oxide abundances of calcium, iron, and magnesium and varies from 0.99 for granite to 0.42 for dunite. The second-order parabolic correlation coefficient (R^2) of 0.91 indicates that these spectral features should be very useful for determining the composition of particulate igneous rocks. It should be noted, however, that some basalts display a weak transparency peak that is difficult to discern, which is due primarily to the presence of abundant opaque minerals.

The extent to which the results of the reflectance measurements summarized above can be used to predict spectral behavior in emittance under planetary surface conditions is still under study. The rock spectra were measured in directional hemispherical reflectance, which should be directly interpretable in terms of directional emittance by using Kirchhoff's law.^{7/} However, Logan et al.^{4/} showed that a vacuum environment introduces a thermal gradient in particulate samples that can change emittance spectra significantly. It appears from their published spectra, which are, unfortunately, limited in number and wavelength range, that transparency features may occur when even a thin atmosphere is present, but may not occur in a vacuum

environment. Thus, both Christiansen frequency and the transparency feature may be useful for spectroscopic remote sensing of surface composition on a planet like Mars, but perhaps only the Christiansen frequency would be useful on an airless body like the Moon. In addition, a vacuum environment causes a shift in the Christiansen frequency. Thus, measurements of actual spectral emittance under appropriate simulated environmental conditions are required to interpret infrared spectra with confidence.

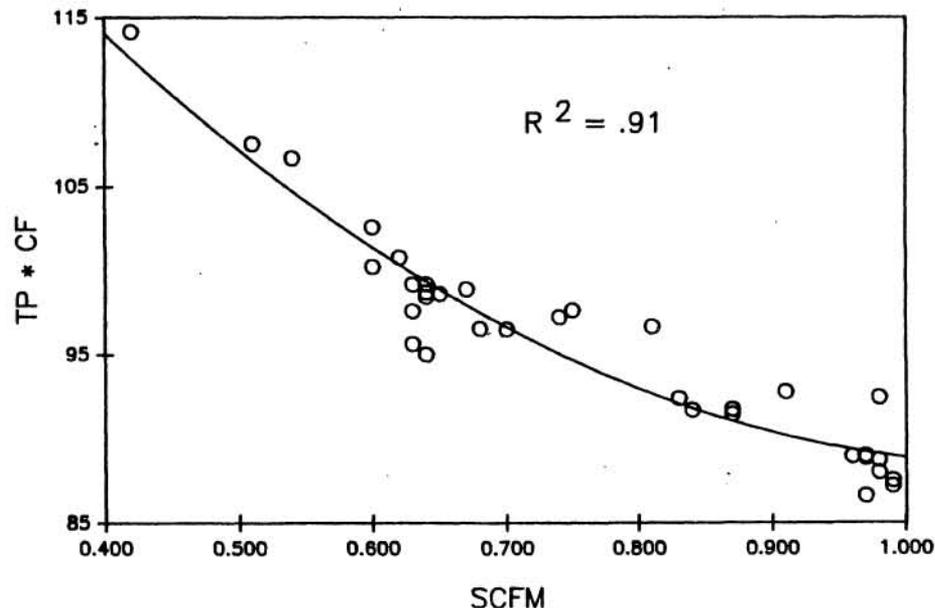


Figure 1. Correlation of the product of the wavelengths of the transparency peak (TP) and Christiansen frequency (CF) with the SCFM index for 34 igneous rocks.

References

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