SPECTRAL VARIATIONS IN THE THERMAL INFRARED 
RESTSTRAHLEN BAND OF SILICATES; L. S. Walter, Goddard Space 
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The observation that the position of the depression in the 8 
to 12 micrometer region of the emittance spectra (the rest-
strahlen feature) of coarse-grained silicate minerals varies with 
mineral type was made some decades ago (1). Several attempts 
have been, and are being, made to use this phenomenon in remote 
sensing studies of terrestrial (2) and planetary (3) surfaces. 
The Mars Orbiting Mission will carry a thermal infrared spectro-
meter for this purpose. The application is complicated, however, 
by several factors such as surface coatings on the rocks and the 
effects of particle size on the spectral contrast. 

Another inherent problem stems from the low energy levels 
received by remote sensors in this region of the spectrum which 
exacerbates the tradeoff between spectral resolution and the 
spatial resolution needed for mapping. Thus, earlier work (4) 
focused on estimating the shift of the reststrahlen band envelope 
within the 8-12 micron region rather than the discrimination of 
specific details of the spectra. 

We have embarked on a systematic investigation directed 
toward establishing the limits of accuracy of the method and 
determining the optimum approach to using it effectively. In 
doing so, we have concentrated on purified, (chemically and 
mineralogically) analyzed samples of the major rock-forming 
silicates (5). As it is possible to integrate laboratory spectra 
of these minerals proportionally to duplicate spectra of the 
rocks they comprise (6), information on the spectral variations 
among mineral types should provide an understanding of the 
variations among rock types and define the accuracy with which 
they can be discriminated. This report presents the preliminary 
results of the study. 

The reststrahlen band in the 8-12 micron region is due to 
Si-O stretching vibrations. Hence, a model which may be used to 
understand the spectral variations in silicate minerals corre-
lates the changes in Si-O stretch frequency with the Si-O bond 
lengths (7). The average Si-O bond length has, in turn, been 
related to the average coordination of the oxygen (8). Finally, 
the average oxygen coordination may be related to mineral 
composition. 

To begin testing this model, thermal IR spectral reflectance 
measurements were made of a wide range of silicate minerals (5) 
using the 74-250 micron size fraction. Integrated intensities in 
two wavelength regions at 8.1 - 9.1 microns (band A) and 11 - 12 
microns (band B) were used to determine the correlation between 
mineral type and the position of the reststrahlen band envelope. 
A summary of these preliminary results is shown in the Figure. 
(Si-O is the average Si-O bond length). The results indicate 
that the simple model holds for sheet- (mica), framework- (quartz 
and plagioclase) and ortho-silicates (olivines and garnets), but 
breaks down for the important chain silicates (pyroxenes).
The problem in the case of the pyroxenes appears to be in using average bond lengths. In diopside, for example, the Si-O distance for bridging oxygens is consistently longer than that for non-bridging oxygens (1.68 vs. 1.6 Å) and is sensitive to the cation in the M2 position (9). The bond may therefore be quite long, spreading out the emission bands to longer wavelengths.

Thus, using the shift of the reststrahlen band envelope for discriminating minerals and, hence, rocks will often result in ambiguities: one or more intermediate bands will be required in order to distinguish specific spectral features or to define more precisely the shape of the spectral curve in this region. Moreover, in the case of planetary exploration, it will be possible to acquire important additional data in other parts of the spectrum.

REFERENCES