

MID-INFRARED SPECTRA OF KOMATIITE VS. BASALT

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Komatiite is an ultramafic extrusive containing > 20% weight MgO, and composed mainly of olivine, with lesser pyroxene, and little or no feldspar. On the Earth komatiites were mainly emplaced during the Archean (>2.7 Ga), were erupted at viscosities of 0.1 to 1 Pa, and at temperatures of 1400-1700° C [1,2]. Komatiite was generated at a depth of 150 to 200 km by massive partial melting of the Archean mantle [3]. Their unique character and origin make komatiite excellent indicators of the early composition and development of the Earth's mantle [4]. Komatiites may also be important constituents on Mars [5], and their discovery would provide important constraints on the composition and temperature gradients of the Martian mantle. In addition, determination of the variation in composition of Martian basalts with time can be used to study the evolution of Martian mantle conditions.

The purpose of this study is to determine the mid-infrared spectral properties of komatiite and to compare these to other basalt types. A suite of samples were selected from the Arizona State University petrology collection which were typical of their rock type. The komatiite samples were originally obtained from one of the best preserved komatiite locations in the world, Munro Township, Ontario, Canada [6]. The basalt samples came from various locations and represent a compositional suite from tholeiitic basalt, to alkali basalt, to basaltic andesite. A total of 8 komatiite and 10 basalt samples were analyzed.

Spectra were obtained using a commercial Fourier transform interferometer at a resolution of 4 cm⁻¹ in emissive mode. Emission measurements were used because they are appropriate for comparison to remotely gathered planetary data. Samples were heated to 80° C in an oven for 24 hours in order to achieve thermal equilibrium and eliminate thermal gradients. Samples were removed from the oven and analyzed in open air within 10 seconds to minimize thermal gradients due to cooling. Samples were also analyzed on their flat, freshly broken surfaces. Emissivity was calculated relative to a blackbody with > 99 % emissivity and adjustable to > 0.1° C.

The spectra shown in Figures 1 and 2 were selected for presentation because they are typical of all the samples surveyed for their respective groups. Figure 1 shows a comparison of komatiite and olivine. Olivine is a major mineral constituent of komatiite and should, therefore, be discernable in its spectrum. In Figure 1 komatiite show absorption bands at approximately 10.75, 11.25, and 16.5 μm which are due to olivine. Other olivine bands at 9.5, 24.5, 20, and 29 μm are present in the komatiite spectrum but are not clearly discernable, due to overlapping absorption bands of other minerals.

Komatiite spectra from 7 to 30 μm are easily distinguished from basalt spectra as seen in Figure 2. In the 8 to 12 μm region basalts have broad and shallow absorption features. This region results from a concentration of the absorption bands of constituent silicate minerals in basalt, typically olivine, pyroxene, and feldspar. In this same region, komatiite has several narrow, deep bands due primarily to olivine. In the 15 to 30 μm region basalt spectra show a broad region of shallow and indistinct absorption bands. Conversely, in this same region, komatiite show distinctly expressed absorption bands, again due to the predominance of olivine in the komatiite. These spectral features clearly separate ultramafic komatiite from less ultramafic tholeiitic basalt and other basalts.

Previous work has shown that there is a detectable and quantifiable shift in the character of spectra in the 8 to 12 μm region as a result of the depolymerization of SiO₂ tetrahedron over large SiO₂ ranges in igneous rocks (ie. rhyolite to basalt) [7]. The results discussed here indicate that this distinction is applicable even to small ranges of SiO₂ content such as from basaltic

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andesite to tholeiitic basalt. These shifts can be seen as a discernable difference among the basalt spectra in Figure 2, and are consistent with the general shift of the Si-O absorption band to shorter wavelengths with increasing SiO₂ content. This information is significant in that it indicates that subtle lithologic distinctions can be made from remotely sensed data. This capability is particularly important for Mars, where large variations in SiO₂ content may not occur.

In summary, preliminary data show that in the 7 to 30 μm region komatiite is easily distinguished from all other major basalt types, based on the detailed spectral signature of its constituent minerals, particularly olivine. In addition, subtle variations in basalt composition can be detected and related to variations in bulk rock composition and mineralogy. Future work will focus on a detailed interpretation of the mid-infrared spectra to identify mineral components in all of the basalt samples and quantify the composition variations apparent in Figure 2. These results will be directly applicable to Mars following the receipt of Mars Observer Thermal Emission Spectrometer (TES) data, which will acquire spectra from 6.25 to 50 μm at a spectral resolution comparable to the spectra illustrated in Figures 1 and 2.

References [1] Huppert, H.E., Sparks, S.J., Turner, J.S., and Arndt, N.T., (3/1984), *Nature*, V. 309, pp.19-22. [2] Arndt, N.T., Francis, D., and Hynes, A.J., (1979), *Canadian Mineralogist*, V. 17, pp. 147-163. [3] Takahashi, E. and Scarfe, C.M. (6/1985), *Nature*, V. 315, pp.566-568. [4] Jahn, B.M. and Gruau, G., (1989), LPI Tech Rpt 89-05, LPI, Houston, pp.47-49. [5] Burns, R.G. and Fisher, D.S., (1989), LPI Tech Rpt 89-04, LPI, Houston, pp.20-22. [6] Pyke, D.R., Naldrett, A.J., and Eckstrand, O.R., (3/1973), *GSA Bulletin*, V. 84, pp 955-978. [7] Walter, L.S. and Salisbury, J.W., (7/1989), *JGR*, V. 94, N. B7, pp. 9203-9213.

FIGURE 1
Mid-infrared Spectra of Komatiite and Olivine.

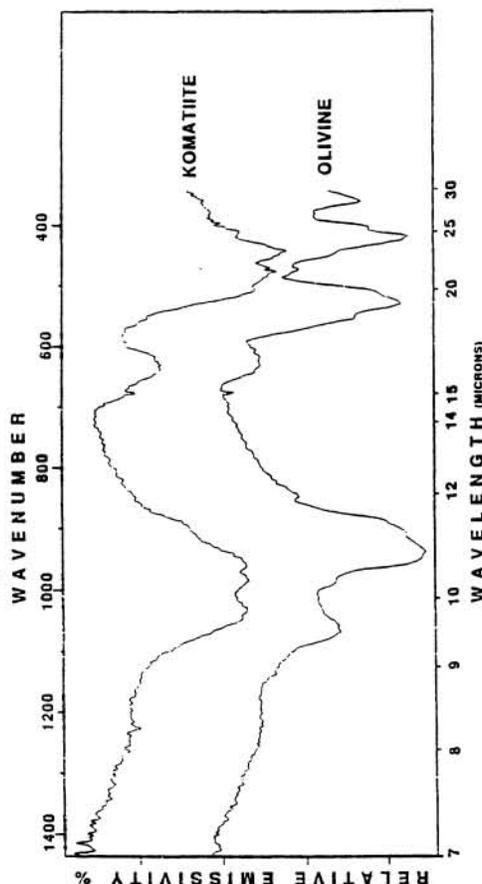


FIGURE 2
Mid-infrared Spectra of Various Basalts.

