Spectral investigations of a variety of magnesium-bearing rock types: implications for kimberlite exploration.

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The aim of this paper is to explore the differences between the spectral response of kimberlite, and other mafic and ultramafic rocks.

Radiation in the short-wave infrared (SWIR) portion of the electromagnetic spectrum can be used to extract mineralogical information from natural materials such as rock and soil. Absorption bands, related to bonds between various cations (Al^{3+}, Mg^{2+}, Fe^{2+}, Fe^{3+}, Ca^{2+} and Na^{+}) and anions (OH^{-}, CO_3^{2-} and SO_4^{2-}), characterise different mineral groups and species. Major absorption band positions for this study are 1400nm, 1900nm, 2200nm, 2250nm, 2290nm and 2300-2330nm. These features are all attributable to vibrational overtone and combination tones involving OH-stretching modes (Hunt and Evarts, 1981, Gaffey et al., 1993).

For this study the samples were measured using the Portable Infrared Mineral Analyser (PIMA) spectrometer. This instrument records reflectance data in 601 channels at 2nm spacing between 1300 and 2500nm.

Mineralogical information is contained in the overall shape, the albedo, and in the positions of individual absorptions. Absorption positions may be shifted due to variation in mineral species, and also because of structural/compositional variations within a species (Clark et al., 1990, Gaffey et al. 1993, King and Clark, 1989).

Figure 1 shows spectra from rock material from two kimberlites. The main features are the 1400nm and 1900nm absorptions, which are related to both interlayer and bound water. Other features which give an indication of the mineralogy are the 2244nm to 2270nm shoulder features, an important 2300nm to 2320nm feature, and a variable 2390nm feature related to Mg-OH. These features can indicate the presence of a variety of mineral species (Hunt and Evarts, 1981, Hunt and Salisbury, 1970, 1973). In the spectra shown in Figure 1 the minerals that can be identified are serpentine and talc, with serpentine dominant. Table 1 indicates the dominant and secondary spectral mineralogy as identified using the PIMA for some other kimberlites.

Sample Number	Location	Facies	Dominant mineral	Secondary Mineral
MW270102	S.E. Zimbabwe	Hypabyssal	serpentine	n/a
ZA052705	S.E. Zimbabwe	Crater	talc	phlogopite?
KMBVEN02	Northern Province	Hypabyssal	serpentine	n/a
HB00003A	Karoo	Hypabyssal	serpentine	talc
PPT00002	Karoo	Hypabyssal	serpentine	n/a

Table 1: Kimberlite rock samples and their mineralogy identified from spectral measurements.

The shape, width and position of the Mg-OH absorption is dependant on the mineral species present.

Other rock types, of variable composition and Mg-content, show a similar variation in spectral response. Three rock samples from the komatiite dominated Tjakastad Subgroup from the

Barberton Mountainland were measured. The spectra indicate the presence of talc, a serpentine and talc mixture, and nontronite. These can be seen in Figure 2.

The spectrally identified minerals from a wider range of rocks are presented in Table 2.

Sample Number	Stratigraphic Position	Rock Type	Spectrally Dominant Mineral
AM108IIR	Allanridge Fm.	Basaltic lava	chlorite
TKBAR078	Tjakastad S.Gp.	Komatiite lava	talc
TKBAR043	Tjakastad S.Gp.	Komatiite lava	nontronite
TKBAR027	Tjakastad S.Gp.	Komatiite lava	talc
ZA052907	Limpopo Mobile Belt, Central Zone	Mafic Dyke	orthopyroxene, talc
ZA053039	Limpopo Mobile Belt, Central Zone 1	Amphibolitic gneiss	Amphibole
ZA052935	Limpopo Mobile Belt, Central Zone	Gabbro intrusion	nontronite and montmorillonite
30018143	Limpopo Mobile Belt, Central Zone	Medium grained granular ultramafic	orthopyroxene, amphibole.
A16R0003	Limpopo Mobile Belt, Central Zone	Sheared amphibolite gneiss	amphibole

Table 2: Mafic and ultramafic rocks from southern Africa, and their mineralogy identified from spectral measurements.

Soil samples show similar features, but as they represent the weathered product of the kimberlite, the mineralogy is different. Soils often contain Aluminium-clay, in addition to the Magnesium-rich mineral phase derived from the kimberlite. Feature ratios may be used as a measure of the different relative proportions of minerals detected. For example the Mg-OH-feature/Al-OH-feature ratio is an approximate measure of the Magnesium-clay versus Aluminium-clay ratio.

From these observations, it can be seen that kimberlites are serpentine dominated, while the other rock types are talc or amphibole dominated. Although the spectra are similar they can, in most cases, be discriminated, implying that the rocks can be distinguished on this basis. The PIMA could be useful for on site identification during drilling, as it is quick and provides reliable results.

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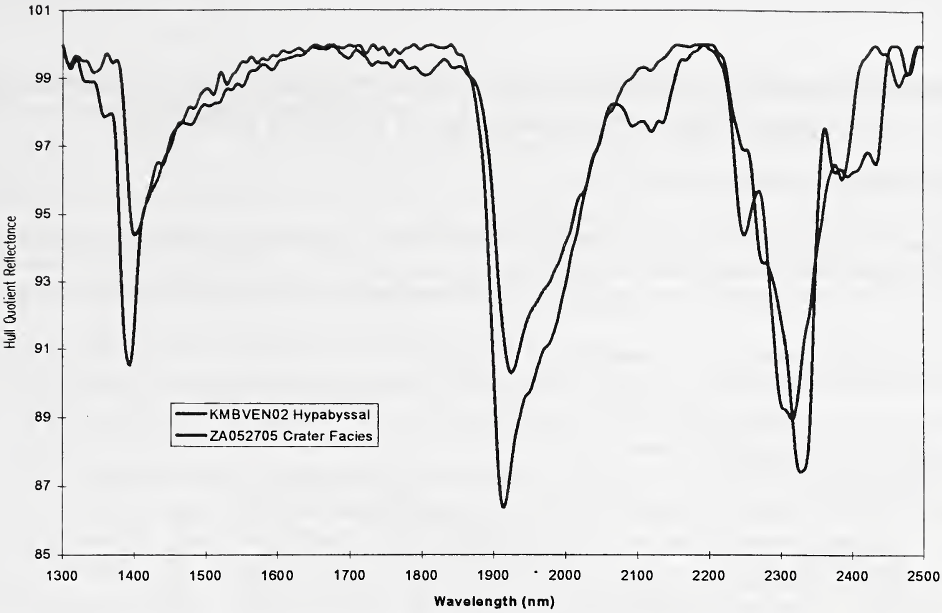

Figure 1: Spectra from kimberlite rock samples showing serpentine in blue, and a mixture of serpentine and talc in red.

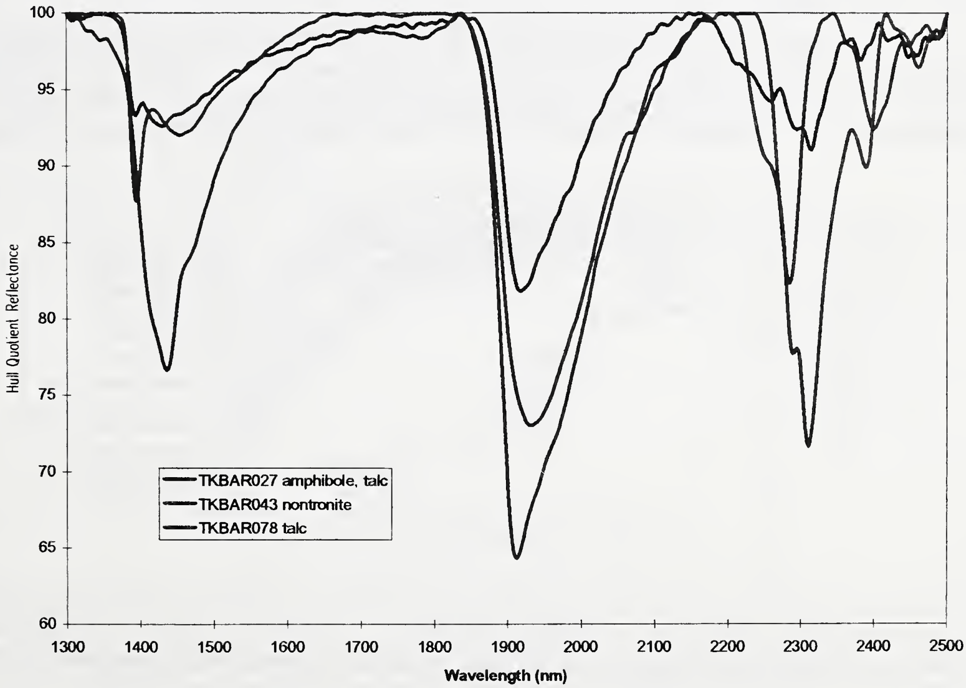

Figure 2: Spectra from three rock samples from the Tjakastad Subgroup. Red - talc dominated spectrum, blue - amphibole dominated spectrum, and green - nontronite spectrum.