The Infrared Study of a South African Kimberlite

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The definition of a kimberlite from mindat.org is:

> A polymict megacryst-rich ultramafic volcanic breccia, consisting of major amounts of serpentinized olivine, with variable amounts of phlogopite, carbonate, garnet (e.g. pyrope), orthopyroxene, clinopyroxene, chromite and oxides. Commonly highly serpentinized and porphyritic, it occurs in vertical pipes, dikes, and sills.

It is entirely possible in kimberlites around the world that all of these mineral constituents cited by mindat have been found in some specimen. The author can only respond to a purchased sample of South African kimberlite studied in infrared and other similar spectra found in locales around the world in his posession. With that, despite is orbicular appearance, it scans with absolutely no included mineral phenocrysts at all. It just shows something in the serpentine group related to antigorite, and olivine water, while missing a key 550 cm-1 peak found in all serpentines.

This spectrum has been found by the author in South African kimberlite, U. of Arizona Speclib spectrum from the eastonite type locality that others have long complained has serpentine but no eastonite (a Mg-biotite), in a scan of Snarum, Norway so-called hydrotalcite with none of that but more kimberlite, and mixed with something else likely chrysotile, in Clear Creek, CA serpentine (Figure 1). The author's specimen is clearly not porphyritic, it is porphyroblastic. It is made of green zoned orbs, not crystal inclusions.

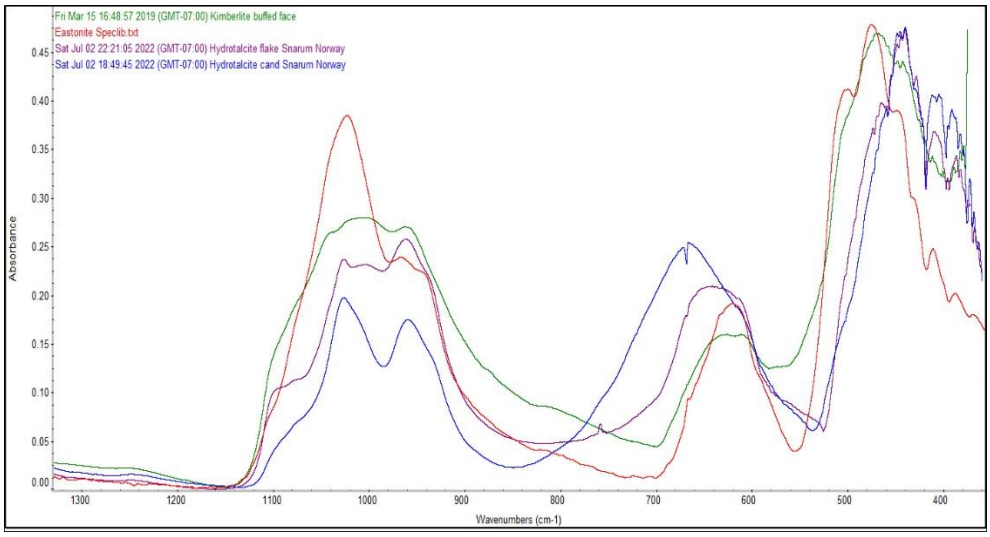

Figure 1. U. of Arizona Speclib eastonite reference (mostly antigorite serpentine, no eastonite, red), South Africa kimberlite, a mixed antigorite-lizardite serpentine (green), lizardite-serpentine from Norway that was supposed to be hydrotalcite (violet), mixed antigorite-lizardite serpentine, same specimen, from Norway (blue). 1100-900 cm^{-1} dominant peak greater than 1000 cm^{-1} the author identifies as antigorite; peak less than 1000 cm-1 is identified as lizardite, two roughly equal peaks above and below 1000 cm^{-1} is mixed. All other peaks for antigorite and lizardite and their water bands are the same. They are otherwise identical as they have the same chemical composition, just different crystal structures. They both have a 550 cm^{-1} peak missing here.

Infrared can show trace mineralization water not seen in these fundamental region bands, likely down to parts-per-million, and when we look there, we find a clear olivine signature in our kimberlite (Figure 2).

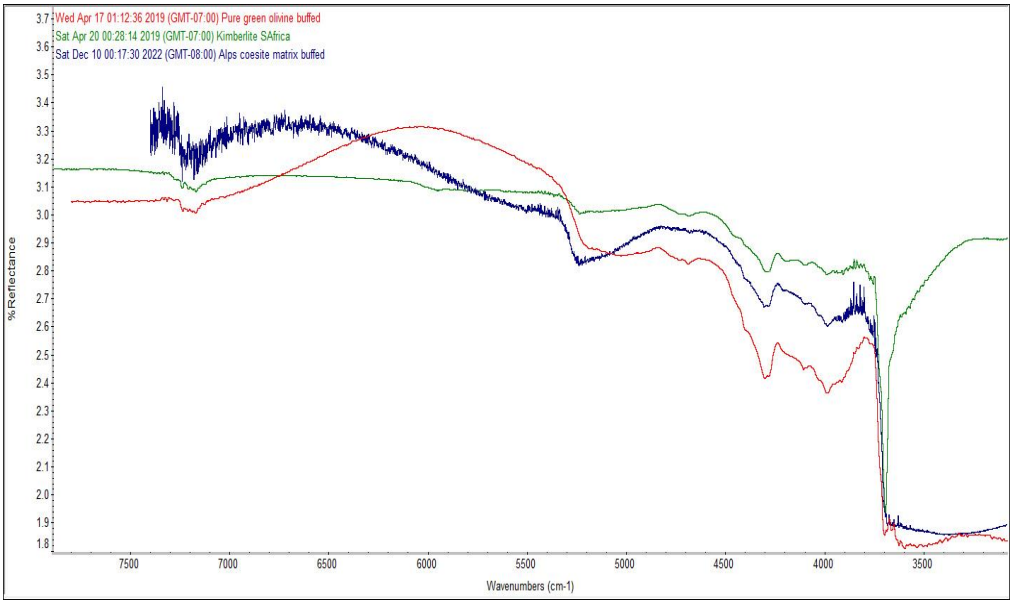

Figure 2. Green olivine (forsterite, red), South Africa kimberlite (green), Alps coesite matrix (blue) all showing olivine water bands. There is often not a lot of water in olivine so that only the sharp band, often a sharp drop instead of sharp trough, is seen at 3700 cm^{-1}.

Over at wikipedia.org the definition is:

> Kimberlite is an igneous rock and a rare variant of peridotite.

Then back at mindat the definition of peridotite is:

> A peridotite is an ultramafic rock containing more than 40% olivine (Mg_2SiO_4).
> A general term for a coarse-grained plutonic rock composed chiefly of olivine with or without other mafic minerals such as pyroxenes, amphiboles, or micas, and containing little or no feldspar. Accessory minerals of the spinel group are commonly present. Peridotite is commonly altered to serpentinite.

Let us compare a pure forsterite olivine (peridot) to a kimberlite (Figure 3). There is no match between this kimberlite and peridot fundamental region peaks but since we do have olivine water, it means the olivine is not 40% but in parts-per-million, orders of magnitude less olivine than reported. When you have mineral water bands without corresponding fundamental peak bands seen, the concentration is very small. Infrared is much more sensitive to water than elemental mineral compositional units to show in the fundamental region.

Where does all the other identified minerals come from in some specimens? The kimberlites are deep volcanic eruptions in narrow, vertical intrusions called pipes that explosively flare out near the surface from water coming out of solution and boiling with eruption decompression. This throttles the host rock, ablating it and carrying it up in the rising eruption. Whatever is in the country rock will come up with the eruption and the heat and force and water will also alter some of them. The core eruption, though, the author identifies as olivine-serpentine. The other minerals are opportunistic.

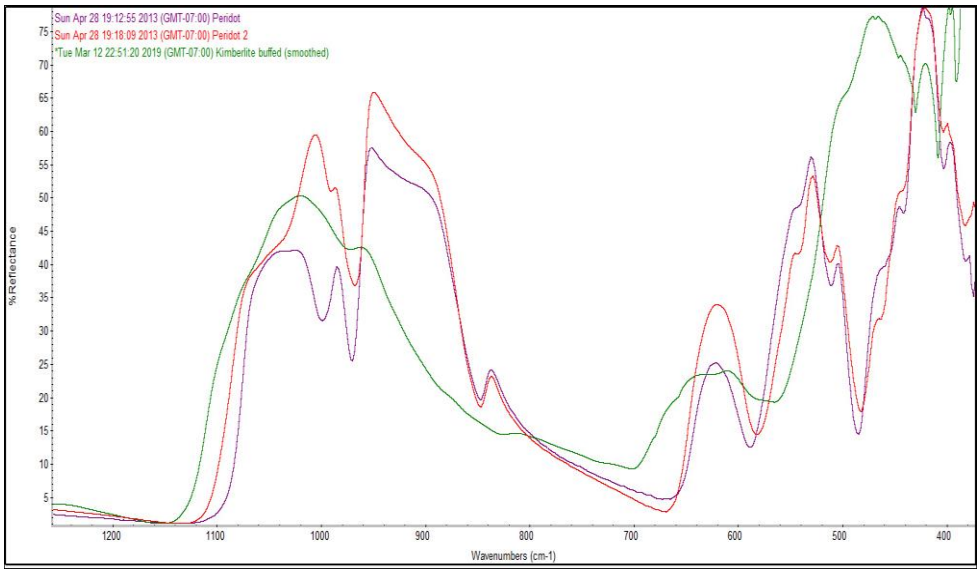

Figure 3. Kimberlite (noisy spectrum so it was smoothed, green), 2 peridot scans (violet and red). Kimberlite spectrum was smoothed, so the two peaks at 400 cm^{-1} are from smoothing noise spikes. There is no evident match to show olivine in this kimberlite and the similar samples from elsewhere.

Conclusions:

Kimberlite is an olivine-serpentine mineral as the dominant composition. Olivine is $Mg_2(SiO_4)$, and both antigorite and lizardite are $Mg_3(Si_2O_5)(OH)_4$, their difference just being different crystal structures, so the olivine provides the magnesium to alter basalt to this unique serpentine group mineral.

It appears kimberlite is not an aggregate of many minerals, but a unique serpentine mineral group species as no kimberlite so far has shown other mineral peaks or water bands. Scans with reflectance infrared of specimens from around the world show the same thing. Serpentine is a group of minerals based on magnesium with various end members including antigorite/lizardite/chrysotile, talc, forsterite olivine, and no we can add kimberlite as a serpentine group mineral.

Just because quartz is found in granite does not make quartz a rock. It means quartz can form as a rock with other minerals. In the same way, kimberlite is an olivine-serpentine end member in the serpentine group.