

Geochemical dissection of a kimberlite: What makes up a whole rock analysis?

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The elemental and isotopic composition of 'primary' kimberlite magma has been the subject of considerable debate for decades. The frequent occurrence of variably sized crustal fragments within hypabyssal and volcanoclastic kimberlite is a clear indication of the potential importance of crustal contamination in modifying the composition of the kimberlite magma. We present a trace element and isotopic study of multiple mineral phases from a kimberlite. Our objective is to see if different phases record different stages of crustal contamination in the evolving kimberlite and to assess which phases are most likely to give the best information on potential source regions.

We have analysed phlogopite, perovskite, olivine and calcite from a Group I kimberlite from Jos, Somerset Island, Nunavut. These results are compared with olivine, phlogopite, perovskite and apatite picked from a parallel study of an olivine melilitite from Saltpetre Kop (SPK), S. Africa. Melilitites are less obviously affected by crustal contamination and are generally less altered by low-T processes but contain a similar suite of minerals to kimberlite and therefore provide a simple analogue.

The minerals were leached and then processed for Sr and Nd isotopes and trace elements. Leachates were also collected.

Preliminary Sr isotope data from the melilitite confirm that olivine and perovskite have similar $^{87}\text{Sr}/^{86}\text{Sr}_i$ ratios to the whole rock; while the later crystallising phases, apatite and phlogopite, show increasingly more radiogenic values. Together they define a reasonable Rb-Sr isochron age of $\sim 77 \pm 3.4$ Ma close to the published emplacement age (72.5–76.8 Ma, [1]), which effectively rules out any significant progressive crustal assimilation.

Preliminary results from the Jos kimberlite are more complex and not consistent with closed system behaviour as with SPK. Variations in initial $^{87}\text{Sr}/^{86}\text{Sr}$ both within and between the different mineral phases so far analysed can be explained by a combination of factors that include progressive crustal contamination and source heterogeneity.

[1] Duncan *et al* (1978), *Geological Magazine*, **115**, 317–396

Unravelling redox processes in mantle wedge peridotites

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Oxygen fugacity ($f\text{O}_2$) is an important parameter in determining the relative stabilities of phase assemblages. Despite a number of studies have been devoted to determine the redox state of low pressure assemblages in the mantle system, the $f\text{O}_2$ of supra-subduction mantle wedge is still poorly investigated. An essential input for $f\text{O}_2$ estimates is represented by the determination of Fe^{2+} - Fe^{3+} content of key mantle minerals such as garnet, which can be measured by the "flank method" technique with electron microprobe.

As case studies, we selected samples of orogenic peridotites from the ultrahigh pressure Sulu belt (Eastern China) and from the Ulten Zone (Italian Alps) corresponding to slices of metasomatised mantle wedge sampled at different depths. They show phlogopite + magnesite and amphibole in equilibrium with olivine, orthopyroxene and Fe^{3+} -bearing garnet. The "flank method" measurements indicate that these pyrope-rich garnets contain $\text{Fe}^{3+}/\Sigma\text{Fe}$ up to 0.12–0.14. For peridotite mineral assemblages $f\text{O}_2$ can be evaluated from equilibria involving Fe^{3+} -garnet component $\text{Fe}_{2+}^{2+}\text{Fe}_{3+}^{3+}\text{Si}_3\text{O}_{12}$ on the basis of Fe^{3+} -Al substitution on the octahedral site, which is sensitive to the garnet oxidation state. We modelled a non-ideal mixing of Al and Fe^{3+} on the octahedral site, and a non-ideal mixing on the dodecahedral site, with a symmetric regular solution model for reciprocal solid solutions of Ca- Fe^{2+} -Mg-Al- Fe^{3+} -garnet. This enabled us to calculate $f\text{O}_2$ of garnet, given the presence of Fe^{3+} . Our results indicate that the Sulu and Ulten peridotites record high oxygen fugacities ($\text{FMQ} \div \text{FMQ} + 2$) compared with peridotite xenoliths from sub-cratonic mantle equilibrated at similar pressure conditions. The determination of $f\text{O}_2$ of these C-H-bearing garnet peridotites enabled us to estimate the speciation of C-O-H metasomatic fluids derived from the subducting slab, which result enriched in CO_2 .

These data might suggest that the relatively high $f\text{O}_2$ of these mantle wedge peridotites corresponds to a bulk oxidation due to the influx of slab-derived metasomatic fluids. However, we demonstrated that the variation of $f\text{O}_2$ in multi-component systems is not a simple increasing monotonic function of the oxygen content in the compositional space. The evaluation of $f\text{O}_2$ of metasomatised mantle wedge peridotites, representing the oxygen chemical potential μO_2 , therefore provides the first step to unravel the relationships between μO_2 and the metasomatic phase assemblages in multi-component mantle systems.