Mapping of the Kaapvaal craton lithosphere with garnets from a polymict peridotite

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Diverse mantle lithologies are assembled in a polymict peridotite xenolith from the Kimberley area, South Africa. The larger part of this peridotite is a breccia and contains olivine, orthopyroxene, garnet and rare clinopyroxene clasts, randomly collected from different mantle lithologies, and amalgamated by a fine-grained olivine matrix. Although entirely different in composition, each xenocryst has preserved its major and trace element homogeneity.

Small (<1.5 mm), deep red and violet xenocrystic garnets give Ni-in-Grt temperatures around 1300°C, which translates to a depth of about 200km along a conductive mantle geotherm. Red, pale violet and purple garnets were collected from shallower (120km) depth's with the lowest temperatures of around 1050°C. This temperature difference between the garnets translates to a depth interval of around 80 km along a geotherm. The sample thus provides an overview of the vertical geochemical changes of the Kaapvaal lithosphere.

All brecciated garnets have coronas of newly grown orange-red garnets, which shielded the cores of the grain. The composition of these rims coincides with the garnet composition of the smaller part of the sample, an intruded and solidified melt with Granny Smith clinopyroxene and ilmenite megacrysts. They have low CaO and Cr_2O_3 and plot in the harzburgite field, and have higher REE (2-10x) and HFSE (10-50x) than their "mother" core. New garnet compositions can be explained as a hybrid product of the existing mantle garnets and a kimberlitic melt, whereby the melt always represented more than 60 percent of the mix. Although, these grains have been affected by a late stage interaction with a kimberlitic melt, which brought them to the surface, it is possible to use this garnet as a window to the chemistry of the craton over an 80 km vertical cross-section.

There are no systematic changes of the major element chemistry of the xenocrystic garnets with depth. However, CaO wt% increases with decreasing temperature, while TiO2 wt% shows the opposite trend. A positive correlation between the LREE and the calcium concentration is observed. Garnets assembled from greatest depths (highest temperature) have characteristic trace element patterns with HREE enrichment and LREE, Zr, Nb and Ta depletion. On the other hand low temperature garnets (<1150°C) have enriched or sigmoidal REE and a wider range of HFSE. The REE and HFSE patterns in the brecciated garnets can only be explained by a depletion event and various consecutive stages of re-enrichment by metasomatic agents.