

Recent advances in pressure-temperature-time histories from single peridotitic garnet crystals: applications to diamond inclusions and xenocrysts

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Garnet now provides a unique opportunity to constrain pressure, temperature and time for key events such as kimberlite emplacement and diamond growth. Recent advances in reference materials and analytical strategies enable U–Pb dating in peridotitic garnet at very low isotope abundances (ppb), while pressure and temperature can be estimated with the use of a new machine learning thermometer and barometer for garnet xenocrysts. Estimates from machine learning geothermobarometry are robust, sitting on xenolith geotherms determined by cation exchange thermobarometry, and are congruent with Ni-in-Grt temperatures. Garnet U–Pb dates most often record emplacement ages for the entraining kimberlite melt in xenocryst and xenolith suites, reflecting open-system behaviour for any garnet above closure temperature of the U–Pb system until frozen at the Earth's surface, though garnet from cool (shallow, cratonic) parts of the lithosphere may preserve ancient ages.

For this study, we investigate peridotitic garnet inclusions from diamonds entrained in Siberian (Aikhal, Mir) and South African kimberlites (Premier, Finsch) using these new tools. We also use compositional, geothermobarometric and age data from large peridotitic garnet xenocryst datasets we have analysed to provide context for the pressures, temperatures, dates and compositions observed in garnet from diamond inclusions entrained in the same kimberlite.

In comparison to garnet from xenocrysts and xenoliths, peridotitic garnet from diamond inclusions skew towards depleted compositions, and variably lie on or off geotherms defined by xenoliths and xenocrysts, indicating the preservation of transient thermal perturbations or relict geotherms. A common feature of most of the analysed diamond inclusion suites is that garnet modal U–Pb ages are not substantially older than kimberlite magmatism e.g. inclusions from the Aikhal kimberlite in Siberia have U–Pb dates ranging from before kimberlite emplacement (531 ± 47 Ma, MSWD = 1.1) up to 0.5 Ga earlier (~1 Ga). Interpretation of ages depends on whether garnet are

assumed to be proto- or syn-genetic, and whether the U–Pb system in garnet included in diamond has behaved as a capsule. We will explore these possibilities in this presentation, in addition to compositional data which provide the lithological and geothermobarometric context to understand diamond growth processes.