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Origin of garnet peridotites in the lithospheric mantle beneath the Siberian craton

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Garnet peridotites represent the largest part of the lithospheric mantle beneath Archean crust, yet the origin of garnet in these rocks continues to be debated. The cratonic mantle is believed to be produced by extensive melt extraction indicated by common low Al and Ca (<1%) and high Mg#WR ($\geq$0.92) of cratonic peridotites [1]. However, even though many garnet peridotites are low in Al and Ca, they usually have lower Mg#WR (<0.92) than spinel harzburgites, which together with common high modal cpx and garnet (>5%) appear to be inconsistent with a residual origin by high degrees of partial melting [2].

To better constraint the origin of garnet in cratonic mantle we report modal, major and trace element compositions for >30 garnet peridotites from the Udachnaya kimberlite in central Siberia (as well as preliminary Nd-isotope data for selected samples). These rocks, unlike many other kimberlite-hosted peridotites worldwide, are unusually fresh, with very low LOI ($\leq$1%) and unaltered minerals [3]. The garnet peridotites in this study are coarse (mostly low-T) to sheared (high-T) harzburgites with Mg#WR of 0.90-0.92 and $\leq$1% $Al2O_3$ and CaO as well as two lherzolites. Their cpx (2-6%) and garnet (1-9%) have complex REE patterns affected by both melt extraction and various enrichment events.

Modal and major oxide compositions of spinel harzburgites from Udachnaya indicate an origin by >35% of partial melting in a broad depth range (2-7 GPa) based on experimental results [4]. By comparison, only 5 out 30 garnet harzburgites in this study plot close to the melting trends defined by spinel harzburgites. The majority of garnet harzburgites in this study (especially high-T) show a range of enrichments in Fe, Si, Ti, HREE etc. relative to pristine melting residues. Moreover, the Nd isotope data for the garnet peridotites (calculated from garnet and cpx analyses) yield an isochron age of 0.8-0.7 Ga, which is much younger than whole-rock Re-Os formation ages (2 Ga [5]). The combined Os and Nd isotope data suggest that the cratonic mantle beneath Udachnaya was formed simultaneously with the assembly of the Siberian craton about 2 Ga ago, but that the majority of garnet peridotites, in particular high-T rocks from the base of the lithosphere, were affected by metasomatism, possibly in the late Proterozoic. The widespread metasomatism could have ben caused by large-scale asthenospheric upwelling. Unmetasomatised garnet-bearing peridotites are very rare among kimberlite-hosted xenoliths, hence in the lithospheric mantle, in Siberia and elsewhere.

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