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Trace element enrichment in off-craton peridotites: comparison of off-craton Proterozoic and Pan-African mantle beneath southern Africa

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Trace element abundances in constituent clinopyroxene, garnet and phlogopite from off-craton mantle beneath the Proterozoic Namaqua-Natal belt (South Africa) and in clinopyroxene and amphibole from the Pan African Damara belt (Namibia) have been determined by laser ablation ICP-MS. Chondrite normalised rare earth element abundances in clinopyroxenes show a wide range of patterns from LREE depleted, through sinusoidal patterns to strongly LREE enriched. In garnets, the patterns range from strongly LREE depleted with flat HREE, through sinusoidal patterns to 'humped' sinusoidal patterns.

Numerical modelling shows that the range of REE enrichment patterns can be generated via reactive porous flow mechanisms involving an alkaline silicate melt and where, in the Proterozoic mantle, there is a high fluid/solid ratio (i.e. all clinopyroxene and garnet are products of modal metasomatism and/or near fully equilibrated with a metasomatic fluid). In contrast, clinopyroxene in the Pan African mantle shows evidence for cryptic metasomatism, where enrichment of pre-existing clinopyroxene by alkaline silicate melts has occurred at the distal regions of an advancing metasomatic front. Extreme fluid/melt compositions are not required to account for the enrichment patterns

Numerical modelling of primitive mantle normalised trace element abundances in clinopyroxenes show that the commonly observed strong relative depletions in Nb-Ta and Rb-Ba present in clinopyroxenes can be accounted for by crystallisation of accessory phlogopite (in Proterozoic mantle) and amphibole (in Pan African mantle) from the metasomatising melt/fluid. In contrast, strong relative depletion in Zr-Hf in some clinopyroxenes in both Proterozoic and Pan African mantle regions requires either metasomatic crystallisation of zircon, or involvement of a carbonatitic melt as metasomatic agent. Trace element enrichment patterns seen in clinopyroxene and garnet in the Proterozoic off-craton regions of southern Africa are indistinguishable from those seen in clinopyroxene and garnet from the Kaapvaal craton, and point to similar processes and history of enrichment.