Progressive metasomatism of the mantle by kimberlitic melts: Sr-Nd-Hf-Pb isotopic compositions of MARID and PIC minerals

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Owing to their high abundance of phlogopite, MARID (Mica-Amphibole-Rutile-Ilmenite-Diopside) and PIC (Phlogopite-Ilmenite-Clinopyroxene) rocks are often inferred to be extreme examples of mantle metasomatism. To determine the source(s) of mantle metasomatic agents, new Sr-Nd-Hf-Pb isotopic compositions have been collected for clinopyroxene and amphibole from MARID and PIC xenoliths hosted by South African kimberlites.

MARID minerals display broad ranges in isotopic composition (e.g., $^{87}Sr/^{86}Sr_i$: 0.705–0.711; εNd_i: –11.0 to −0.4), whereas PIC clinopyroxene has a restricted range of isotopic compositions ($^{87}Sr/^{86}Sr_i$: 0.704–0.705; εNd_i: +0.7 to +3.6). The Nd-Hf isotopic compositions of MARID minerals predominantly fall below the mantle array ($\Delta\varepsilon Hf_i$ from −13.9 to +1.0). This is attributed to mixing of a MARID end-member (i.e., $^{87}Sr/^{86}Sr_i = 0.711$; $\varepsilon Nd_i = -11.0$, $^{206}Pb/^{204}Pb_i =$ 17.3) with the entraining kimberlite magma (e.g., $^{87}Sr/^{86}Sr_i \approx$ 0.703; $\varepsilon Nd_i \approx +2.5$, $^{206}Pb/^{204}Pb_i \approx 19.7$). Numerical modelling of such mixtures was carried out using empirical mineral-melt partition coefficients, the results of which broadly match the Sr-Nd-Hf-Pb data for MARID minerals. This supports the notion that ranges in MARID isotopic composition are the result of partial equilibration with kimberlite melts either at mantle depths or during transport. The isotopic composition of the MARID “end-member”, reflecting an “enriched mantle” affinity, sugggests that MARID lithologies formed from metasomatic agents possibly derived from recycled crustal material [1]. In contrast, PIC clinopyroxene isotopic compositions cluster near kimberlite values, which is consistent with previous interpretations that PIC rocks are formed by intense metasomatism of peridotites by kimberlite melts.

[1] Fitzpayne *et al.* (2019) *EPSL* **509**, 15-26.