

Sr and Nd Isotope Decoupling in the Mantle by Melt Percolation Metasomatism: Evidence from Peridotite Xenoliths from Spitsbergen

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Peridotite xenoliths brought up by mantle-derived alkali basaltic magmas are direct samples of off-cratonic lithospheric mantle. Their Sr-Nd isotope compositions commonly plot within the "mantle array" defined by oceanic basalts or near the DM (depleted mantle) model end-member characterised by low $^{87}\text{Sr}/^{86}\text{Sr}$ and very high $^{143}\text{Nd}/^{144}\text{Nd}$. That compositional range is consistent with the existence of ancient refractory residues of partial melting and with local enrichment of those residues in incompatible elements through metasomatism by enriched OIB-type melts or fluids. Here we report results of a Sr-Nd-Pb isotope and trace element study of metasomatised spinel peridotite xenoliths in alkali basaltic rocks on the island of Spitsbergen, Svalbard archipelago (e.g., Ionov et al., 1996). Some of those xenoliths plot off the Sr-Nd mantle array and show strong fractionation of elements with similar compatibility. We argue that those features do not directly result from mixing between the DM and EM end-members but can be explained by chromatographic effects of melt percolation in the peridotite mantle.

The contents of compatible to moderately incompatible elements in Spitsbergen peridotites and their minerals indicate that most of those rocks are residues after partial melting and melt extraction. A smaller number of samples may have been produced by crystallization from or reaction with various melts as veins or cumulates. The initially depleted xenoliths bear a record of later metasomatic events that precipitated amphibole, phlogopite and apatite and/or produced enrichments in the incompatible trace element concentrations of pyroxenes. Trace element compositions of clinopyroxene define two principal enrichment patterns. Type-1 cpx, in most cases without any co-existing amphibole, are characterized by very high La/Ce and La/Nd ratios and also have lower concentrations of the middle REE and Sr and therefore lower MREE/HREE ratios relative to Type-2 cpx. On primitive mantle-normalised trace element distribution diagrams, Type-1 clinopyroxenes have nearly flat HREE-MREE patterns followed by moderate depletion from Eu to Nd and a steep La-Ce-(Pr) inflection. Type-2 cpx, generally co-existing with amphibole, have somewhat lower HREE concentrations followed by a continuous increase in normalised REE concentrations from Ho to Ce. Both types of clinopyroxene have strong negative Nb anomalies and small to moderate positive Sr anomalies. Vein minerals have convex trace element patterns with strong enrichment of Nb and Ta in amphibole and phlogopite.

Sr-Nd isotopic compositions of minerals separated from the xenoliths indicate an unusual type of enrichment with Sr decoupled from Nd such that Type-1 clinopyroxene has high $^{87}\text{Sr}/^{86}\text{Sr}$ but low $^{143}\text{Nd}/^{144}\text{Nd}$ values resulting in displacement of the data points to the right of the mantle array on Sr-Nd isotopic covariation diagrams. Two-component mixing of DM-type residual mantle and an enriched melt with an unusually high Sr/Nd ratio could produce some Sr-Nd isotope decoupling but that model does not appear to be supported by the trace element data. Moreover, the very high La/Ce and La/Nd ratios in some of the xenoliths cannot be produced by mixing of LREE-depleted peridotites with any known type of enriched mantle magmas. The geochemical evidence suggests that chemical fractional processes took place during metasomatism. The REE patterns of Type-1 clinopyroxenes are very similar to those produced by modelling chromatographic effects during melt percolation (Navon & Stolper, 1987; Vasseur et al., 1991; Takazawa et al., 1992) and appear to show evidence of different stages of interaction with percolating REE-rich melts. The 'chromatographic' models imply that elements with higher cpx/melt partition coefficients, like HREE, are selectively removed from the percolating melt by interaction with clinopyroxene in the host peridotite so that the melt at the percolation front becomes progressively enriched in the most incompatible elements. Because cpx/melt partition coefficient for Sr is lower than for Nd, the Sr enrichment front advances faster than Nd enrichment front. This creates a zone where the host peridotites have experienced enrichment in Sr (with radiogenic isotope composition), but not in Nd thus producing Sr-Nd isotope decoupling. The Type-2 patterns may have been formed at a later stage in the same metasomatic event and approach some degree of equilibration with the percolating melts. Strong depletion of Nb in some of the xenoliths cannot be completely reproduced by models of melt percolation through amphibole-bearing rocks and may be partially related to source characteristics.

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