Local Preservation of Ancient Fertile Mantle Domains in the Shallow Continental Mantle

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Spinel-facies mantle xenoliths from continental areas with significant Phanerozoic tectonic activity may have "fertile" modes and major element compositions similar to those predicted for the source of Mid- Oceanic Ridge Basalts (DMM), depleted by extraction of only 1-3% melt compared to the primitive mantle. The question is whether the "fertility" of these xenoliths is truly "primary" (i.e. the rocks represent the residue of ancient partial melting of a fertile mantle source) or whether it results from more recent re-fertilization of initially highly depleted mantle material by mantle metasomatism. For this purpose we studied the thermal and geochemical evolution of 18 clinopyroxene-rich anhydrous spinel lherzolite xenoliths hosted in Cenozoic alkali basalts from worldwide intra-plate volcanic fields (SW-US, Mongolia, Europe).

The coarse- to fine-grained recrystallized xenoliths originated at depths between 30 and 60 km in the shallow continental lithospheric mantle. Light REEs and other incompatible trace elements in bulk rocks and clinopyroxenes are slightly to moderately depleted, middle and heavy REE are flat to weakly depleted. Recent secondary enrichment of incompatible trace elements is excluded because (1) mineral/mineral trace element ratios follow systematic trends indicating attainment of chemical equilibrium and (2) even highly incompatible elements (e.g. La, U, Th) are homogeneously distributed within mineral grains.

The Sr-Nd isotope signatures of the clinopyroxenes are different from those of the host basalts. Clinopyroxenes from 12 samples plot in the Sr-Nd isotope diagram on the "Mantle Array" between DMM and PREMA. Six lherzolite samples (cpx 11-18%) extend the trend of Sr-Nd isotopes towards more residual mantle compositions (^{143}Nd/^{144}Nd 0.51331-0.51362; ^{87}Sr/^{86}Sr 0.70169-0.70194). Minimum Proterozoic Sr-Nd model ages of depletion are consistent with Re-depletion model ages (Meisel et al. 2001, Lee et al. 2001) and suggest that the fertile xenoliths have undergone ancient melt extraction. Thus, these lherzolites represent remnants of ancient small-degree partial melting of the convecting upper mantle and did not undergo any significant metasomatic overprint or melt infiltration process since the Proterozoic. This indicates that local Proterozoic "fertile" domains in the shallow continental mantle can survive re-working episodes such as rifting and crustal differentiation and remain unaffected by Phanerozoic refertilization.

References

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