Beyond garnet: REEs in the sub-continental lithospheric mantle

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Mantle xenoliths provide a valuable record of the long-term evolution of the mantle. Their mineralogy tells us that the subcratonic lithospheric mantle (SCLM) formed by partial melting of a fertile lherzolite source. A highly depleted nature of average SCLM is also required to explain the PT conditions, chemistry of garnets, the low heat flow into the Moho, and the unradiogenic Os-isotope composition. Many xenoliths also show evidence that multiple episodes of metasomatism followed original depletion, but several aspects of SCLM formation remain poorly understood: including the depth of partial melting and the nature of metasomatism.

To date, much geochemical work has focused on the REE composition of garnet, the dominant host of incompatible trace elements in clinopyroxene-free mantle lithologies. Many harzburgitic garnets from the SCLM are enriched in MREE, giving rise to unusual sinusoidal chondrite-normalised REE patterns. The sinusoidal REE patterns are widely attributed to metasomatic enrichment. Various mechanisms have been proposed to explain the REE patterns, which apparently do not obey the lattice strain predictions. Explanations include limited equilibrium between pre-existing garnet and metasomatic carbonatite melt [1] [2], metasomatism by ascending silicate melts that have undergone garnet crystallisation [3], and multi-stage processes involving melting in the garnet then spinel stability fields followed by metasomatic re-enrichment [4].

We present new REE data for individual minerals from a variety of SCLM xenoliths. Importantly, this includes data for olivine, orthopyroxene, and spinel crystals as well as garnet. The data were obtained by LA-ICP-MS. We will discuss the results in the context of understanding sinusoidal REE patterns in harzburgitic garnet. This study offers a new perspective on mantle metasomatism, furthermore, this approach offers the ability to investigate garnet-free lithologies and so can provide better constraints on the extent of cryptic metasomatism in the mantle and on the global abundance of REEs in the SCLM.

[1] Griffin et al. (1999) *Contrib. Min. Pet.*, **134**, 232-250, [2] Wang et al. (2000) *Contrib. Min. Pet.* **139**, 720-733, [3] Burgess and Harte (2004), *J. Pet*, **45**, 609-634, [4] Stachel et al. (1998) *Earth Planet. Sci. Lett.*, **159**, 1-12.