Insights into refertilization processes in lithospheric mantle from integrated isotopic studies in the Lherz Massif

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Differentiation of the Earth's mantle occurs principally through partial melting and extraction of basaltic melt. Among the mantle rocks occurring at the Earth's surface, harzburgites are widely considered as refractory mantle residues left after extraction of a basaltic component. In contrast, fertile lherzolites are generally regarded as pristine mantle, only weakly affected by partial melting. However in the Lherz Massif (France), structural mapping shows that the lherzolites are secondary rocks formed at the expense of the harzburgites. Variations of major, minor and trace elements across the harzburgite-lherzolite contacts indicate that the lherzolites were formed through a refertilization process involving interaction of refractory, lithospheric mantle with upwelling asthenospheric partial melts. Rare-earth elements (REE) in clinopyroxenes display variable chondrite-normalized REE patterns. Massive harzburgite bodies show U-shaped REE patterns whereas lherzolites have classic N-MORB REE patterns as observed in orogenic lherzolites worldwide. However at the contact, both lherzolite and harzburgite show more LREE-enriched clinopyroxenes than their distal counterparts. These REE enrichments also cannot be explained by partial melting model and provide further evidence for refertilization.

In order to further constrain the mechanisms involved in the refertilisation process, we investigated Sr, Nd and Hf isotopic compositions of over 15 samples accross a harburgite-lherzolite contact, as well as "distal" samples. Sr isotopes were measured in whole-rocks and clinopyroxene separates (TIMS and MC-ICP-MS), combined with the Sr in-situ method on clinopyroxenes (LA-MC-ICPMS). Al_2O_3 is negatively correlated with $^{87}Sr/^{86}Sr$ and positively correlated with $^{143}Nd/^{144}Nd$. These correlations are consistent with REE patterns. Distal harzbugites have $^{87}Sr/^{86}Sr$ = 0.703638(6), while distal lherzolites have $^{87}Sr/^{86}Sr$ between 0.7020 and 0.7025. Towards the contact, the lherzolites show a steady increase in $^{87}Sr/^{86}Sr$ up to 0.7032. The harzburgites within the contact radiogenic compositions up to 0.7055. The highly radiogenic composition of the contact zone is not compatible with melting models. Further investigations are in progress to characterise the scale and range of isotopic variations across the transition from harzburgite and lherzolite.