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The Lherz massif: 2 Ga history of mantle evolution.

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Differentiation of the Earth's mantle occurred 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 Archean harzburgites (2.3 Ga, Os ages). 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. The refertilization likely occured during the post-collisional thermal event recognized in the Variscan belt in Pyrenees, and was probably associated with strain localization. Rare-earth elements (REE) in clinopyroxenes display variable chondrite-normalized patterns. Massive harzburgite bodies have U-shaped REE patterns whereas lherzolites show the classic N-MORB REE pattern observed in orogenic lherzolites worldwide. However, at the contact, both lherzolite and harzburgite show more LREE-enriched clinopyroxenes than their distal counterparts, a feature that cannot be explained by partial melting. These enrichments rather lead to interpret the contact as a reaction front.

To further constrain the mechanisms involved in the refertilisation process, we investigated the Sr, Nd and Hf isotopic compositions of 16 samples (whole-rocks and

clinopyroxene separates) across a harburgite-lherzolite contact, as well as of “distal” samples, using TIMS and MC-ICP-MS techniques. Combined with previous works, these new data indicate that:

1) the Lherz peridotites show a wide range of isotopic signatures almost covering the whole domain of cratonic and non-cratonic peridotites worldwide, notably for Hf and Nd;

2) the distal harzburgitic protolith and refertilized lherzolites have well-individualized isotopic signatures defining two different poles;

3) near the contact, the isotopic signatures of the harzburgites and lherzolites are different from those of the more distal peridotites and tend to converge toward similar values. However they do not plot on a mixing line between the two poles, indicating a probable decoupling of Nd-Hf isotopes during melt percolation.

The refertilization in Lherz is part of a $\sim$2 Ga-long history of a fragment of subcontinental lithospheric mantle involving three main stages: (1) individualization of refractory lithosphere by high degrees of partial melting during the Archean; (2) thermomechanical erosion and rejuvenation of the lithosphere associated with infiltration of asthenospheric melts, probably in the late Variscan; this second stage was followed by thermal relaxation and integration of the refertilized peridotites in the lithospheric mechanical boundary layer (3) alkaline vein-metasomatism that occurred in the Cretaceous, shortly before the exhumation of the peridotite bodies along the N-Pyrenean fault.