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Correlated Geothermometry, Geochemistry and Texture of French Massif Central coarse-grained Peridotite Xenoliths with Geophysical Manifestations of Plume-lithosphere Interaction

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Extensive volcanic activity in the Massif Central (France) has entrained a large number of mantle-derived peridotite xenoliths. Several geophysical observations indicate that this volcanic activity is related to upwelling of small-scale mantle plumes as has been also postulated for other Cenozoic volcanic areas in Europe. Mantle xenoliths in Massif Central constitute a unique opportunity to investigate geochemical and thermal evolution of the Subcontinental Mantle Lithosphere (SCLM) during its interaction with a mantle plume, in both time (60 Ma to Quaternary) and space ($2x10^4$ km^2)

The quantitative textural study of a large suite of mantle peridotite xenoliths reveals the presence of two groups of coarse-grained xenoliths in Massif Central, located respectively in volcanic centers north and south of latitude 45^0 $30^{\prime}$. The peridotite xenoliths of the northern domain show protogranular textures, whereas peridotites of the southern domain are devoid of pyroxene-spinel clusters. In agreement with textural variations, the geochemistry of xenoliths defines two contrasting lithospheric domains beneath Massif Central. Coarse-grained peridotite xenoliths in the northern domain are refractory and depleted in MREE relative to HREE, but pervasively enriched in LREE and LILE. They show normalized patterns with negative anomalies of Nb, Ta, Zr and Hf relative to LILE and REE. Coarse-grained peridotite xenoliths from the southern domain are distinguished by more fertile compositions and relatively flat MREE-HREE patterns. We ascribe these spatial geochemical differences of coarse-grained xenoliths to the existence of two different SCLM blocks beneath

Massif Central that were likely accreted during the Variscan orogeny.

On the other had, the thermometric study of coarse-grained xenoliths reveals a remarkable regional coherence between the thermal record of xenoliths and seismic tomographic evidence for plume upwelling. Pyroxenes rims of coarse-grained peridotite xenoliths record peak temperatures that are positively correlated with temperatures inferred from seismic tomography, with lower equilibration temperatures in volcanic centers farther from geophysical manifestations of plume upwelling. These re-equilibration temperatures are interpreted as recording re-heating of the subcontinental lithosphere due to Cenozoic plume upwelling. Olivine Crystal Preferred Orientations (CPO) measured by EBSD also vary as a function of the distance to the seismic anomaly in the shallow mantle. Xenoliths from volcanic centers distant from the anomaly show strong olivine CPO, typical of high-temperature, low stress deformation by dislocation creep with dominant glide on (010)[100]. In contrast, xenoliths from volcanic centers atop from the seismic anomaly, that display higher rim equilibration temperatures, show significantly weaker olivine CPO.

Seismic tomography as well as rim equilibration temperatures and olivine CPO in xenoliths indicate that asthenospheric upwelling and lithosphere re-heating beneath Massif Central are focused beneath the southern domain and follow a NW-SE trend parallel to Variscan crustal structures. This trend roughly coincides with the boundary of the two compositionally distinct SCLM domains. These observations lead us to suggest that the inherited “architecture” of the SCLM may have played a critical role by channeling Cenozoic plume-lithosphere interaction in this region.