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Metasomatic interactions in the lithospheric mantle beneath the Massif Central, France: Characterization of metasomatic processes by trace element and redox features of spinel peridotites

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Textural and geochemical studies of mantle-derived xenoliths suggest the existence of two distinct domains in the SCLM beneath the Massif Central that were amalgamated during the Varisican orogeny (Lenoir et al., 2000). The boundary between the two domains appears to run approximately E-W at 45° 30' (Lenoir et al., 2000; Downes et al., 2003). The northern domain is generally more refractory, but has undergone a pervasive re-enrichment of LREE. In contrast, the southern domain is more juvenile (less depleted) in composition, but is less enriched or is even depleted in LREE. The two mantle domains are also reflected by differences in their redox state (Uenver-Thiele et al. submitted). Downes et al. (2003) reported trace element data for clinopyroxene (cpx) from a limited number of samples indicating different types and degrees of metasomatic effects in xenoliths from across the Massif Central. Here, we present a significantly expanded data set (from 45 localities) of cpx trace element compositions (LA-ICP-MS) coupled with redox data in order to better characterize these metasomatic processes on a local and regional scale.

In the northern domain, $\Delta \log fO_2$ values are predominantly $\geq$ FMQ+1, in spite of most samples being harzburgites. Clinopyroxenes are mostly marked by Lu/Hf values far higher than those from the southern domain, consistent with many of these samples having undergone almost twice as much fractional melting. These data also suggest that melting occurred in the presence of garnet prior to being uplifted into the spinel peridotite field. In contrast, $\Delta \log fO_2$ values of southern domain xenoliths are more variable, but the lherzolites reveal a subtle gradient in fO_2 increasing from south to north. The cpx have Lu/Hf values <1, typical for melting in the spinel peridotite field. REE patterns reveal variable degrees of metasomatic enrichment in most samples from both domains. Northern domain cpx have mostly high La/Nd (>10), but low Sm/Yb (<0.8). The trace element signatures of cpx and high $\Delta \log fO_2$ values for samples from Les Angles suggest that the boundary between the northern and southern domains lies somewhat to the south of that proposed by Lenoir et al. (2000), at about 45° 20'.

The presence of small amounts of amphibole in some samples, mostly in the south, does not correlate with the degree of enrichment or the highest fO_2 values in the suite. Only a couple samples have evidence (high Zr/Hf , low Ti/Eu) for interaction with a carbonatitic melt. Other samples have negative normalized anomalies in Zr, Hf, Nb and Ta, which are interpreted to represent metasomatism by a CO_2-rich alkaline silicate mafic melt (Grégoire et al. 2009). Differences in REE signatures between samples can often be related to variable intensities of metasomatism through chromatographic effects. In general, harzburgites appear to be more sensitive to changes in oxidation state and LREE enrichment, presumably due to their generally low spinel and cpx contents.

We find for a given locality a correlation between increasing fO_2 and LREE enrichment. A global correlation between fO_2 and trace element enrichment is complicated by differing styles of metasomatism as well as the effect of differing rock type, texture and whether melt extraction had occurred in the spinel or garnet field.

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Downes H. et al. (2003) Chem. Geol., 200, 71-87.
Grégoire et al. (2009) Lithos, 112, 203-216.
Uenver-Thiele et al. (submitted)