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Relationship between oxidation state and texture and the influence of metasomatism in the lithospheric mantle beneath the Massif Central, France

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Investigating regional variations in structure and composition of the subcontinental lithospheric mantle (SCLM) is usually hampered by the lack of samples. However, the numerous volcanic centers of the French Massif Central have brought samples of the SCLM to the surface over a geographic area of $\sim$20.000km^2. Lenoir et al. (2000) and Downes et al. (2003) identified textural and geochemical differences between two domains lying north and south of 45˚30' latitude, respectively. The northern domain is relatively refractory, but has experienced pervasive enrichment of LREE. The southern domain is generally more fertile, although the peridotites are LREE depleted. Many xenolith suites have undergone variable degrees of metasomatism. Variations in oxidation state might be expected from the differing histories of these two domains.

We have undertaken an extensive study to determine the oxidation state of the SCLM beneath the Massif Central over the largest geographical area possible, including 140 peridotite xenoliths from 45 localities. All xenoliths are spinel peridotites and vary in composition from lherzolites to harzburgites. Using the nomenclature of Mercier and Nicolas (1975) the xenoliths are mostly protogranular or protogranular-porphyroclastic, although some are porphyroclastic or equigranular. Small amounts of amphibole or biotite occur in some xenoliths, particularly in the southern domain, reflecting modal metasomatism. These metasomatic phases are found predominantly in peridotites with protogranular textures.

Oxidation state was determined using the equilibrium between the Fe-bearing components of olivine and pyroxene and the magnetite component in spinel (i.e. Wood et al. 1990). Major element compositions of the individual minerals were determined by microprobe. Ferric iron contents of spinel were determined by Mössbauer spectroscopy and gave values of Fe^{3+}/ Fetot from 0.159 to 0.459, with a conservative uncertainty of $\pm$0.02. Oxygen fugacity (fO_2) of the peridotites was determined using the Nell-Wood calibration of the above equilibrium (Wood et al. 1990) and are referenced to the fayalite-magnetite-quartz (FMQ) redox buffer. Generally, $\Delta\log(fO_2)$ values lie between FMQ-0.47 and FMQ+1.66 log units for the entire data set. In this fO_2 range propagated uncertainties are $\sim$ 0.1 log units.

The texture - fO_2 systematics differ between the northern and southern domains. Protogranular lherzolites from the northern domain record fO_2values >FMQ+1.25. In contrast, the protogranular harzburgites exhibit values >FMQ+0.9 whereas the protogranular-porphyroclastic or porphyroclastic harzburgites record lower values. The texture - fO_2 systematics of southern domain harzburgites are directly reversed. Southern domain lherzolites record fO_2 values $\sim$FMQ+0.6 $\pm$0.3. These systematic variations between texture and oxidation state are particularly evident for a given locality. Metasomatic interaction in the SCLM has produced notable changes in redox state at the regional as well as local scale, generally through oxidation. However, the most oxidized samples are not those containing amphibole, suggesting that cryptic metasomatism, (carbonate-melt metasomatism?) occurred in both domains. At certain localities, both modal and cryptic metasomatic events can be observed.

Downes H. et al. (2003) Chem. Geol., 200, 71-87.

Lenoir, X. et al. (2000) Earth Planet. Sci. Lett. 181, 359–375.

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