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Oxidation state of the lithospheric mantle beneath the Massif Central, France

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Tertiary and Quaternary volcanism of the French Massif Central has sampled the underlying subcontinental lithospheric mantle (SCLM) in the form of xenoliths over a wide geographic area of $\sim$20.000km^2. Such an extensive distribution of xenoliths provides an unique opportunity to investigate regional variations in mantle structure and composition Textural and geochemical studies suggest that two different mantle domains exist, lying north and south of 45˚30' latitude, respectively (Lenoir et al. 2000; Downes et al. 2003). 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. The different histories of these two juxtaposed blocks of SCLM should also be reflected in their oxidation state, with local variations also to be expected due to metasomatic interactions. For example, if carbonate-melt metasomatism played a role in the LREE enrichment of the northern domain (Lenoir et al. 2000; Downes et al. 2003), then such mantle should be relatively oxidised. Since surprisingly little redox data are currently available, we are undertaking a study to determine the oxidation state of the SCLM beneath the Massif Central over the largest geographical area possible.

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, although some are porphyroclastic or equigranular. Some samples with protogranular texture are distinguished by the presence of pyroxene-spinel-clusters. Small amounts of amphibole or biotite occur in some xenoliths, particularly in the south, reflecting modal metasomatism.

Major element compositions of the individual minerals were determined by microprobe. Xenolith equilibration temperatures range from 650˚ to $\sim$1200˚C at an assumed pressure of 15 kbar. Ferric iron contents of spinel were determined by Mössbauer spectroscopy and gave values of Fe^{3+}/ Fetot from 0.191 to 0.418, with a conservative uncertainty of $\pm$0.02. These data were used to calculate oxygen fugacity (fO_2) of the peridotites using the Nell-Wood calibration for the equilibrium between olivine, orthopyroxene and spinel (Wood et al. 1990) and are referenced to the fayalite-magnetite-quartz (FMQ) redox buffer. Generally, $\Delta\log(fO_2)$ values lie between FMQ-0.17 and FMQ+1.65 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 blocks. Protogranular lherzolites from the northern block record values $>$ FMQ+1.25. In contrast the protogranular harzburgites exhibit values $>$FMQ+0.9 whereas the protogranular to porphyroclastic or porphyroclastic harzburgites record lower values. The texture-fO_2 systematics of southern block harzburgites are directly reversed. Southern block lherzolites record fO_2 values $\sim$FMQ+0.6 $\pm$0.3. Metasomatic interaction in the SCLM has produced notable changes in redox state at the regional as well as local scale.

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

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