The nature of the mantle beneath La Grille volcano (Grande Comore Island, western Indian Ocean) as revealed by mineral chemistry, noble gas geochemistry and CO_2 abundance in ultramafic mantle xenoliths

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Petrology and fluid inclusions (FI) geochemistry are increasingly used in tandem to constrain the compositional features and evolution of the lithospheric mantle. In this study, we combine petrography and mineral chemistry with the first analyses of noble gases (He, Ne and Ar) and CO_2 concentrations in olivine-, opx- and cpx-hosted FI from ultramafic xenoliths collected at La Grille volcano in Grande Comore Island, in the attempt to better characterize one of the most controversial portions of the western Indian Ocean lithospheric mantle. Xenoliths have been divided in three groups on the basis of their textural features: Group 1 (Opx-bearing), characterized by protogranular to porphyroclastic texture overprinted by metasomatic reactions; Group 2 (Opx-free), with ad-cumulitic, infiltrated characteristics, and Group 3 (Cumulate), showing ortho-cumulitic texture. Petrographic observations and mineral phase compositions indicate that the sampled lithospheric portion experienced variable degrees of melting (from 5% to 35%), recorded by Group 1 most refractory harzburgites and lherzolites, as well as modal metasomatic processes as evidenced by the severe recrystallization of cpx at the expenses of opx in Group 1 fertile lherzolites and wehrlite and by Group 2 xenoliths. Crystallization of oversaturated basic silicate melts seems also to have occurred, as shown by Group 3 xenolith. The calculated equilibration temperatures range from 930°C to 1180°C with oxygen fugacity values between −0.93 and +0.71 $\Delta \log fO_2$ [FMQ]. A positive trend between temperature and fO_2 can be envisaged, with Group 2 and 3 xenoliths testifying for hotter and more oxidised conditions than Group 1. The variability of the He/Ar ratio (0.005-0.42), significantly below typical values of a fertile mantle (He/Ar = 1-5), can be explained by the variable degrees of partial melting coupled to metasomatism enrichment that may account for increasing He/Ar, as also indicated by the mineral composition. He-Ar-CO_2 relationships support the presence of a metasomatic process post-dating the melt extraction and affecting their relative abundances, as suggested by Coltorti et al. (1999). The $^3He/^4He$ isotopic signature corrected for air contamination (6.30 to 7.36 Ra) are intermediate between the lower limit of MORB mantle signature (8±1Ra) and the higher values of SCLM (6.1±0.9Ra). The Ne and Ar isotopic signatures are consistent with a mixing between an air-derived component and a MORB-like mantle, supporting the hypothesis for a lithospheric origin of the Comoros magmas. This is also corroborated by combining Ne with He isotopes, showing that La Grille ultramafic xenoliths are far from the typical plume-type compositions.

Coltorti M., Bonadiman C., Hinton R.W., Siena F. & Upton B. (1999) - Carbonatite metasomatism of the oceanic upper mantle: evidence from clinopyroxenes and glasses in ultramafic xenoliths of Grande Comore, Indian Ocean. J. Petrol., 40, 133-165.