Phlogopite- and amphibole-bearing ultramafic xenoliths from Kerguelen archipelago (TAAF, Indian Ocean): Evidence of variable trace element signature of melt fraction percolating oceanic lithospheric mantle

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Mantle metasomatism processes play an important role in the concentration, the distribution and the fractionation of incompatible trace elements in the upper mantle. New mineral parageneses which crystallize in mantle during the circulation of metasomatic agents may have positive partition coefficients for some of the trace elements which usually behave as incompatible element in ordinary upper mantle chemical conditions. This study documents trace element characteristics both in bulk rocks and in hydrous silicates of both mantle xenoliths (harzburgite and dunite) and deep ultramafic segregates (cpx-rich lherzolite, hornblendite, glimmerite) from the Kerguelen archipelago. These rocks give an insight into the metasomatic reactions and trace element behaviour occuring in the oceanic upper mantle beneath a thick oceanic crust (15–25 km). The Kerguelen islands are the third largest oceanic archipelago after Iceland and Hawaii and magmatic activity has extended over 30 Ma. They have evolved from a location near the SEIR to a present-day intraplate setting and therefore present a geological setting combining characteristics of the Iceland and Hawaiian regions.

Ultramafic xenoliths occur in the youngest and more alkaline Kerguelen lavas. Harzburgites and cpx-bearing dunites were equilibrated in the spinel peridotite stability field (T = 850–1150°C). Phlogopite and amphibole appear in numerous coarse-grained cpx-bearing dunites and more rarely in harzburgites displaying poikilitic textures. Harzburgitic phlogopite occurs as millimetric interstitial crystals enclosing spinel, olivine and opx and associated with cpx. More rarely phlogopite appears as crystals in thin veinlets. Amphibole only appears as small rounded interstitial grains and more rarely included in phlogopite. In dunites, the interstitial clinopyroxene is sometimes concentrated in thin layers between olivine crystals. Phlogopite is usually euhedral and interstitial but can be included in olivine. Amphibole usually replaces interstitial clinopyroxene. Some dunites and harzburgites display interstitial small patches composed of coexisting glass, globules of carbonates and phenocrysts of cpx, amphibole, olivine, rutile, ilmenite and Ti-chromite. The occurrence of 'hydrous mineral' and anhydrous mineral composition key parameters indicate that Kerguelen peridotites are highly metasomatised samples. For example harzburgitic cpx is a Mg-augite, in contrast to the typical mantle Cr-diopside, suggesting a 'magmatic' origin. Spinels of harzburgites and dunites are Mg-Al chromites characterized by high contents of Fe_2O_3 (2.5–7 wt.%) and TiO_2, especially in dunites (TiO_2: 0.65–1.45 wt.%) but also in harzburgites (0.25–0.6 wt.%). The cpx:opx ratio, as well as textural features, indicates the occurrence of important dissolution crystallisation processes (e.g. opx + liquid 1 → ol + cpx + liquid 2). Phlogopites occurring both in harzburgites and cpx-bearing dunites have mg numbers ranging from 84 to 91 and are characterized by high Cr_2O_3 (1.5–2 wt.%), Na_2O (0.3–1 wt.%) and Al_2O_3 (16–17 wt.%) contents. Amphiboles are magnesio-hastingsites and Ti-pargasites (mg numbers: 89-90). Whole rock and cpx of harzburgites and dunites show *LREE*-enriched or convex upward *REE* patterns (Fig. 1a). Cpx in

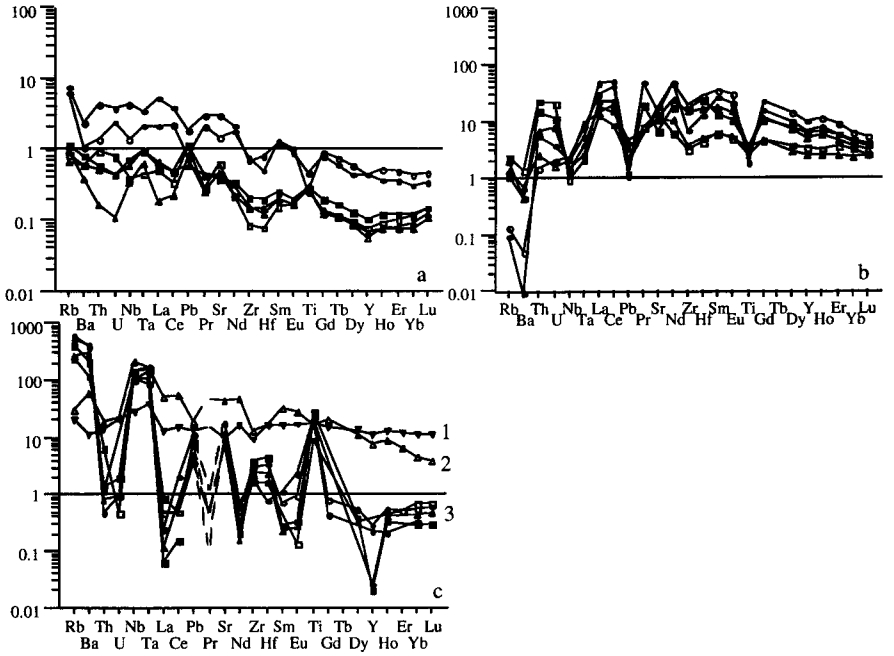

FIG. 1. Primitive mantle normalized abundance patterns in bulk rocks (a), cpx (b) and phlogopite (c.3) from the Kerguelen archipelago mantle xenoliths. lot c also displays amphibole from cpx-rich lherzolite (1) and hornblendite (2) segregates. Bulk rock data by solution ICPMS and mineral data by laser ablation ICPMS.

harzburgites and dunites display the same type of normalized-trace element patterns characterized by strong negative anomalies in Ti, Pb, Nb, Ta and Ba sometimes associated with Sr and Zr negative anomalies. But cpx-bearing dunites and harzburgites differ in their bulk rock normalized-trace element patterns respectively characterized by positive Ti, Sr and Pb anomalies and negative Ti, Zr, Hf, Pb and Ba anomalies (Fig. 1b). Phlogopite shows important ITE fractionation processes characterized by strong enrichment in Rb, Ba, Nb, Ta, Sr, Pb and Ti. Bulk rock of type II ultramafic segregate (Cpx-amphibole-rich lherzolite) displays a 5 to 10 × primitive mantle normalized *LREE*-enriched pattern [$(La/Yb)_N$ = 5], whereas amphibole shows a flat *REE* pattern [$(La/Yb)_N$ = 1] (Fig. 1c). Amphibole incompatible trace element pattern which is also flat and displays Rb, U, Nb, Ta positive anomalies, differs from those of the hornblendite. This latter shows similarities with the Kerguelen high alkaline lamprophyric lavas.

Petrological and geochemical characteristics of hydrous mineral-bearing Kerguelen dunites and harzburgites imply a formation by extensive equilibration with large volume of silicate melts. These conditions can be achieved either in wall-rocks to magma conduits (cpx-bearing dunites), or during percolation of lithospheric peridotites by magmas from the Kerguelen plume (poikilitic harzburgites) (Gregoire *et al.* 1997). Amphibole and carbonate-bearing patches evidence a late metasomatic event related to the pervasive percolation of mantle peridotites by low viscosity melts or fluids (Bedini *et al.* 1997).

References

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