Mantle xenoliths from the Lihir Volcano Group (Papua New Guinea): evidence of a refractory mantle metasomatised by subduction-derived fluids

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Numerous mantle xenoliths in addition to various volcanic, plutonic and sedimentary xenoliths have recently been discovered in the Tubaf volcano south of Lihir Island (New Ireland, Papua New Guinea). The Tubaf submarine cinder cone (1280 m below sea level) is related to the post-collisional high-K calc-alkaline volcanism (< 3.5 Ma) in the New Ireland fore-arc basin occuring after the collision of the Ontong-Java plateau with the Australia-Pacific convergent plate boundary.

Ultramafic xenoliths from Tubaf are spinel harzburgite (>90 %), with minor spinel lherzolite,

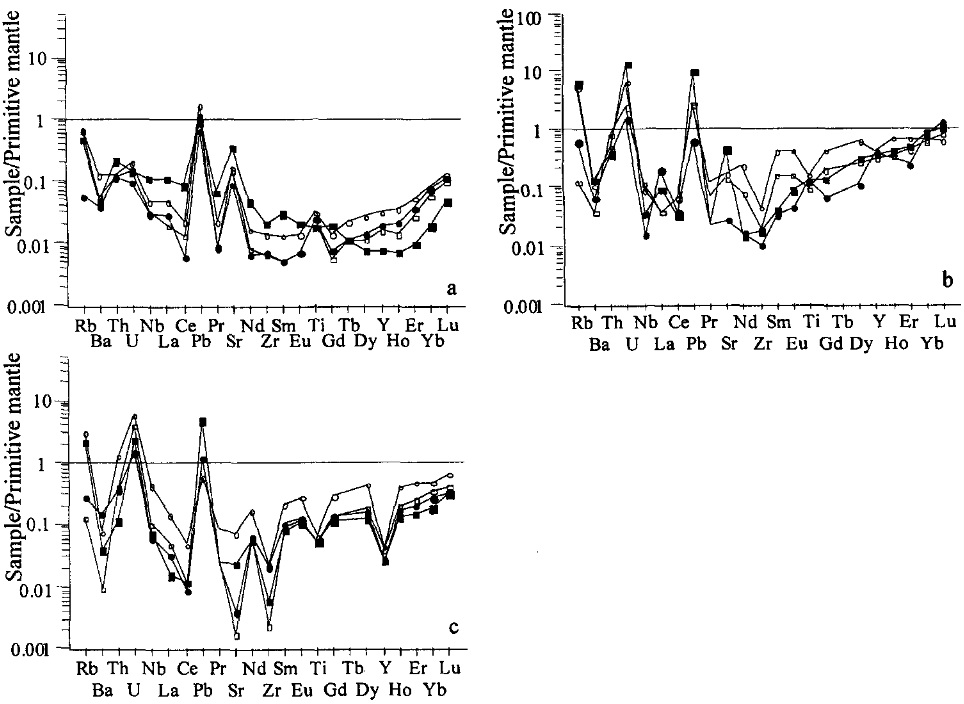

FIG. 1. Primitive mantle normalized trace element abundance patterns in bulk rocks (a), cpx (b) and opx (c) from the Lihir island mantle xenoliths. Bulk rock data by solution ICPMS and mineral data by laser ablation ICPMS. Primitive mantle abundances after McDonough and Sun (1995).

which indicates that the Lihir upper mantle is predominantly made up of refractory rocks. Many peridotite xenoliths have been affected by a modal metasomatic event evidenced by the occurrence of cross-cutting networks of orthopyroxenite veins. The veins are dilational in nature with no shear component and are inferred to have been produced by hydraulic fracturing. They contain a metasomatic mineral assemblage consisting of fibrous, radiating orthopyroxene and fine-grained Fe-Ni sulphide with minor olivine, clinopyroxene, phlogopite and magnetite. No silicate glass has been observed in the veins that are sharply terminated at contacts with host volcanic rocks. The fibrous silicate minerals are often euhedrally terminated and appear as if they grew into open space from a fluid. Close to the veins the primary peridotitic clinopyroxene and orthopyroxene becomes cloudy and exhibit replacement textures characterized by a secondary fibrous orthopyroxene similar to those occurring in the veins. This texture is quite common in samples with no veins cross-cutting the peridotite, inferring that the metasomatic agent transgressed through the sample along grain boundaries as well as by hydraulic fracturing.

The mineralogical and geochemical characteristics of the Tubaf mantle xenoliths are the product of at least two geological processes, an early partial melting depletion event overprinted by a later metasomatic enrichment event. Depletion by partial melting is indicated by the high refractory indices of both whole rocks and minerals (Fo87-91, Cr-rich spinel, high MgO and low CaO, Al_2O_3, Na_2O and total FeO contents in bulk-rock analyses). Modelling the abundance of *HREE* in clinopyroxene from the least metasomatized peridotites infers that they are the residues from a 15–25% partial melting event (fractional melting model).

Trace element characteristics both in bulk rocks and minerals suggest that the modal metasomatism event is responsible for the chemical enrichment in the most incompatible trace elements of the previously depleted mantle. The bulk rock *REE* content patterns systematically display *LREE* enrichment over *MREE* (La/Sm: 5.8–8.5). The trace element abundance patterns in both bulk rocks and minerals (opx, cpx) show positive anomalies in Pb, U and sometimes Th and Sr (Fig. 1).

The trace element characteristics, the presence of H_2O-rich fluid inclusions in the orthopyroxene and the lack of shear structures in the veins indicates that the modal metasomatism event is recent and probably occured via hydraulic fracturing may be caused by the influx of slab-derived hydrous fluids into the upper mantle beneath the Tubaf volcano. This oceanic upper mantle has been previously affected by high degree of partial melting, probably in an oceanic ridge context.

References

McDonough, W.F. and Sun, S.S (1995) *Chem. Geol.*, **120**, 223–53.