Geochemical signatures of high-T mantle xenoliths from Noyamadake, SW Japan: Implications from trace-element characteristics

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Mantle peridotite xenoliths from Noyamadake all record very high equilibrium temperatures (1100-1250C). Trace-element abundance in the clinopyroxene from these xenoliths has been determined by laser ablation microprobe (LAM)-ICPMS reveal distinctive signatures of depletion and subsequent metasomatic enrichment. Samples that are more depleted in melt component as calculated using mineral modes and major-element mineral compositions are more enriched in incompatible trace elements (the commonly-observed REE paradox) and thus display cryptic metasomatism. The trace-element patterns and relative abundances indicate that the possible metasomatic agents are a silicate melt/fluid (which may be represented by associated clinopyroxenite) and possibly carbonatite melt/fluid.

Noyamadake is one of the exceptional localities worldwide that provides samples of the wedge mantle. The locality is a small hill of basanitoid and basanite pyroclastics and lavas of erupted at 6-7.3 Ma (K-Ar ages; Uto, 1995). The occurrence of xenolith types was described in detail by Hirai (1987) and Arai et al (1998). Cumulate mantle xenoliths (dunite, websterite and clinopyroxenite) are almost equal in volume to those of the mantle peridotites in the Noyamadake lava (Hirai, 1987). The Noyamadake spinel peridotite xenoliths are distinctive in recording very high equilibrium temperatures (1100-1250C). Peridotite xenoliths from Noyamadake vary from clinopyroxene-rich (23 vol.%) lherzolite to almost clinopyroxene-free (0.1 vol.%) harzburgite. The microstructure of peridotite xenoliths is protogranular to porphyroclastic (Hirai, 1987). The grain sizes of olivine and orthopyroxene are relatively large (2 mm). The grains of pyroxenes have a rounded shape. Olivine grains show remarkable kink-band and undulatory extinction under microscope.

Olivine Fo in peridotites varies from 87.0 to 91.6 and from 83.9 -87.2 in the cumulate xenoliths. Cr# of spinel has a wide range (0.11 to 0.70). Al2O3 content in orthopyroxene is very high, up to 6.7 wt%. The Na2O content in clinopyroxene is higher (up to 1.5 wt%) than that of other localities from Japan arcs.

Selected clinopyroxenes were analyzed in situ for trace-elements using a laser ablation microprobe (LAM)-ICPMS at GEMOC, Macquarie University. Their chondrite-normalised REE patterns can be classified into three groups; (1) light rare earth element (LREE)-depleted convex-upward pattern, (2) LREE-enriched pattern and (3) HREE-depleted with LREE-enriched pattern.

The Ti/Zr ratio is has a restricted range (41-245), but the LREE/HREE [Ce/Yb)N (N= chondrite-normalised)] and Ti/Eu ratios vary widely 0.4-9.6 and 2280-6400, respectively.

The clinopyroxenes in the more depleted peridotites (calculated using mineral modes and mineral major-element compositions), is more enriched in LREE and LILE; the so-called "REE paradox (Frey and Green, 1974; McDonough and Frey, 1989; OReilly et al, 1991)". These peridotites thus show evidence of "cryptic metasomatism (Dawson, 1984)", as no metasomatic mineral formation accompanies the LREE-enrichment.

It is quite difficult to determine the metasomatic agent for such peridotites. Using the discriminants of (La/Yb)N and Ti/Hf ratio in clinopyroxene as suggested by Coltorti et al. (1999), the involvement of more than one metasomatic agents is indicated as the plotted values span the fields defined to be distinctive for specific metasomatic agents. These fluids are firstly a ubiquitous silicate melt and/or H2O fluid with silicate component which may be related to the formation of cumulus ultramafic suite such as clinopyroxene, websterite and wehrlite and secondly, a rarer carbonatite melt and/or CO2 fluid as the plotted values span the distinctive regions for each metasomatic agent type.

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