1994

In (Meyer, H.O.A. and Leonardos, O., eds.) Proceedings of the 5th Internat. Kimberlite Conf. (in press)

NORTHERN TANZANIAN PERIDOTITE XENOLITHS: A COMPARISON WITH KAAPVAAL PERIDOTITES AND INFERENCES ON METASOMATIC INTERACTIONS

By

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ABSTRACT

New mineral chemical data, P-T-fO_2 estimates and modal mineralogies are reported for peridotite xenoliths from the Lashaine and Olmani cinder cones of northern Tanzania. The Lashaine garnet peridotites are similar to low temperature peridotite xenoliths of the Kaapvaal craton: olivines are forsterite-rich (Fo typically > 91), spinels are chromites with Cr# from 60 to 83 and enstatite is abundant (up to 35%). Garnet compositions trend towards low CaO content, and are similar to rare subcalcic garnets in some Kaapvaal harzburgite xenoliths. Equilibration pressures and temperatures are also similar to cratonic xenoliths, lying near a 44 mW/m^2 geotherm. Garnet-free peridotites from Lashaine exhibit equilibration temperatures slightly below or similar to those of garnet peridotites, suggesting they were derived from similar depths. Lashaine garnet peridotites have higher SiO_2, Al_2O_3 and CaO compared with garnet-free peridotites, but Mg#'s are similar. Cratonic peridotites, which are refractory and enstatite-rich, have recently been suggested to be residues of komatiite extraction. However, SiO_2-enrichment is not a characteristic of residues generated by komatiite extraction unless melting occurs within the majorite stability field, and this is unlikely considering the compositions of both erupted komatiites and cratonic peridotites.

We suggest that enrichments of SiO_2 and minor Al_2O_3, CaO and Na_2O in the Tanzanian garnet-bearing peridotites resulted from the interaction of refractory peridotite residues with a silicic melt derived from partial melting of a subducting slab.

Olmani peridotites are extremely refractory (Fo up to 94, Cr# up to 89) yet typically contain olivine and clinopyroxene without enstatite; the most clinopyroxene-rich sample also contains apatite intergrown with clinopyroxene. The clinopyroxene in the Olmani samples is texturally secondary and may have formed by interaction of a Ca-carbonatite melt with a refractory peridotite protolith at relatively low pressures. Monazite occurs in the single clinopyroxene-free harzburgite as inclusions within olivine (Fo_{94}). This is the first reported occurrence of monazite as an upper mantle phase. This sample is enigmatic but may represent the reaction product between magnesite carbonatite and residual harzburgite.

INTRODUCTION

Recent studies have highlighted the differences between peridotite xenoliths from cratonic settings (mainly the Kaapvaal craton of southern Africa) and non-cratonic regions (Boyd, 1989, Hawkesworth et al., 1990, McDonough, 1990). Compared with peridotites carried by off-craton alkali basalts, kimberlite-hosted cratonic peridotite xenoliths have more refractory compositions (i.e., lower CaO, Al_2O_3 and higher Mg#) and higher modal enstatite, reflected in high SiO_2 in the whole rock. These characteristics of the Kaapvaal peridotites have been ascribed to extraction of komatiitic melts in the Archean, thus apparently explaining their restriction to Archean cratons (Boyd, 1989, Hawkesworth et al., 1990).

We report here petrography and mineral chemistry of newly collected peridotite xenoliths from the Lashaine and Olmani volcanoes in northern Tanzania (major and trace element geochemistry and isotopic compositions will be reported elsewhere (Rudnick et al., 1992)). The Lashaine garnet peridotites share many characteristics with the low temperature peridotites of the Kaapvaal craton, but do not occur within an Archean craton. Lashaine spinel peridotites are chemically distinct from Lashaine garnet peridotites and spinel peridotites carried in alkali basalts. The Olmani peridotites are chromite-bearing ultra-refractory residues that have experienced subsequent enrichment of clinopyroxene and phosphates, possibly due to interaction with carbonatite melts.

The Neogene (Quaternary) Lashaine and Olmani ankaramite volcanoes erupted within the southern extension of the east African rift near the town of Arusha in northern Tanzania (see Fig. 113 in Nixon, 1987). They lie within the Usagaran province, a ~1.9 Ga series of sedimentary and volcanic rocks (Gabert, 1984), and occur ~150 km to the east of the Archean Tanzanian craton. The crust here is at least early Proterozoic in age, based on 2.2 Ga Depleted Mantle Nd model ages from granulite xenoliths from Lashaine (Cohen et al., 1984), and has undergone significant pan-African (~550 Ma) reworking (Gabert, 1984).

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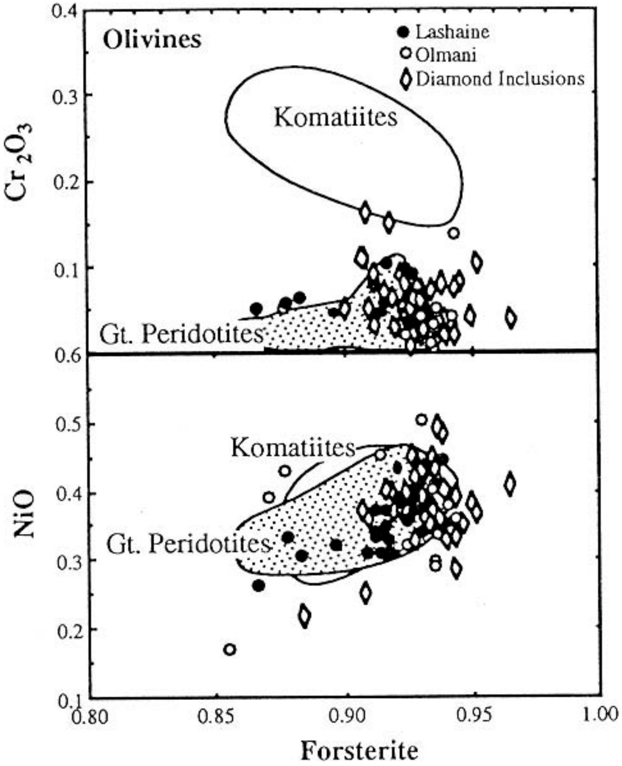

Figure 2. Forsterite content (Mg/(Mg+Fe)) versus NiO and Cr_2O_3 for northern Tanzanian peridotite olivines. In this and subsequent diagrams the northern Tanzanian data are from Tables 2-10 and from Reid et al. (1985), Jones et al. (1983), Pike et al. (1980) and Henjes-Kunst and Altherr (1992). Shown for comparison are diamond inclusion olivines and field of olivines from low temperature garnet peridotites and komatiites; data taken from the literature.