

Subduction-Related Mantle Pyroxenites from Zabargad Island, Red Sea

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Peridotite bodies on the remote island of Zabargad are host to numerous pyroxenite veins. The dominant pyroxenite type in the Central Peridotite is spinel websterite and two distinct populations can be recognised in the field, although intermediate compositions are also present. The two end-members fall in to the classical categories of Cr-Di and Al-Di (Wilshire & Shervais, 1975) based on the composition of the cpx (Cr-Di = Cr₂O₃ 0.5-1.2 wt%, Al₂O₃ ~7 wt%; Al-Di = Cr₂O₃ <0.1 wt%, Al₂O₃ >8 wt%). The Al-Di pyroxenites in this study have similar LREE-enriched patterns to the Cr-Di which they appear to cross-cut. Both types contain pargasitic amphibole. These Al-Di veins are not equivalent to the much less common, deformed, HREE-enriched, and anhydrous Al-Di veins also reported from Zabargad (Vannucci et al., 1993).

The websterites are produced by a reaction between silicate melt flowing along a conduit and the peridotite wall rocks. The pyroxene-rich, olivine-free nature of the veins is simply a consequence of the reversal of the spinel lherzolite melting reaction; cpx + opx + spinel = liquid + olivine. The stoichiometric coefficients of this reaction are P,T-dependent (Walter et al., 1995; Gaetani & Grove, 1998) but at 0.8 to 1.6GPa closely match the modes of the pyroxenites.

The Li isotopes of the pyroxenites ($\delta^7\text{Li} = +8.6$ to $+11.8\%$) are distinctly ⁷Li-enriched compared to the host peridotites ($+4.4$ to $+5.0\%$) which are similar to the expected mantle $\delta^7\text{Li}$ value as implied from fresh MORB. Sea water has a $\delta^7\text{Li}$ value of approximately $+33\%$ and ⁷Li-enrichment approaching this value is limited to altered oceanic rocks which have interacted with this reservoir at low temperatures (Chan et al., 1992). As the pyroxenites crystallized from high temperature melts in a mantle environment, the high $\delta^7\text{Li}$ strongly suggests the involvement of a Li component that was transferred from a dehydrating, subducted slab. One of the pyroxenites has a negative $\delta^7\text{Li}$ value (-4.2%) which may indicate a different Li source in the subducting slab, possibly related to dewatered sediment (Moriguti & Nakamura, 1998) or high temperature alteration of

oceanic crust at Mid-Ocean Ridges. A lower crustal meta-basalt in tectonic contact with the Central Peridotites not only displays the positive $\delta^7\text{Li}$ signature ($+10.1\%$) seen in the pyroxenites (suggesting it is the surface expression of a related magma) but also the trace element pattern of an IAB.

Unlike the Li isotopes, the trace element inventory of the pyroxenites is not directly equivalent to that of the parental melt, but is a combined function of the melt composition and the mineral-melt D's under the conditions of formation. However, it is possible to model this process and a comparison of the incompatible trace element signature of Al-Di and Cr-Di samples suggests that the principle difference is due to the change in D's as a function of pressure; Al-Di representing lower pressures of crystallization than Cr-Di. The calculated trace element composition of the equilibrium melt for both sets of pyroxenites is similar, and closely resembles modern IAB and the collision-related basalts of the African-Nubian Shield.

Although the generation of pyroxenites at Zabargad has previously been attributed to recent rifting events associated with the opening of the Red Sea basin, the association with a subduction environment appears to implicate them in the more ancient continent forming processes which operated in the region during the Pan-African orogeny (700-600 Ma).

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