CHEMISTRY OF MANTLE PERIDOTITES FROM TROODOS OPHIOLITE

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ABSTRACT

A detailed geochemical mapping of the mantle peridotite section in the Troodos ophiolite massif has revealed a km-scale compositional heterogeneity. Based on the Cr# (Cr/(Cr+Al)) of spinel and modal abundance of clinopyroxene (cpx) we subdivided the mantle section into two units: 1) spinel lherzolite with a Cr# of 0.22-0.28, and 5-7 modal % cpx and 2) harzburgite with a Cr# 0.51-0.70, and 0.5-1 modal % cpx. The boundary between spinel lherzolite and harzburgite units coincides with that separating Wilson's (1959) limit between zone abundant chrysolite veinlets and rare chrysolite veinlets.

Small-scale compositional heterogeneity is present within both lherzolite and harzburgite units. The spinel lherzolite contains numerous dunite bodies. Zones of cpx-bearing harzburgites are located between the spinel lherzolites and the dunite bodies and have higher Cr# of spinel (0.32-0.45) and lower modal cpx 1.5-4.5 % than surrounding spinel lherzolite. These harzburgites will be refereed later on as a harzburgites-II to distinguish them from the harzburgites of the main unit (harzburgites-I). The dunites display the highest Cr# of spinel (between 0.70-0.84). Contacts between spinel lherzolite and harzburgite-II are gradational. Contacts between harzburgite-II and dunite are sharp. While cpx is present in the contact zone between harzburgite-II and dunite, dunites themselves are cpx free. Clinopyroxenite and enstatitite veins are associated with dunite bodies.

The harzburgite-I unit underlies the ultramafic metacumulates representing the "petrologic" Moho (Allen, 1975; etc). Dunite, plagioclase lherzolite bodies and gabbroic impregnation zones are abundant within the main harzburgite. Spinel lherzolites display a narrow compositional range over the entire unit, well within compositional variations of abyssal peridotites in respect to both trace element concentrations of cpx and mineral chemistry. The incompatible element patterns of cpx are very close to those of abyssal peridotites with only difference in a slight upward inflection of La and Ce of former (Fig. 1A). Cpx from harzburgite-II surrounding the dunite bodies within the lherzolite unit have lower HREE concentrations and extremely low (close to SIMS detection limit) MREE concentrations (Fig. 1B). They show very significant upward inflection of La and Ce relative to Nd. Cpx from the enstatitite vein shows the same trace element pattern. Cpx from the clinopyroxenite veins differs from those of harzburgite-II by having higher MREE concentration (Fig. 1B). All these rocks are close in their cpx trace element composition and mineral chemistry to forearc peridotites and most depleted Oman harzburgite (Fig. 1B). Cpx from the harzburgite-I unit are extremely depleted in HREE (Fig. 1A). Their MREE concentrations are below detection limit of SIMS. The close association of cpx with opx and grains morphology suggests that cpx formed by exsolution from opx during recrystallization accompanying solid-state deformation (Sobolev and Batanova, 1995). The modeling suggest that spinel lherzolite represents the residue of 12% critical melting of a depleted (MORB-like) mantle source with a low residual mantle porosity (0.1%) The upward inflection of La and Ce could be explained by subsequent melt percolation event. The structure of cpx-bearing harzburgite – dunite zones, their position within the spinel lherzolite and their association with magmatic pyroxenite veins allows us to suggest that these zones could be produced by reaction of spinel lherzolite with percolating melts. Dunite bodies and surrounding cpx-bearing harzburgite-II represent pathways of the melts in the mantle.

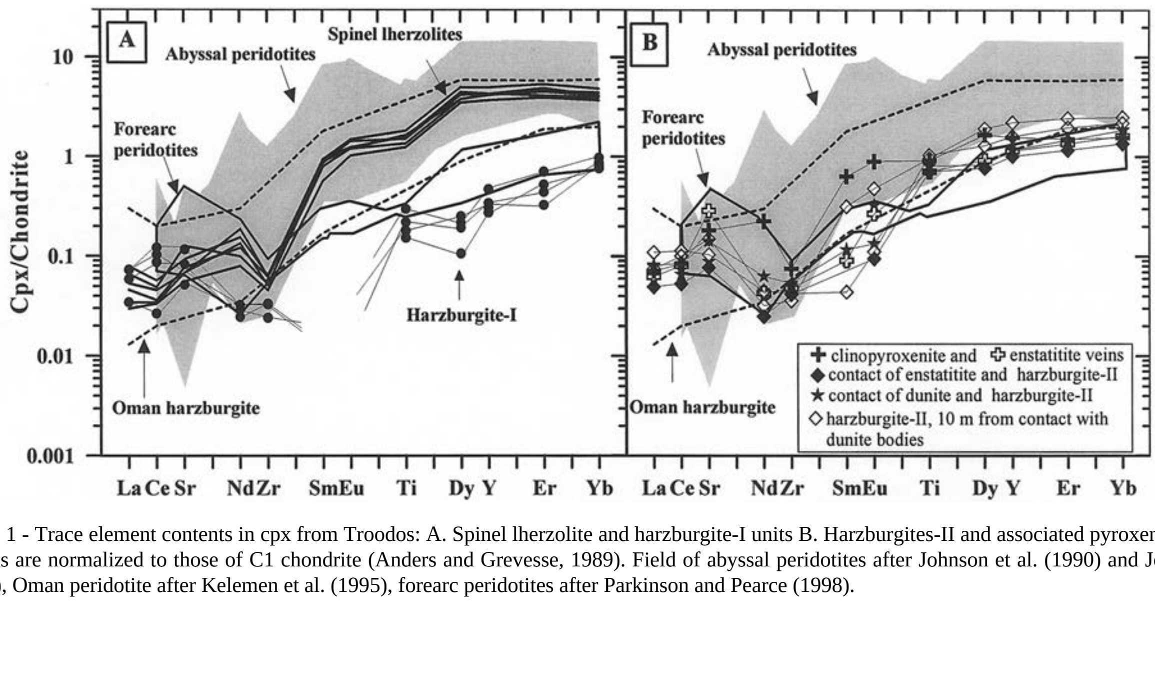

Figure 1 - Trace element contents in cpx from Troodos: A. Spinel lherzolite and harzburgite-I units B. Harzburgites-II and associated pyroxenites. All concentrations are normalized to those of C1 chondrite (Anders and Grevesse, 1989). Field of abyssal peridotites after Johnson et al. (1990) and Johnson and Dick (1992), Oman peridotite after Kelemen et al. (1995), forearc peridotites after Parkinson and Pearce (1998).

Some of these melts were close to ultra-depleted boninites from Troodos upper pillow lavas. However the majority of analyzed clinopyroxenes suggest a percolation of melts significantly more depleted in MREE than any known so far. Such melts could form by second stage melting of refractory lherzolite but require addition of LREE and Zr enriched component likely of subduction related origin.

A more plausible mechanism for the production of the harzburgite-I can be regarded as an open-system reaction between infiltrating melt and the initial spinel lherzolite.

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