

CRUSTAL METASOMATISM IN SUBDUCTED MANTLE: RECORDS FROM THE ULTEN PERIDOTITES (UPPER AUSTRALPINE, EASTERN ALPS)

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ABSTRACT

In the Ulten Zone (Upper Austroalpine), small bodies of mantle peridotites are incorporated within high-grade basement rocks (gneisses and migmatites) which represent remnants of lower crust subducted and reequilibrated at eclogite-facies conditions during the Variscan orogenic cycle. The Ulten peridotites record a complex metamorphic and deformational evolution, which is testified by the transition from coarse-grained protogranular spinel-bearing peridotites, to fine-grained garnet and amphibole (Ca-hornblende)-bearing peridotites with porphyroclastic to mosaic granoblastic textures. Thermometric estimates on the coarse-type spinel lherzolites have yielded high temperatures of equilibration, in the range 1100-1300°C (Obata and Morten, 1987). In the porphyroclastic peridotites, the metamorphic recrystallization to (garnet + amphibole)-facies conditions is evidenced by the development of: i) garnet coronas around spinel, ii) fine-grained granoblastic aggregates made by olivine + garnet + Ca-hornblende + new pyroxenes, iii) garnet and Ca-hornblende exsolutions within primary spinel-facies clino- and ortho-pyroxenes. The P-T conditions of the high-pressure eclogitic recrystallization which produced the spinel- to garnet-facies transition have been recently estimated to 850°C and 27 kbar (Nimis and Morten, 1999).

The peculiar thermobarometric reequilibration recorded by the Ulten peridotites has been interpreted as the result of a wedge to slab evolution (Nimis and Morten, 1999; Godard et al., 1996). In this scenario, the spinel peridotites represent portions of a mantle wedge which were incorporated (by convection) in a downgoing slab of cold continental crust, and were then subducted together with the slab to depths of about 90 km. Entrainment in the cold slab and subduction caused the reequilibration of the peridotites at 850°C and 27 kbar. The metamorphic transition from spinel- to garnet-bearing assemblage occurred therefore in a dynamic regime, and was accompanied by significant input of metasomatic fluids, as testified by the crystallization of abundant amphibole in the garnet-bearing high-pressure assemblage. Petrologic investigations on the host gneissic basement rocks have evidenced that they also experienced high-pressure recrystallization, which was accompanied by in-situ partial melting and migmatization (Godard et al., 1996).

The particular geodynamic evolution of the Ulten peridotites thus offer the unique opportunity to investigate the effects of crustal-derived metasomatism on mantle rocks involved in a subducting environment. Previous whole-rock chemical and isotopic investigations on the Ulten peridotites have evidenced that the fine-type garnet-facies ultramafics are enriched in LREE, K, Sr and that the alkalis enrichment is positively correlated with the $^{87}\text{Sr}/^{86}\text{Sr}$ ratios.

In this study, we present the results of detailed *in situ* in-

vestigations (performed by the ion microprobe operating at CICC, Pavia, Italy) on the trace element chemistry of the main mineral phases (clinopyroxene, amphibole and garnets) from seven selected samples representative of the various stages of the tectonometamorphic evolution recorded by the peridotites. Major aims have been to investigate the geochemical signature of fluids responsible of the amphibole crystallization, and provide further constraints on the nature of the metasomatic processes. The data obtained are potentially useful to characterize, by direct evidence, the chemical changes induced in mantle rocks by crustal metasomatism.

The coarse-type spinel peridotites, which are relics of the "pre-subduction", mantle-wedge equilibration stage, display modest metasomatic effects. In these samples, modal metasomatism is only recorded by the incipient crystallization of amphibole as rims around clinopyroxene. Clinopyroxenes have almost flat REE spectra ($\text{Ce}_\text{N}/\text{Sm}_\text{N} = 0.76-0.87$) at 4-8 x C1 values, or display concave shape with selective LREE enrichment ($\text{Ce}_\text{N}/\text{Sm}_\text{N} = 2.50-4.50$, $\text{Sm}_\text{N}/\text{Yb}_\text{N} = 0.53-0.97$). The REE concentrations of amphiboles are very similar to those of clinopyroxenes. Both amphiboles and clinopyroxenes in sample MK5D, a coarse-type garnet-bearing peridotite, exhibit a convex-upward REE pattern characterized by LREE and HREE depletion ($\text{Ce}_\text{N}/\text{Sm}_\text{N} = 0.17-0.19$; $\text{Sm}_\text{N}/\text{Yb}_\text{N} = 3.07-6.13$). Their low HREE abundances are due to the equilibration with garnet which, as expected, show severely fractionated patterns ($\text{Ce}_\text{N}/\text{Yb}_\text{N} < 0.001$; HREE at about 20-30 x C1). Amphiboles, in the coarse-type rocks, also show low Sr (18-35 ppm) and K (171-964 ppm) abundances.

The most evident metasomatic effects are recorded by the eclogite-facies recrystallized fine-type peridotites. In these rocks, modal metasomatism is documented by abundant crystallization of amphibole (Ca-hornblende, Mg values: 90-92) in equilibrium with garnet. In some samples, the gnt+cpx+amph+opx+ol assemblage is replaced by amph+opx+ol assemblages, this feature indicating progressive degrees of hydration. Amphiboles display significant LREE enrichment ($\text{Ce}_\text{N}/\text{Yb}_\text{N} = 3.90-11.50$; LREE in the range 20-50 x C1) and high Sr (150-250 ppm), K (1910-7280 ppm) and Ba (280-800 ppm) contents. By contrast, they have relatively low concentrations in HFSE (e.g., Zr = 14-25 ppm, Y = 6.7-16 ppm, Ti = 1150-2500 ppm, Nb = 2-7 ppm).

The geochemical signature recorded by amphibole in the fine-type peridotites, i.e. the strong enrichment in LILE relative to HFSE, is a peculiar feature of crustal-derived metasomatic agents. The lack of evidence of major element modifications in mantle minerals (e.g. Mg-value decrease, crystallization of orthopyroxene around olivine) strongly suggest that the metasomatic agent was an hydrous fluid rather

than a silica-rich melt. Moreover, experimental studies have demonstrated that aqueous fluids preferentially partition elements like alkalies, Ba, Sr and Pb, whereas they have scarce affinity for HFSE. The results of our study therefore indicate that the chemical modifications occurred in the Ulten peridotites during the high-pressure reequilibration were most likely produced by the input of hydrous, LILE-enriched, fluids, which caused crystallization of abundant amphibole. Such H₂O-rich fluids could represent the residual fluids left after the crystallization of leucosomes, starting from water-undersaturated melts produced during migmatization of the host gneisses.

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