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Spinel peridotites from Lanzo South (Western Alps, Italy): records of melt/peridotite interaction in the mantle lithosphere

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Present knowledge indicate that the ophiolitic peridotites of the Lanzo South Massif were exhumed from spinel facies conditions to shallow levels during the rifting stage of the Jurassic Ligurian Tethys ocean. During exhumation, these spinel peridotites were diffusely percolated and impregnated by asthenospheric melts, giving rise to plagioclase peridotites (Piccardo, 2003; Muentener and Piccardo, 2003). Preliminary investigations on some spinel peridotite samples, have revealed that they are products of melt/rock interaction, rather than simple melting processes (Piccardo et al., 2004a, 2004b).

The present study is focused on spinel peridotites from Mt. Arpone (Lanzo South), which show heterogranular textures, made by coarse-grained, strongly deformed olivine and pyroxene porphyroclasts and fine-grained olivine and pyroxene grains and aggregates. They have variable clinopyroxene contents and peculiar microtextures: i) coronas of new unstrained olivine partly replacing exsolved pyroxene porphyroclasts, which indicate peridotite interaction with pyroxene-undersaturated melts; ii) interstitial grains and aggregates of unstrained ortho- and clinopyroxenes along borders and triple points of spinel-facies porphyroclasts, which indicate the interstitial crystallization of pyroxene-saturated melts.

A detailed mineral trace element investigation has been performed by means of LA-ICP-MS technique on pyroxenes from representative spinel peridotite samples. Notwithstanding the similar petrographic-microtextural features, the clinopyroxenes from different reactive spinel peridotites show significant differences in terms of the geochemical composition, which, in most of them, do not correspond to those of clinopyroxenes in mantle residua after partial melting.

One group of Cpx (Group 1) is characterised by strongly-fractionated, LREE-depleted patterns. They have coherent LREE concentration ($\mathrm{Ce}_N/\mathrm{Sm}_N$ = 0.06, Ce_N = 0.22-0.36), but variable HREE content and fractionation [$\mathrm{Eu}_N/\mathrm{Lu}_N$ from 1.0 (with Yb_N = 9) to 1.80 (with Yb_N = 3)]. In particular, the composition of the clinopyroxene from the HREE-richest sample is very close to that expected for crystallisation in equilibrium with melt produced by 5% fractional melting of spinel-facies DMM.

A second group of Cpx (Group 2) has slightly humped REE patterns with lower LREE fractionation ($\mathrm{Ce}_N/\mathrm{Sm}_N$ = 0.15-0.27). The absolute REE content is rather variable (Ce_N = 0.86-3.02), but it is always associated with marked HFSE^{4+} negative anomaly.

A third group of Cpx (Group 3) is characterised by L/MREE-enriched (Ce_N = 4.3-5) sinusoidal patterns determined by a convex-upward shape in the L-MREE region with maximum at Pr-Nd ($\mathrm{La}_N/\mathrm{Nd}_N$ about 0.50; $\mathrm{Nd}_N/\mathrm{Ho}_N$ about 3.0) associated with a slight positive slope in the Er_N-Lu_N range (Er_N-Lu_N about 0.85).

Finally, a fourth group of Cpx (Group 4) is characterised by strongly humped REE patterns with maximum at Eu_N (12.3). LREE (Ce_N = 0.3; $\mathrm{Ce}_N/\mathrm{Sm}_N$ about 0.04) and HREE (Yb_N = 2.7; $\mathrm{Gd}_N/\mathrm{Lu}_N$ = 3.85) are significantly depleted and fractionated.

The geochemical modelling suggests that the trace element variability exhibited by clinopyroxenes from the Lanzo South spinel peridotites is the result of interaction between different uprising melts and a depleted lithospheric mantle column, most probably consisting of refractory residua after 15-20% of fractional melting.

Based on the LREE composition of Group 1, 2 and 3 Cpx, it is estimated that the injected melts were produced by $<1\%$ to 5% of fractional melting of spinel-facies DMM. The differences in terms of trace element composition among the putative melts calculated in equilibrium with Group 1 and 3 Cpx can be reproduced by assuming that the melt-peridotite interaction occurred under increasing melt mass conditions. Conversely, decreasing melt mass conditions should be invoked for the chemical gradient shown by Group 2 Cpx.

The REE patterns of Group 4 Cpx could derive from complete equilibration with a primary melt produced by 5% fractional melting of a garnet-facies mantle source.

Our results indicate that Lanzo South peridotites, prior to impregnation and refertilization forming plagioclase peridotites, were constituted by depleted spinel peridotites which had been subjected to reactive percolation and partial to complete equilibration with variable melt increments deriving from low degree fractional melting of mantle sources under different pressure conditions (both garnet and spinel facies conditions). This composite evolution supports the interpretation that the Lanzo South peridotite derived from spinel-facies subcontinental lithospheric mantle, and excaped low-pressure partial melting during the “oceanic” evolution.

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