ORIGIN OF POST-VARISCAN GABBRO-DERIVED GRANULITES (NORTHERN APENNINES, ITALY): CRUSTAL CONTAMINATION PROCESSES AND IMPLICATIONS FOR MANTLE SOURCES

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ABSTRACT

The Late Cretaceous sedimentary melanges from the External Liguride Units of Northern Apennines include large slide-blocks of subcontinental mantle peridotites, MOR-basalts and lower and upper continental crust rocks. The slide-block association has been interpreted as representative of a continent-ocean transition between the Internal Liguride oceanic domain (Late Jurassic Western Tethys) and the thinned continental margin of the Adria plate (Marroni et al., 1998). The slide-blocks of lower continental crust consist of mafic and felsic granulites, which locally preserve primary contacts. The mafic granulites commonly display a metamorphic layering, but undeformed rocks preserving a gabbroic fabric are locally found. Undeformed mafic granulites are mostly represented by spinel-bearing gabbronorites, usually containing significant amounts of either olivine or Fe-Ti-oxides. Olivine- and Fe-Ti oxide-bearing rocks locally show spinel-pyroxene symplectites and garnet coronas, respectively. The felsic granulites are mainly quartzo-feldspathic rocks consisting of mesoperthitic to perthitic feldspar, quartz and garnet. The gabbroic protoliths of the granulites were emplaced at about 290 Ma at deep crustal levels, where they underwent slow cooling and recrystallisation under granulite-facies conditions (P = 0.7-0.8 GPa, T = 800-900°C). They were exhumed to upper levels, in association with the felsic granulites, in late Triassic-middle Jurassic times.

The gabbro-derived granulites can be recognized as cumulus rocks with negligible amounts of residual trapped liquid, on the basis of low SiO_2/Al_2O_3 ratios and overall low contents of incompatible trace elements. The Mg# value ranges from 80 to 52, and point to negative correlations with TiO_2 and MnO, thus indicating a tholeiitic differentiation trend. Most gabbro-derived granulites have slightly LREE-enriched patterns showing decreasing Eu positive anomaly with increasing total REE abundances. Chondrite normalization of incompatible trace elements reveals spikes at Ba and Sr, and a slight Zr depletion. The quartzo-feldspathic granulites have LREE enriched patterns, with nearly flat HREE and no or slightly positive Eu anomaly; Ba is abruptly enriched relative to REE, whereas Nb and Ti are depleted.

The gabbro-derived granulites show a wide range in Sr and Nd isotopic compositions. The Sr isotopic ratio recalculated at 290 Ma varies between 0.7031 and 0.7077, and the initial ε_{Nd} ranges between +6.8 and -4.5. Two samples of quartzo-feldspathic granulite yield age-corrected Sr isotopic ratios of 0.7107 and 0.7109, and ε_{Nd} of -8.0 and -5.7. As a whole, the Nd and Sr isotopic data at 290 Ma form a hyperbolic array, in which the olivine-bearing gabbronorites have the highest ε_{Nd} values and the lowest Sr isotopic ratios.

Clinopyroxenes have been analyzed for trace elements by ion microprobe. Clinopyroxene from olivine-bearing gabbronorites shows peculiar compositions that indicate a metamorphic origin through olivine-plagioclase reaction, i.e. the igneous protoliths of the olivine-bearing gabbronorites were most likely troctolite-type cumulates. Clinopyroxenes from Fe-Ti oxide bearing gabbronorites show igneous geochemical trends, thus suggesting that these rocks contained clinopyroxene as original igneous phase.

Petrography, bulk-rock and mineral composition indicate that the gabbro-derived granulites can be related to a fractional crystallization process, with early separation of olivine and plagioclase, followed by the replacement of olivine by pyroxene at the liquidus. Trace element modelization of the parental liquid compositions applied to the olivine-bearing rocks yields LREE- and LILE-enriched liquids, with absence of negative Nb anomaly, similar to plume-type MOR-basalts and continental tholeiites. However, a P-MORB origin seems to contrast with the initial Nd and Sr isotopic compositions, which are close to depleted mantle values at the time of emplacement.

AFC modelization was successfully applied to obtain the isotopic compositions of the most contaminated samples, starting from the trace element and isotopic compositions of the parental liquids of the olivine gabbronorites and assuming a crustal contaminant with low Sr/Nd and isotopic composition comparable to that of the quartzo-feldspathic granulites. AFC calculations also indicate that the parental liquids of the olivine-bearing gabbronorites cannot be ascribed to N-MORB primary liquids. The primary mantle magma was necessarily characterized by moderate LILE enrichment, although an increase in LILE concentrations could have been enhanced by a small crustal contribution. The LILE enrichment in the parental liquids of the gabbro-derived granulites may be explained with a low degree partial melting of a rather fertile lithospheric mantle source. Alternatively, the primary liquids of the gabbro-derived granulites were related to a mantle source enriched in LILE as a result of the Variscan subduction event.

REFERENCES

Marroni M., Molli G., Montanini A. and Tribuzio R., 1998. The association of continental crust rocks with ophiolites in the Northern Apennines (Italy): implications for the continent-ocean transition in the Western Tethys". Tectonophysics, 292: 43-66.