GEOCHEMISTRY, ISOTOPIC GEOCHEMISTRY AND U-PB AGES ON ZIRCONS FROM METAGABBROS AND METABASITES IN THE HERCYNIAN LOWER CRUST OF THE SERRE MASSIF (CALABRIA)

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In the Serre Massif (southern Calabria, Italy), a Variscan crust section crops out consisting, from the top to the bottom, of: *i)* middle-to low-grade metamorphic rocks, *ii)* a "layer" of granitoids having a thickness of about 13 km, and *iii)* 7-8 km thick lower crust (Schenk, 1981; Caggianelli *et al*., 1994). The lower crust section includes from the bottom: a) layered metagabbros with interbedded meta-peridotites; b) felsic- and mafic-granulites with interleaved metapelites; c) migmatitic metapelites with interleaved metabasites, rare marbles and felsic orthogneisses (Colonna & Piccarreta, 1975; Paglionico & Piccarreta, 1978; Atzori *et al*., 1984; Schenk, 1984; Schenk, 1990; Acquafredda *et al*., 1994; Graessner & Schenk, 2001; Messina *et al*., 2004).

In order to characterize the evolution of the basic magmatism in the lower crust of the Serre Massif, petrographic, geochemical, and geochronological studies were performed on mafic rocks occurring in the lower part of the deep crust. They consist of metagabbros, meta-monzogabbros and metabasites interleaved with metasediments, involved by Hercynian metamorphism. The aim of this work points to define the origin of the mafic magma and to indicate the geodynamic context in which Neo-Proterozoic magmatism was realized.

At the base of the deep crust, the metagabbros (Pl + Opx + Amph ± Cpx ± Bt ± Qtz ± Grt) have coarse grained size and isotropic texture. Trondhjemitic leucosomes or thick amphibole layers are interspersed within the main gabbroic body. Some samples of metagabbro contain clinopyroxene nodules surrounded by an Amph + Opx or Opx + Amph ± Pl corona. Porphyroblastic garnet with symplectitic corona is interspersed within these rock-types.

Meta-monzogabbro bodies form layers or lenses having metric size. This rock type is characterized by medium grained size and anisotropic texture; it consists of Pl + K-Feld + Opx + Cpx + Bt ± Qtz ± Grt. This rock-type contains biotite, K-feldspar and centimeter sieno-granitic pockets having magmatic texture. In some samples of meta-monzogabbro (*e.g.*, TUR75) abundant amphibole and clinopyroxene nodules can be present.

Lenses or layers (up to 20-30 cm thick) of metabasites are interleaved within migmatitic metapelites and felsic granulites of the upper part of the deep crust. Mineralogical association consists of Pl + Opx + Cpx ± Bt ± Amph ± Qtz ± Grt. The content in amphibole and biotite is variable. They show medium grained size, isotropic texture and trondhjemitic portions.

In the studied rocks, plagioclase generally ranges from An_{50} to An_{60} with reverse zoning in more mafic metagabbros and in some meta-monzogabbros, whereas an andesinic plagioclase (An_{40-49}) is present in more differentiated types. Plagioclase of symplectitic coronas around garnet or included in garnet has bytownitic composition (An_{70-85}). A bytownitic-anortitic plagioclase (An_{80-90}) is present in more primitive metabasites whereas a calcium-poorer plagioclase (An_{40-49}) appears in more differentiated metabasites.

Orthopyroxene is generally Mg-rich having Mg# value [$Mg/(Mg+Fe^2)$] of ~ 0.70 in all rock types but in some samples it shows Mg# around 0.60 or 0.50. Clinopyroxene is a diopside and shows Mg# generally higher than 0.92; its composition is homogeneous in matrix, nodules and symplectitic corona.

Within the metagabbros and metabasites, different types of amphibole have been distinguished: Mg-rich/K-poor amphibole (ferroan-pargasitic hornblende in metagabbros, magnesium hornblende and edenitic hornblende in metabasites) and Mg-poor/K-rich amphibole (potassian-ferroan pargasites and potassian-ferroan-titanian pargasites in metagabbros; potassian-ferroan pargasitic hornblende in meta-monzogabbros and in metabasites).

When present, micas shows homogeneous composition; they correspond to phlogopite with Mg# around 0.60 and high Ti content (Ti/22ox around 0.60 and 0.70).

Porphyroblastic garnets shows similar features in metagabbros, in meta-monzogabbros and in metabasites: they have almandine-pyrope composition (Mg# ranging from 0.30 to 0.50) and record homogeneous core and reabsorbed rim enriched in Fe. The porphyroblastic garnet might be rimmed by a symplectitic corona consisting of Amph + Pl + Opx ± Bt (in metagabbros) or Pl + Bt ± Opx (in meta-monzogabbros) or Pl + Opx + Bt (in metabasites).

The variable composition of the mineral phases in the studied rocks is related to the heterogeneity of the magma source to which overlap differentiation processes and metamorphic recrystallization.

Major and trace element analyses evidenced that metagabbros and metabasites are sub-alkaline rocks (Na_2O + K_2O = 1-5 wt.%) with K_2O < 1 wt.% whereas meta-monzogabbros show alkaline character (Na_2O + K_2O = 5-7 wt.%) with K_2O around 3 wt.%, thus reflecting the contents of biotite.

The other major elements have quite similar abundances in the studied rocks, varying from more mafic types (cumulitic portions) to more differentiated ones.

The metagabbros and metabasites show lower contents of Ba, Rb, Sr, Zr, Nb, Hf, Cs, Ce, K, Th, U, and LREE with respect to the meta-monzogabbros.

Mineral chemistry, chemical compositions, ACF and A’KF diagrams and isotopic data indicate a common mantle origin for the magma source of the studied rocks.

Rb-Sr and Sm-Nd isotopic analyses were performed on five samples of metagabbros, two samples of meta-monzogabbros and five samples of metabasites.

The $^{87}Sr/^{86}Sr$ initial ratios were calculated at 570 Ma, considered as the emplacement age of the basic magma. In metagabbros, $^{87}Sr/^{86}Sr_{(570Ma)}$ ratio ranges from 0.703 to 0.708 with low values of $^{87}Rb/^{86}Sr$ (from 0.001 to 0.024; Fig. 1). Meta-monzogabbros show $^{87}Sr/^{86}Sr_{(570Ma)}$ ratio around 0.705 with high $^{87}Rb/^{86}Sr$ (0.489-0.544) (Fig. 1). Metabasites have higher $^{87}Sr/^{86}Sr_{(570Ma)}$ values (0.707-0.710) with $^{87}Rb/^{86}Sr$ values from 0.025 to 0.237 (Fig.1).

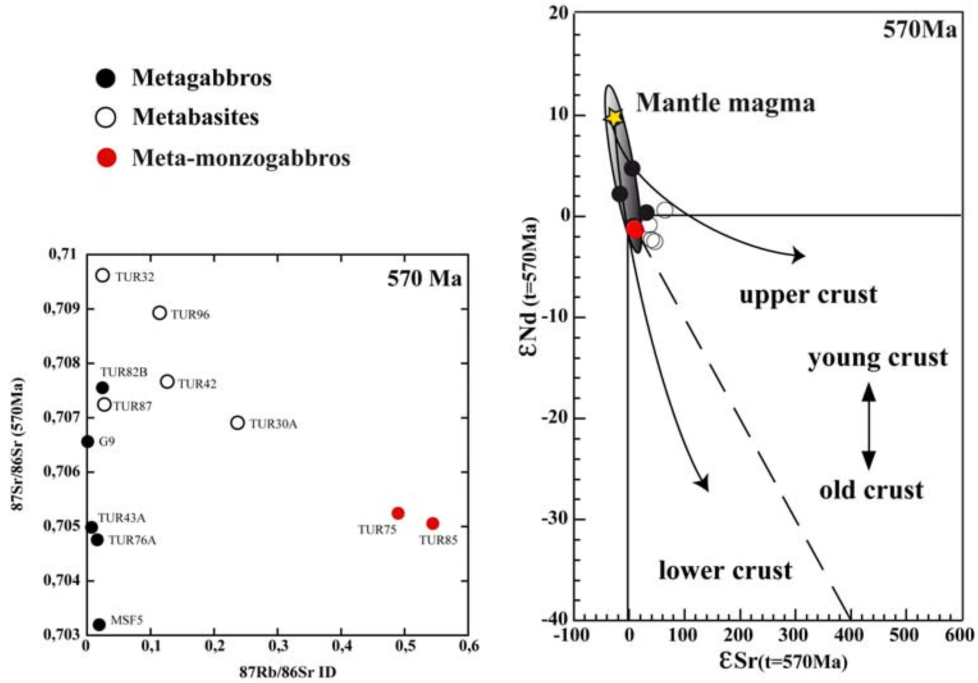

Fig. 1 - $^{87}Rb/^{86}SrID$ *vs.* $^{87}Sr/^{86}Sr_{(570Ma)}$ $\varepsilon Sr_{(t=570Ma)}$ *vs.* $\varepsilon Nd_{(t=570Ma)}$ diagrams.

The εNd_{570Ma} becomes progressively more negative when the content of biotite increases: it varies from 4.902 to -0.843 in metagabbros, from 0.741 to -2.388 in metabasites, whereas in meta-monzogabbros it varies from -1.078 to -1.253 (Fig. 1).

Metagabbros and meta-monzogabbros show a mantle origin without implication of crustal material whereas a crustal contamination process can be relied for metabasites.

The geodynamic setting for the basic magmatism is difficult to define owing to the ambiguous and inconsistent chemical characters: tholeiitic-calc-alkaline feature of metagabbros and metabasites indicates collisional context whereas for the meta-monzogabbros a distensive setting can be deduced.

The geochronological study has been performed on twelve zircon crystals from a sample of garnet-bearing-metagabbro (TUR76A): seven crystals separated from the rock and five analysed in thin section. They show rounded shapes and complex inner textures due to resorption and solid state recrystallization during the high-grade metamorphism.

The analysed zircon domains show fractionated patterns of HREE and, in some rims (181r, 12, 11 and 157c zircons) dated between 303 Ma and 278 Ma, the HREE abundance decreases. The HREE competition between zircon and garnet during Hercynian metamorphism did not affects the shape of pattern but the budget of HREE in zircon rim.

Concordant and sub-concordant ages ranging from 513±9 Ma to 276±6 Ma have been obtained. The Cambrian age (513±9 Ma) was determined at the core of a zoned crystal (145 zircon). This age has been interpreted as due to partial resetting of an older crystal.

Ordovician-Devonian ages, from 466±15 Ma to 413±6 Ma, were determined on mostly structureless reabsorbed core and on luminescent rims. Probably these ages indicate an Ordovician/Silurian tectono-thermal activity evidenced in many rock-types of the lower crust of the Serre (Fornelli *et al.*, 2011).

Carboniferous-Permian ages ranging from 345±4 Ma to 276±6 Ma, were obtained on structureless homogeneous cores or chaotic texture cores or on intermediate domains. These ages reflect the Variscan metamorphic events with crustal thickening around 345 Ma and subsequent multistage decompression between 303 and 276 Ma.

Petrographic, geochemical, isotopic and geochronological data suggest a compositional heterogeneity of the basic magma with overlapping local chemical modification connected to Hercynian metamorphism.

The meta-monzogabbros showing alkaline character and enrichment of incompatible elements are interpreted as derived from small degree of partial melting of enriched mantle, probably as underplating magma in Neoproterozoic times. Subsequent or incremental mantle partial melting events produced melts with tholeiitic and calc-alkaline affinities forming the protoliths of metagabbros and metabasites. These primitive magmas intruded the metasediments and disjointed the protoliths of meta-monzogabbros; the current metabasites were contaminated by crustal components assisted by fluids derived from host metasediments, as indicated by their isotopic features (Sm-Nd, Rb-Sr).

During the Variscan orogenesis, the basic magmatic sequence and the overlying pile of metasediments were involved by granulite-amphibolite facies metamorphism with local partial melting events: the small bodies of monzogabbros, enriched in biotite and incompatible elements (K, Rb, Sr, Ba, LREE, Ti, Nb, Zr, P, Hf, U and Th), produced sieno-granitic pockets whereas, in the metagabbros and metabasites, trondhjemitic melts currently interspersed in these rock-types, were produced.

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