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DIFFERENTIATION OF MAFIC MAGMA IN A CONTINENTAL CRUST-TO-MANTLE TRANSITION ZONE (VAL MALENCO, ALPS)

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ABSTRACT

The Braccia gabbro complex (Eastern Central Alps, Val Malenco, N-Italy) intruded the boundary between the Adriatic lowermost continental crust and the upper mantle in Permian times. The gabbro intrusion caused granulite facies metamorphism and partial melting in the overlying continental crust. Metamorphic paragenesis in granulite facies metapelites were formed at a pressure of 1.0 GPa and indicate that the crust-mantle transition was situated at 35 km depth at the time of gabbro intrusion (Hermann et al., 1997). The petrology and geochemistry of the gabbro complex are investigated to provide constraints on differentiation of mafic magmas in continental crust-mantle transition zones.

The gabbro complex consists mainly of gabbro-norites with minor dikes of quartz-diorite and Fe-Ti-P-rich diorite. The gabbro-norites contain abundant cumulus clino- and orthopyroxene and only small amounts of olivine in agreement with crystallization at 1.0 GPa. Bulk rock compositions of the gabbro-norite display a variation in Mg# from 0.82 to 0.54. With decreasing Mg# the incompatible elements are enriched up to two orders of magnitude. Most of the whole rock REE patterns display a positive Eu-anomaly indicating a cumulate origin of the rocks. The change in Mg# and the large variation in incompatible elements at a constant modal abundance of minerals suggests that the gabbro-norites crystallized *in situ* as defined by Langmuir (1989). The major element composition of a gabbro-norite cumulate is close to the composition of the liquid from which it crystallized. Thus, apart from the Mg#, major element concentration and consequently the mode remains constant during differentiation resulting in a tholeiitic differentiation trend.

The Mg# of pyroxenes decreases with the one of whole rocks. A Mg# of 0.81 of pyroxene in the most primitive cumulates found indicates that the most primitive dunitic cumulates are not exposed in the Braccia gabbro. It is suggested that some part of the parental gabbro melt differentiated either in a laterally situated magma chamber or even below the crust mantle boundary.

Trace elements in minerals were measured with Laser-Ablation ICP-MS. Shooting 80 μm craters and using an argon/helium mix gas plasma resulted in very low detection limits for light REE of about 10-30 ppb permitting to analyze REE contents of plagioclase and orthopyroxene in primitive gabbros accurately. The REE-contents of pyroxene strongly increase with decreasing Mg#. Some REE-rich pyroxenes display an accentuated negative Eu-anomaly. The REE partitioning between clinopyroxene, orthopyroxene and plagioclase was constant over several measured samples with different Mg# (Fig. 1). Even the partitioning between early crystallized clinopyroxene and late, interstitial Ti-pargasite was constant (Fig. 1) indicating that the rocks equilibrated near the solidus. This is supported by the absence of zoning in the measured minerals.

Such an equilibration during cooling of gabbros intruding the base of the continental crust makes the interpretation of trace elements ambiguous because the observed trends can be caused either by differentiation or by different amounts of trapped melts in the cumulates. The combination of Mg# in pyroxenes and modeling of trace element contents in minerals permits to estimate the contribution of these two processes to trace element enrichment in minerals and whole rocks. The modeling indicates that trapped melt can be recognized by REE patterns of pyroxenes with a strong negative Eu-anomaly and an enrichment of LREE. Application of this method to different gabbro-norites showed that some trace element-rich gabbros represent frozen melts whereas others are cumulates formed from highly differentiated residual melts. The high degree of differentiation documented in some rocks indicate that differentiation of mafic magma at the crust-mantle boundary may be an important process for explaining different compositions of erupted mafic magmas.

The REE composition of the parental melt from which the gabbro crystallized can be estimated from primitive clinopyroxenes from pure cumulates using known cpx/melt partition coefficients. The recalculated parental melt of the Braccia gabbro is very similar to T-MORB although it was emplaced at the base of the continental crust and not in the

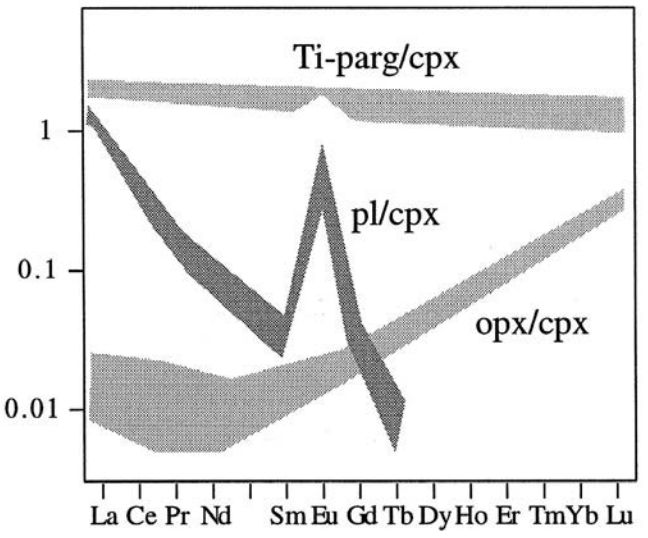

Fig. 1 - Partitioning of REE between magmatic minerals of the Braccia gabbro. Data are normalized to C1 chondrite of Sun and McDonough (1989).

oceanic crust. It is suggested that similar to MORB, the parental melt of the Braccia gabbro originated from decompression melting of upwelling mantle within the spinel peridotite field. Thus, a thinned lithosphere with a high geothermal gradient existed at the northern part of the African plate in Permian times.

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