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Chemical signature of migmatite-related melts migration in lower mafic crust: mineral geochemistry and zircon dating constraints (Variscan lower crust, SW Calabria, Italy)

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This work deals with a portion of the Variscan lower to intermediate crust exposed in the Palmi area (SW Calabria, Italy). It mainly consists of amphibole-bearing tonalite and migmatitic paragneiss. The latter shows a peak metamorphic assemblage of biotite, K-feldspar, garnet, sillimanite and cordierite. Gabbros occur as foliated, decimeter-thick layers within the migmatites and as a decametric main body adjacent to the paragneiss. No contacts are exposed between the migmatites and the gabbro body, which is mainly weakly foliated and fine-grained, even though unfoliated, coarse-grained portions rarely occur. The gabbros overall contain plagioclase (An_{89-80}) frequently developing triple junctions, amphibole, biotite, and accessory zircon + ilmenite ± allanite. Minor quartz is present in the gabbro layers within the paragneiss. Amphibole consists of cummingtonite grading into hornblende on the rims and retains some relic cleavage from a pyroxene predecessor.

Major and trace element mineral data in tandem with U-Pb zircon dating of the gabbro were examined to achieve information about: (i) the chemical effects triggered by the migration of migmatite-related melts into lower mafic crust, and (ii) their relationship with grain size and foliation variation.

U-Pb dating of sector-zoned, magmatic zircon cores from the gabbro body yielded a Carboniferous age of intrusion. Rare thin, homogeneous zircon rims gave Lower Permian ages, which could be related to a thermal event that caused the partial resetting of the U–Pb zircon isotope system and was most likely related to the partial melting of the paragneiss. Mineral geochemistry reveals that the amphibole from the gabbro interlayered with the paragneiss is depleted in Mg#, and enriched in Al and K with respect to the amphiboles from the main body. It also shows a highly evolved REE geochemical signature, thereby suggesting the involvement of a melt with an evolved geochemical signature, rich of Al, Fe, K and incompatible elements. In the main body, amphibole shows decreasing Mg# and increasing K and Al from the coarse- to the fine-grained domains. Amphibole from the fine-grained portions also differs for showing LREE-depleted patterns reflecting crystallization of a LREE-rich phase (i.e., allanite) simultaneously with amphibole. Taken as a whole,

parallel patterns and increase of REE and incompatible trace elements contents indicate that the transition from cummingtonite to hornblende did not involve reaction with other minerals or exotic agent, but most likely reflect decrease of temperature conditions associated with the closure of the system.

We propose that anatectic melts from the migmatitic paragneiss migrated and interacted with the gabbro promoting the replacement of precursor mafic minerals (e.g., orthopyroxene) with amphibole (associated with segregation of biotite ± allanite). The migration of the migmatite-related melt governed a geochemical gradient within the gabbros, with the foliated and fine-grained domains recording the strongest modification of the initial compositions. We thus speculate that small grain-size and anisotropy promoted high melt migration, which enabled better interaction with precursor minerals and nucleation of new mineral phases.