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Constraining the prograde P-T path using mineral inclusions in kyanite and garnet: an example from metapelites of the Ulten Zone gneiss (Northern Italy)

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We present new petrologic and thermobarometric data on metapelitic gneisses from the Ulten Zone (UZ), a high-pressure, high-temperature Variscan basement included in the Austroalpine tectonic system of the Italian Alps. These new results allow us to document, for the first time, the prograde metamorphic history of this Variscan basement and to discuss possible tectonic implications. The UZ consists mainly of strongly foliated garnet-kyanite gneisses and migmatites and metric to hectometric pods and lenses of garnet-spinel-peridotites. Previous petrologic studies and P-T estimates for the UZ gneisses have shown that these rocks well record only the late exhumation from about 1.5 GPa, 850 ˚C to 0.8-0.6 GPa, 600 ˚C (Godard et al., 1996; Hauzenberger et al., 1996). The prograde section of the P-T path is, however, poorly constrained. According to Tumiati et al. (2003), the inferred prograde evolution occurred before 330 Ma possibly reaching peak pressures of 2.5 GPa at 850 ˚C.

On the basis of a detailed microtextural analysis coupled with the examination of garnet zoning and the relations between zoning and mineral inclusions, we have recognized three distinct metamorphic assemblages. Minerals (garnet + paragonite + biotite + Al-pargasite + epidote + rutile) included in kyanite porphyroclasts document the prograde assemblage (M1). The lack of quartz might suggest that this metamorphic stage was characterized by a silica activity below one. Multi-equilibrium thermobarometry yields a pressure range of 1.2-1.5 GPa at about 520 ˚C. The conditions of the thermal peak assemblage (M2) at 1.0-1.4 GPa, 565-715 ˚C were calculated from compositions of large porphyroclastic garnet cores and phengite + biotite included therein. The late (M3) metamorphic stage involving the rim of porphyroclastic garnet together with matrix phases (phengite + biotite + plagioclase + rutile and ilmenite) marks the previously mentioned decompression to about 0.8 GPa, 600-750 ˚C.

The overall P-T path is clockwise, characterized by a near isobaric heating stage, which led to dehydration melting of white mica responsible for the origin of migmatites, followed by a nearly isothermal decompression representing exhumation. The metamorphic evolution is similar to that of other felsic granulites from the European Variscides such as those occurring in the Saxonian Granulitgebirge (Massonne, 2006). The clockwise P-T loop may be related to subduction of continental crust as suggested by Nimis and Morten (2000) and Tumiati et al. (2003). However, the same P-T evolution may be also explained by crustal thickening resulting from continent-continent collision (Laurussia - Gondwana) during the Variscan orogeny. The heating stage was likely caused by the recovery of the perturbed geotherm to steady state values whereas the reasons for the exhumation stage could be erosion or buoyancy of hot lower crust. The pressure gap between our study and previous estimates, if real, can suggest that different crustal levels are exposed in the UZ crust.

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