Spinel-bearing carbonates as petrogenetic recorders of the Variscan p-T evolution of the Austroalpine basement of the Ötztal Complex (Tyrol, Austria)

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The Ötztal Complex (ÖC) consists of quartzofelspatic and metapelitic metasediments with various intercalations of orthogneisses, amphibolites and rare metacarbonates. The dominant metamorphic overprint in the ÖC is the Variscan metamorphic overprint, which occurred from 390–270 Ma (Hoinkes et al., 1997). The first stage of the Variscan event was a high pressure metamorphism around 373–359 Ma, leading to the formation of eclogites in the central part of the ÖC (Miller and Thöni, 1995). The conditions of the eclogite facies were estimated to be 700–750 °C and 27 kbar (Miller and Thöni, 1995). The subsequent dominant amphibolite facies metamorphism occurred around 300–330 Ma (Tropper and Hoinkes, 1996). The metamorphic *P-T* conditions of the event were estimated to be 570–670 °C and 4–8 kbar. The youngest metamorphic event in this Austroalpine basement is the Cretaceous Eo-Alpine orogeny (100–73 Ma). The intensity of the Alpine overprint varies within the ÖC and increases from NW (lower greenschist facies) to SE and reaches 550–600 °C and > 11 kbar in the Schneebergerzug (Hoinkes et al., 1991). This leads also to resetting of Variscan cooling ages from the NW to the SE.

Carbonates are present only in the central part of the ÖC. These marbles are intercalated between a thick mass of metabasic units and the surrounding granitic gneisses. This tectonic contact zone also contains amphibolites, eclogites, granitic gneisses, peridotites and calcsilicate lenses. Within this zone two groups of carbonates can be distinguished: eclogite-facies carbonates and amphibolite-facies carbonates.

Eclogite-facies carbonates

The small lenses of eclogite-facies marbles from the Pollestal from the central part of the ÖC contain the assemblage calcite + dolomite + phlogopite + clinopyroxene (diopside and omphacite) + garnet + biotite + geikelite + titanite + apatite. In addition, some of the marbles also contain chromite and exotic accessory phases such as zirconolite and baddelyite (Mogessie et al., 1988; Purtscheller and Tessadri, 1985). The following mineral assemblages can be distinguished based on textural and chemical criteria:

1) The Pre-eclogite-facies assemblage: containing the assemblage Cr-rich garnet + Cr-spinel + rutile + calcite + low-Al titanite.

2) The eclogite-facies assemblage containing Cr-poor garnet + omphacite + biotite + rutile (?) + calcite + high-Al titanite.

3) The retrograde amphibolite-facies assemblage: amphibole + diopside + plagioclase.

The assemblage garnet + omphacite + biotite + geikelite + titanite + calcite represents the eclogite facies peak assemblage. Due to subsequent decompression from eclogite-facies conditions to amphibolite-facies conditions, retrogression led to the formation of extensive symplectite rims around garnet and omphacite. Garnet is replaced by Al-rich Ca-amphibole (20 wt% Al_2O_3) and omphacite (Jd_{50}) is replaced by either diopside (Jd_{10}) or by a symplectite of hornblende and plagioclase ($An_{40}Ab_{60}$). Garnet shows discontinuous zoning with an older generation of Cr-rich (3–4 wt% Cr_2O_3) garnet in the core and younger overgrowths of Cr-poor (<1 wt% Cr_2O_3) garnet. The latter also show complex zoning and occasionally two zones of overgrowth can be distinguished. The Cr-poor garnet overgrowths contain abundant omphacite and titanite inclusions. Titanite also shows discontinuous zoning with Al-poor cores (1–2 wt.% Al_2O_3) and Al-rich overgrowths (3–4 wt.% Al_2O_3). Further investigations to constrain the P-T conditions are currently in progress.

Amphibolite-facies carbonates

Most carbonate lenses show amphibolite-facies conditions. The marbles contain an assemblage of olivine + calcite + dolomite ± spinel ± phlogopite ± Ti-clinohumite ± Mg-ilmenite ± diopside ± omphacite. In rare cases, this assemblage also contains an exotic accessory phase suite including baddeleyite ZrO_2, zirconolite $CaZrTi_2O_7$, chromite and apatite with Fe-sulfide exsolution lamellae (Mogessie et al. 1988; Purtscheller and Tessadri 1985). The peak metamorphic assemblages olivine, olivine + spinel and Ti-clinohumite + Mg-ilmenite are ascribed to reactions (1) dolomite + diopside = calcite + forsterite + CO_2 as suggested by relict diopside grains in olivine, (2) dolomite + chlorite = calcite + 3 forsterite + spinel + H_2O + CO_2 and (3) Ti-clinohumite = olivine + Mg-ilmenite as evidenced by myrmecitic Ti-clinohumite + Mg-ilmenite + olivine intergrowths. The stable assemblage olivine + calcite in orogenic marbles along a geotherm in the kyanite stability field would require temperatures in excess of 800 °C at pressures around 10 kbar in the pure CMSH system (Bucher and Frey 1994) if X(CO_2) is high. Olivine + calcite in the ÖC marbles at temperatures of 550–600 °C therefore requires coexistence with a very H_2O-rich fluid with X(CO_2) <0.1. This would be consistent with the presence of wollastonite in calcsilicate lenses associated with the marbles. Calcite-dolomite thermometry yielded temperatures ranging from 450 °C to 610 °C. Olivine – spinel thermometry yields temperatures of 440 °C to 770 °C. In addition, it was possible to set constraints on X(CO_2) of the coexisting fluid based on an invariant point within the assemblage olivine + spinel + dolomite + calcite which was calculated with THERMOCALC v. 2.7 (Holland and Powell, 1998) involving the following reactions: diopside + dolomite = forsterite + calcite + CO_2, forsterite + hercynite = fayalite + spinel and hercynite + diopside+ dolomite = fayalite + spinel + calcite + CO_2. This limits X(CO_2) in the fluid phase to values of 0.01–0.05 at amphibolite-facies conditions at temperatures of 600 °C and pressures of 5–7 kbar.

These data show that the carbonates from the central ÖC thus seem to be very useful recorders of the Variscan *P–T* evolution of the ÖC in addition to the metapelites and eclogites.

References

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