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FLUID INCLUSIONS IN METAMORPHIC GARNET FROM SELECTED AUSTROALPINE BASEMENT AREAS

by

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The investigation of the fluid phase, which is involved in most metamorphic reactions and plays a major role for a number of rock-forming processes, has become one of the most active fields in metamorphic petrology. The direct approach is the study of fluid remnants preserved as inclusions in minerals. Interpretation of fluid inclusion data can only be done by comparison with independent P-T estimates [1].

Within the Austroalpine basement sequences of the Radenthein Complex (RC) and the Schneeberg complex (SC) east and west of the Tauern window the index minerals garnet and kyanite occur commonly together with quartz and contain frequently fluid inclusions. By combining various methods such as petrography, microthermometry, Raman spectroscopy, mineral chemistry, oxygen isotope measurements, geochronology and phase petrology with fluid inclusion data an improved pressure-temperature-time-path of the Eoalpine and pre-Alpine metamorphic event can be derived.

Amphibolite facies metapelites of the Radenthein Complex contain fluid inclusions in garnet, kyanite and quartz. Geothermobarometry, stable isotope data and fluid inclusion studies revealed inconsistencies between peak metamorphic pressure-temperature conditions on one hand and the observed fluid composition and density of fluid inclusions trapped within the peak metamorphic minerals garnet and kyanite on the other hand. Oxygen isotope thermometry on several mineral pairs yielded concordant peak metamorphic temperatures in the range of 560 to 590°C. Combining these temperature estimates with the analysis of phase relations suggests that the pressure was between 5.5 and 7.5 kbars and that X_{H2O} was between 0.4 and 0.5 during peak metamorphism. The fluid inclusion assemblages within garnet and kyanite are dominantly - CO_2-N_2, and CO_2-H_2O respectively. The generally low X_{H2O} (< 0.26) of the fluid and the high fluid molar volumes of 42 to 70 cm^3/mole are inconsistent with the estimated peak metamorphic conditions.
Scanning electron images, as well as Raman and infrared spectra of solid phases in fluid inclusions indicate retrograde closed system reactions producing chlorite within garnet-hosted and aluminum sheet silicates within kyanite-hosted inclusions. Fluid modeling corroborates this mechanism.

A virtual fluid inclusion that trapped the presumed peak metamorphic fluid ($X_{H2O} = 0.46$, molar volume = 33 cm^3/mole) changes its composition and density by producing chlorite and quartz at the expense of garnet and the water fraction of the fluid. The final density of such an inclusion is consistent with the observed density range of the fluid inclusion assemblage entrapped in garnet. Alternative reequilibration phenomena such as leakage or diffusive water loss cannot be excluded but are not necessary to explain the present day composition and density of the fluid inclusion assemblages in garnet and kyanite.

The mostly monometamorphic Schneeberg complex (SC) was intensely folded into the polymetamorphic Ötztal-Stubai complex (OSC) during the Eoalpine orogeny. The metapelites and metacarbonates of the SC differ significantly from the dominantly quartzo-feldspathic rocks of the OSC. It is considered to represent the remnants of a Palaeozoic sedimentary cover unit overlying the OSC and missing in other parts of the OSC due to erosion.

P-T data from the literature [2] and this study yielded peak metamorphic temperatures between 550 - 600°C and pressures from 8 - 10 kbar for the SC. Rims of mica schist garnet from the transition zone between the SC and the OSC grew during the Eoalpine orogeny which is confirmed by monazite inclusions yielding an average age of 93 ± 11 Ma. A clearly pre-Alpine origin of the garnet cores is indicated by garnet zoning profiles and aqueous fluid inclusions with low salinity and density (0.57 - 0.72 g/cm^3). These inclusions may have been trapped after the Variscan high-pressure event during pressure release and contemporaneous heating. Their low densities can be explained by reequilibration of these inclusions during a low-P/high-T extensional event affecting large areas of the Austroalpine basement [3], [4]. Few monazite ages above 200 Ma in the matrix of the garnet-mica schist and K-Ar hornblende ages within various parts of the SC [5] as well as numerous post-Variscan – pre-Alpine diabase dikes distributed all over the OSC [6] confirm increased heat-flow and extension in the late Permian – early Triassic. Alternatively, the garnet cores and the inclusions may be of Permo-Triassic age. Their low density and high resistance of garnet against plastic deformation prevented these inclusions from resetting to Eoalpine metamorphic conditions.

In conclusion, fluid inclusions in monometamorphic metapelitic garnet from the Eoalpine metamorphic RC were changed due to metamorphic reaction involving the host mineral and the trapped metamorphic fluid. In contrast garnet from the transitions zones between the polymetamorphic OSC and the monometamorphic SC records pre-Alpine trapped fluid inclusions which remained unchanged during Eoalpine high-pressure overprint. The most common preferential water diffusion or leakage of quartz during the Eoalpine metamorphic event cannot be excluded for inclusion assemblages in garnet but is not necessary to explain their observed composition and density.

References

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