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The granulite facies metamorphism in the Tongbai area (east-central China): New insights from equilibrium-assemblage calculations and fluid-inclusion studies

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The Tongbai is a segment of the multi-stage Qinling-Tongbai-Hong'an-Dabie-Sulu orogen located in east-central China. Within a narrow slice, Silurian granulites form elongated lenses included in gneisses. Although been subject of several studies, the composition of the fluid present during granulite facies metamorphism has not been addressed yet, but researcher focused on geochronology and the determination of metamorphic conditions. However, available peak PT estimates vary distinctly (770-920°C at 0.69-1.00GPa; Liu et al., 2011; Xiang et al., in press). In this study, we determine PT conditions together with the water activity ($a(H_2O)$) using both equilibrium-assemblage calculations (DOMINO; de Capitani & Petrakakis, 2010) and multi-equilibrium calculations (TWQ; Berman, 1991) and check the reliability of the estimated $a(H_2O)$ by the investigation of fluid inclusions.

Felsic granulite 811133A shows the mineral assemblage garnet-orthopyroxene-plagioclase-K feldspar-quartz-rutile. Remarkably, hercynite absent in the matrix is included as armored relics in core sections of larger garnet porphyroblasts. Based on garnet, orthopyroxene, plagioclase, K feldspar, and quartz we got 750°C, 0.75GPa, and an $a(H_2O)$ of 0.20 using TWQ. Equilibrium-assemblage relations and compositional isopleths calculated with DOMINO in the TNCKFMASHO system point to a similar $a(H_2O)$ of 0.19 but yield a bit higher temperatures and pressures of 805°C and 0.93GPa, respectively. According to the DOMINO calculations, the presence of hercynite points to ultrahigh metamorphic temperatures of >900-950°C at pressures <0.8GPa. The high gahnite content of up to 22mole% may, however, shift this stability field towards lower temperatures and higher pressures (Nichols et al., 1992).

Pyribolite 811134A consists of garnet, orthopyroxene, clinopyroxene, plagioclase, amphibole, quartz, magnetite, and ilmenite. Equilibria between major phases intersect at ∼775°C, ∼0.80GPa, and an $a(H_2O)$ of 0.10. The compositional isopleths of all ferromagnesian phases intersect within the stability field of the observed mineral assemblage at 750°C, ∼0.8GPa and an $a(H_2O)$ of 0.65. The distinct discrepancy among calculated $a(H_2O)$ could stem from higher uncertainties of the TWQ calculations because they critically depend on the activity of amphibole endmembers.

Garnet porphyroblasts from both samples contain numerous primary fluid inclusions with a negative crystal shape and diameters <10μm. Using the Raman probe, CO_2 and magnesite were identified in felsic granulite 811133A; CO_2, CH4, and siderite were detected in pyribolite 811134A.

The discovered relic spinel substantiates earlier postulated UHT-conditions (Xiang et al., in press) that were explained by the thermal input of magmatic underplating at the base of the Qinling crust. The derived PT conditions of 750-805°C and 0.80-0.93GPa agree with earlier estimates based on conventional methods and multi-equilibrium calculations (Liu et al., 2011) and represent a retrograde but still granulite facies recrystallization influenced by a CO_2-rich fluid that was present during garnet growth and coincides with low $a(H_2O)$ implied by two independent methods. Possible CO_2-sources are marbles associated with the granulites or the mantle.

The equilibrium assemblage calculations furthermore demonstrate that reduced water activities have a distinct influence on both the stability of considered phases and the location of compositional isopleths. We therefore suggest that $a(H_2O)$ should be taken into account when applying this method.

References

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