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Quantitative determination of the prograde P-T path by garnet zonation pattern from the Buchan-type pelitic schists of the Hamadan crystalline basement, Sanandaj-Sirjan zone, western Iran

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Garnet frequently records the P-T evolution of metamorphic rocks by changes in their chemical composition during growth. Unless diffusive modifications or resorption of the garnet grains occur, the chemical zonation pattern can be used to quantitatively model the prograde metamorphic history. A case study using an automated calculation method determining the P-T path based on garnet zoning (Moynihan and Pattison 2013) is presented for the Hamadan metamorphic area. The studied area is located in the Sanandaj-Sirjan Zone (SSZ) and consists of a large region $\sim$ 600 km2 of mainly five different types of medium- to high-grade garnet-bearing rocks: (1) garnet$\pm$staurolite schist, (2) andalusite$\pm$staurolite schist, (3) silimanite$\pm$andalusite schist, (4) andalusite$\pm$cordierite hornfels, and (5) cordierite hornfels adjacent to the eastern/south-eastern part of the middle-Jurassic Alvand pluton. Garnet is nearly ubiquitous and occurs in different grain sizes and textures mainly having a post-deformation origin in all metamorphic zones. Garnets contain quartz, graphite and ilmenite inclusions and typically appear euhedral to subhedral in shape, although corners and edges of crystals show some retrograde features such as rounding and partial replacement by biotite and chlorite. Nearly all mentioned different schists contain compositionally zoned garnet with dominant almandine (66–81%), minor spessartine (4–20%) and pyrope (7–13%) and subordinate grossular (2–8%) components. Core-to-rim profiles of garnet porphyroblasts from garnet-staurolite schists typically display a remarkable increase in XAlm, a slight increase in XPrp, whereas XGrs is roughly constant and XSps decreases. Garnet zonation patterns reflect prograde metamorphism and zonation variations apparently are due to bulk-rock depletion caused by fractional garnet crystallization. Best-fit P-T paths were calculated for the five different Hamadan metamorphic zones using a MATLAB script and the THERIAK software (de Capitani & Petrakakis, 2010) that matches the compositional zonation pattern by applying a fractional equilibrium forward model (Moynihan and Pattison 2013). Our results show that garnet crystals from the different areas started growing at variable P-T conditions but all follow a metamorphic evolution during prograde growth. Apparently, peak metamorphism in andalusite-staurolite bearing rocks reached 580 $\pm$ 20 °C, while in sillimanite and/or andalusite bearing rocks slightly higher temperatures of 630 $\pm$ 20 °C are recorded. The pressure remains nearly similar in the area and is 4.5 $\pm$ 1.0 kbar. The determined prograde P-T path exhibits low to medium-pressure at elevated temperatures which is compatible with the “Buchan” style marked by the widespread growth of andalusite and occasionally staurolite and cordierite at higher grade within the sillimanite zone. The large Alvand pluton is likely the source of the high thermal gradient but additional tectonic processes are needed to explain the observed P-T path.

References

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