Scale of the equilibration volume in eclogites: insights from a new micro-mapping approach - Example of Atbashi range, Kyrgyzstan

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Understanding geodynamic processes in subduction zones and mountains belts relies on the reconstruction of precise pressure-temperature paths (P-T paths) from metamorphic rocks. Most P-T paths are obtained using quantitative thermobarometry such as forward thermodynamics models. The question of the scale of the equilibration volume is of prime importance because its chemistry is used as input for the calculation of P-T sections. In chemically homogeneous rocks the bulk rock may be obtained either by ICP-MS or XRF analysis on whole rocks. For chemically heterogeneous rocks, containing different mineral assemblages and/or a high proportion of zoned minerals, the concept of local effective bulk (LEB) is essential. In the last 10 years, X-ray micro-mapping methods have been developed in this aim. Here we show how standardized X-ray maps can be used to estimate the equilibration volume at the pressure peak in an eclogite sample.

The study area lies in the Atbashi range, in Kyrgyzstan, along the South-Tianshan carboniferous suture of the Central Asian Orogenic Belt with the Tarim block. We use the micro-mapping approach to unravel the P-T path of a mafic eclogite containing mm-scale garnet porphyroblasts. Quantitative compositional maps of a garnet and its surrounding matrix are obtained from standardized X-ray maps processed with the XMapTools program (Lanari et al, 2014). By using these maps we measured the LEB corresponding to the different stages of garnet growth. The equilibration volume is then modeled using the local compositions (extrapolated in 3D) combined with Gibbs free energy minimization. Our model suggests that equilibrium conditions are attained for chemistry made of 90% of garnet and 10% of matrix. P-T sections are calculated from the core of the garnet to the rim taking into account the fractionation at each stage of garnet growth by changing the bulk composition.

We obtained the following P-T path: (1) garnet core crystallization during prograde stage at $450 \pm 50°C$ and 17 ± 2 kbar; (2) metamorphic peak conditions at $510 \pm 50°C$ and 24 ± 2 kbar; (3) garnet rim crystallization during retrograde stage at $400 \pm 50°C$ and 8 ± 2 kbar. This P-T path involves a burial and exhumation along a cold geothermal gradient suggesting a rapid subduction and exhumation. The exhumation probably occured within a deep sedimentary channel as suggested by eclogitic sediments hosting the mafic eclogites boudins.

This study shows that in the case of mm-scale round minerals presenting zoning growth patterns, the calculation of LEB requires to take into account the 3D geometry of the grains. The scale of the equilibration volume in eclogitic rocks bearing mm-scale porphyroblasts corresponds to that of a major proportion of porphyroblasts and a minor fraction of the surrounding matrix.

References
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