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Diffusion Modelling of Garnets from Granulites in Southern Bohemia

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Determination of Pressure-Temperature-time (P-T-t) evolution in any part of orogenic belt primarily entails detailed studies of petrography and geochronology of metamorphic rocks and their minerals. Elemental and isotopic composition of minerals in metamorphic rocks are related to the composition of reservoir from which they crystallized and to the mobility of elements and isotopes in this reservoir. Diffusion exchange of elements and isotopes between the reservoir and the minerals may be recorded in mineral composition and provide us with a useful information on the changes in P-T conditions during the evolution of the orogenic belt.

Garnet is a ubiquitous phase in metamorphic rocks and detailed study of its composition often allows to reconstruct burial and exhumation rates as well as heating and cooling rates. Here we present results of major cation diffusion modelling in garnets from felsic granulites from the Moldanubian Zone in southern Bohemian Massif. The matrix of granulites is composed of quartz, feldspar-mesoperthite and plagioclase. Garnet porphyroblasts that contain inclusions of quartz and plagioclase often have different compositions of cores (200 μm) and rims (20 μm), which reflect a change in P-T conditions during their prograde/retrograde evolution.

Chemical zoning in the proximity of plagioclase and quartz inclusions is indicative of diffusion exchange between inclusions and the host garnet. Such diffusion profiles often have two distinct parts that formed as result of two different diffusion processes. Garnet composition within ca. 20 m from the garnet/inclusion boundary is characterized by progressive increase in Mg and Ca contents and decrease in Fe content away from the inclusion. Beyond 20 m from the inclusions, garnet composition is characterised by decrease in Fe and Mg contents and an increase in Ca content.

Both diffusion profiles were modelled using diffusion equations of Crank (1975) for the semi-infinite medium with constant surface concentration and diffusion coefficients of Chakraborty and Ganguly (1992). Change in garnet composition in the vicinity of inclusions has probably resulted from rapid boundary diffusion. Similar diffusion profiles exist at the outermost border (ca. 10 m) of garnets. We suppose that this type of diffusion followed retrograde phase of metamorphism. According to both, relatively short profiles and their formation in the latest stages of garnet evolution, can be assumed that the profiles formed by interaction with the fluid phase during alteration of the rock at relatively low temperatures (below ca. 300 ºC). The time required for formation of observed diffusion profile at 300 ºC is less than 1 Ma.

On the other hand, the more distant part of diffusion profile provides an information on cooling following the peak of HP/HT metamorphism. As the diffusion afflicted the internal zones of the garnet we used in modelling the diffusion coefficients for volume diffusion. The temperature for modelling would fall to between 1100°C (the peak HP/HT metamorphism) and 600°C (LP/HT metamorphism). Modelling of diffusion profiles yielded unrealistically high cooling rates (>>200 ºC/Ma) that means that the concentration at the contact of garnet and inclusion was not constant. The changes in composition were limited probably by slow exchange of elements between garnet and surroundings.

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Crank J., *The mathematics of diffusion. Oxford University Press.*, 414, (1975).