Pressure-temperature-(time) path constraint of metamorphism using thermodynamic and diffusion modeling applied to compositional zoning in garnet

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Modification of compositional zoning in garnet is function of temperature and time of metamorphic events. The preservation of prograde zoning in garnet from (U)HP rocks, even those with granulite facies overprint, suggests that the metamorphic event or its high-temperature overprint was not long enough to homogenize totally the growth zoning profiles in garnet. The commonly long duration times of metamorphic events, estimated using geochronological data in high-grade terranes, could be due to the presence and formation of limited number of dateable minerals (e.g., garnet, mica, etc.) during prograde stage or peak pressure-temperature conditions of metamorphism. A good example are the eclogites and felsic granulites in the Bohemian Massif, where growth zoning of both major and trace elements in garnet is preserved, while available geochronological data yield a range of 380–340 Ma for the duration of this high-pressure metamorphic event.
In addition to determination of crystallization ages for cores and rims of garnet by Lu-Hf dating, duration of both burial and exhumation stages of a metamorphic event can be constrained by diffusion calculation of the initial profiles of major component contents in garnet. To quantify the modification of growth zoning of the major elements in garnet during metamorphism, we combine pseudosection and diffusion modelling in garnet (Faryad & Ježek, 2019). The method uses initial compositional profiles in garnet, calculated using Gibbs-free energy minimization, and quantifies diffusion by multicomponent diffusion approach along a selected PT path. This approach allows to estimate time duration of metamorphic event in rocks with garnet that stabilizes during burial stage to its exhumation back to the crustal position and cooling to the temperature when diffusion of major components stops in garnet. In case of garnet formed by two separate events with compositional gap, modification of the calculated initial compositions across the interfaces of two garnets can be used to estimate duration of the second metamorphic event.

Faryad, S.W., Ježek, J. 2019. Compositional zoning in garnet and its modification by diffusion during pressure and temperature changes in metamorphic rocks; an approach and software. *Lithos*, 32–333, 287-295.