

Switching of metamorphic growth kinetics due to volume fraction of metamorphic fluid

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In general, it is predicted that the growth kinetics should switch from interface-controlled to diffusion-controlled kinetics with increasing grain size. Rate constant and diffusion coefficient are required for estimate the critical grain size for the switching. It is assumed that the effective diffusivity is a product among diffusivity of solute in water, volume fraction of metamorphic fluid and tortuosity. Using rate constant of silicate in aqueous fluid and diffusion coefficient of solutes in aqueous fluids, the switching will occur around 1 mm in diameter at 500 degree C and 1 G Pa with 0.02 volume % of metamorphic fluid. The switching will occur around 1 cm with 0.2 volume % of metamorphic fluid, and will occur around 10 cm with 2 % volume of metamorphic fluid, respectively. Accompanying the switching with diffusional instability, growth kinetics can be predicted by degree of supersaturation. Recently, degree of supersaturation or reaction affinity, which is a function of degree of supersaturation, were reported from different metamorphic belts (e.g. Miyazaki, 2015; Spear and Pattison, 2017). Typical value for reaction affinity of the nucleation of a porphyroblast, such as garnet, is 300 J/mol oxygen (Spear and Pattison, 2017). Using this value, diffusional instability will occur above 1 μ m. Therefore, garnet should grow unstable and result in highly irregular morphology after the switching. However, such garnet is rare in general regional metamorphic belt. In other word, existence of euhedral to subhedral garnet larger than cm-scale implies interface-controlled growth under sufficient metamorphic fluid condition at deep crustal depths. Unlike in the case of garnet porphyroblast, matrix mineral, such as phengite, probably grew by interface-controlled dissolution-precipitation with non-hydrostatic condition, because supersaturation of the dissolution-precipitation is perhaps much lower than that of net-transfer reaction and size of phengite is usually less than 1 mm.

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