Geophysical Research Abstracts
Vol. 18, EGU2016-5040, 2016
EGU General Assembly 2016

Characterisation of a garnet population from the Sikkim Himalaya: implications for the mechanisms and rates of porphyroblast crystallisation

Freya George and Fred Gaidies
Department of Earth Sciences, Carleton University, Ottawa, Canada (freyageorge@cmail.carleton.ca)

Analysis of porphyroblast distribution in metamorphic rocks yields insight into the processes controlling metamorphic reaction rates. By coupling this textural record with microprobe analysis and phase-equilibria and diffusion modelling, a detailed view of the nucleation and growth history of metamorphic minerals can be obtained. In this study, we comprehensively characterise the 3D distribution and compositional variation of a garnet population in a garnet-grade pelitic schist of the Lesser Himalayan Sequence (Sikkim), in order to investigate both the rates and kinetic controls of porphyroblastic crystallisation.

Quantification of the size, shape and spatial distribution of garnet using high-resolution μ-computed X-ray tomography and statistical analysis reveals a log-normal crystal size distribution, systematic variation of aspect ratio with crystal size, and a significantly clustered garnet texture in the study sample. The latter is indicative of interface-controlled nucleation and growth, with nucleation sites controlled principally by a heterogeneous precursor assemblage. At length-scales less than 0.7 mm, there is evidence for adjacent grains that are on average smaller than the mean size of the population; this minor ordering is attributed to secondary redistribution of porphyroblast centers and reduction of crystal sizes due to syn-kinematic growth and resorption, respectively.

Geochemical traverses through centrally sectioned garnet crystals of variable size highlight several features: (1) core compositions of even the smallest crystals preserve primary prograde growth zonation, with little evidence for diffusional modification in any crystal size; (2) rim compositions are within error between grains, suggestive of sample-scale equilibration of the growth medium at the time of cessation of crystallisation; (3) different grains of equal radii display equivalent compositional zoning; and (4) gradients of compositional profiles display a steepening trend in progressively smaller grain sizes, converse to anticipated trends based on classic kinetic crystallisation theory. The observed systematic behaviour is interpreted to reflect interface-controlled rates of crystallisation, with a decrease in the rate of crystal growth of newly nucleated grains as the crystallisation interval proceeds.

Numerical simulations of garnet growth successfully reproduce observed core and rim compositions, and simulations of intracrystalline diffusion yield rapid heating/cooling rates along the P-T path, in excess of 100 °C/Ma. Radial garnet crystallisation is correspondingly rapid, with minimum growth rates of 1.5 mm/Ma in the smallest crystals. Simulations suggest progressive nucleation of new generations of garnet occurred with an exponentially decreasing frequency along the prograde path; however, measured gradients indicate that core compositions developed more slowly than predicted by the model, potentially resulting in a more evenly distributed pattern of nucleation.