Geophysical Research Abstracts
Vol. 19, EGU2017-9661, 2017
EGU General Assembly 2017

LA-ICP-MS trace element mapping: insights into the crystallisation history of a metamorphic garnet population

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

In comparison to our understanding of major element zoning, relatively little is known about the incorporation of trace elements into metamorphic garnet. Given their extremely slow diffusivities and sensitivity to changing mineral assemblages, the analysis of the distribution of trace elements in garnet has the potential to yield a wealth of information pertaining to interfacial attachment mechanisms during garnet crystallisation, the mobility of trace elements in both garnet and the matrix, and trace element geochronology. Due to advances in the spatial resolution and analytical precision of modern microbeam techniques, small-scale trace element variations can increasingly be documented and used to inform models of metamorphic crystallisation. Laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) in particular, can be used to rapidly quantify a wide range of elemental masses as a series of laser rasters, producing large volumes of spatially constrained trace element data.

In this study, we present LA-ICP-MS maps of trace element concentrations from numerous centrally-sectioned garnets representative of the crystal size-distribution of a single sample's population. The study sample originates from the garnet-grade Barrovian zone of the Lesser Himalayan Sequence in Sikkim, northeast India, and has been shown to have crystallised garnet within a single assemblage between 515 ˚C and 565˚C, with no evidence for accessory phase reaction over the duration of garnet growth. Previous models have indicated that the duration of garnet crystallisation was extremely rapid (<1 Myr), with negligible diffusional homogenisation of major divalent cations. Consequently, the trace element record likely documents the primary zonation generated during garnet growth.

In spite of straightforward (i.e. concentrically-zoned) major element garnet zonation, trace elements maps are characterised by significant complexity and variability. Y and the heavy rare earth elements are strongly enriched in crystal cores, where there is overprinting of the observed internal fabric, and exhibit numerous concentric annuli towards crystal rims. Conversely, the medium rare earth elements (e.g. Gd, Eu and Sm) exhibit bowl-shaped zoning from core to rim, with no annuli, and core and rim compositions of the medium rare earth elements are the same throughout the population within crystals of differing size. Cr exhibits pronounced spiral zoning, and the average Cr content increases towards garnet rims. In all cases, spirals are centered on the geometric core of the crystals. These LA-ICP-MS maps highlight the complexity of garnet growth over a single prograde event, and indicate that there is still much to be learnt from the analysis of garnet using ever-improving analytical methods. We explore the potential causes of the variations in the distribution of trace elements in garnet, and assess how these zoning patterns may be used to refine our understanding of the intricacies of garnet crystallisation and the spatial and temporal degree of trace element equilibration during metamorphism.