

Using Li in garnet as a tracer of fluid flow processes during metamorphism: Insights from trace-element analysis and petrologic modeling

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Fluids released and transported within metamorphic settings affect fundamental Earth processes, including seismicity, generation of arc magmas, concentration of ore metals, formation of continental crust, and geochemical evolution of the mantle. Lithium is a fluid-mobile element that is used as an indicator of metamorphic fluid flow. Its rapid diffusivity and the preservation of Li diffusion profiles in rocks permits estimates of timescales of short-lived fluid infiltration events. Recent studies indicate that diffusion of Li is also recorded by garnet. However, very little is understood about Li incorporation within garnet, and the studies that exist suggest that coupling of Li with less mobile, more slowly diffusing elements (e.g., Y+REE, P) within the garnet structure may limit the diffusive mobility of Li. Such coupling would allow Li to be retained within garnet, enhancing its ability to be utilized as a monitor of fluid-rock interaction, but potentially hamper its potential as a chronometer.

Garnet from both collisional and subduction environments and differing bulk rock compositions from the Picuris Mountains, USA; Passo del Sole, Switzerland; Syros and Sifnos, Greece; and the Beartooth Mountains, USA was studied to better understand factors that govern the incorporation of Li into garnet. Lithium concentrations were determined in 1-dimensional traverses and 2-dimensional maps using LA-ICP-MS. Results were used in petrologic modeling of breakdown of metamorphic minerals to develop a geochemical model for the distribution of Li in garnet.

A few processes dominate the zonation of Li in garnet including Rayleigh fractionation and breakdown of major minerals (Picuris), diffusion-limited uptake (Passo del Sole), and potentially cyclic fluid fluxing (Sifnos). Overall, the variability in Li can be related to its availability, its effective intergranular mobility, and the crystal growth rate.

Our findings indicate that the incorporation of Li into garnet is complex and is not just a function of any one controlling parameter. Y+REE and P are likely partners for Li incorporation under some circumstances, allowing for Li zoning to be retained under some metamorphic conditions. This relationship is not exclusive, however, leaving open the possibility for the application of Li chronometry to *in situ* studies of garnet.