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Lithium diffusion in pyrope-almandine rich garnets

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Evidence for fluid infiltration events in the deep crust can be recorded by garnet zoning. Lithium is a fluid-mobile element that diffuses rapidly and can act as a tracer of fluid-rock interactions in metamorphic terrains. While bulk lithium concentrations have been used to determine the timescales of short-lived events including time-integrated fluid event durations in metamorphic settings [1], resolving individual fluid pulses requires detailed *in situ* measurements of lithium concentrations across metamorphic minerals, such as garnet. However, interpreting timescales of fluid infiltration in metamorphic rocks on the basis of variations in lithium concentration in garnet requires quantitative knowledge of diffusion coefficients (D) that have not yet been experimentally determined. For this study, powder source diffusion experiments were performed in fused quartz tubes with polished pyrope-almandine garnet grains from Gore Mountain, New York surrounded by spodumene powder at temperatures ranging from 600° to 700°C for durations of up to 3 weeks. Garnet starting material and experimental run products were analyzed for their lithium concentration using LA-ICP-MS depth profiling. The garnet starting material (control) displayed a uniformly low lithium concentration (<5 ppm). Experimental run-product garnets exhibited an enrichment in lithium of up to 100s ppm at the rim followed by a smooth decrease towards the interior over length scales on the order of 5 μm, indicative of diffusive uptake. One-dimensional diffusion modeling was performed to calculate a best-fit D for each temperature. The data were best fit by a model with two independent mechanisms. The calculated Ds for lithium in garnet vary with temperature. The diffusivities of both mechanisms are slower than lithium diffusion in olivine along interstitial sites [2], comparable to diffusion through metal vacancies [2], and faster than lithium+REE coupled substitution into garnet [3]. These results appear to be the first experimentally derived diffusion coefficients for lithium in garnet and can be used to constrain the number and duration of fluid flow events in metamorphic settings.

[1] Penniston-Dorland et al. 2010, *EPSL*, *292*, 181–190.

[2] Dohmen et al. 2010, *GCA*, *74*(1), 274–292.

[3] Cahalan et al. 2014, *AM, 99*(8–9), 1676–1682.