Stopping crystal clocks: The role of electrons in arresting diffusion of lithium in subduction zone garnets

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"Crystal clocks" within minerals record the duration of a geologic event as a diffusion profile arrested from reaching equilibrium. This approach, also referred to as geospeedometry, has the potential to reveal the timescales of short-lived geologic processes. Its interpretation requires a better understanding of processes controlling the formation and preservation of arrested diffusion profiles within minerals. Its application to rocks exhumed from paleo-subduction zones has promise for estimating timescales of the duration of fluid infiltration events within subducting crust, revealing details about processes that ultimately contribute to the generation of arc volcanoes. The classic interpretation of these profiles is interruption due to thermal closure of minerals to diffusion, however in deep crustal settings this interpretation sometimes yields unreasonable timescales.

In this study we use lithium isotopic measurements in garnets from the Franciscan Complex (CA), a paleo-subduction zone. Profiles across garnets reveal troughs in d^7Li in garnet mantles ranging to 19‰ lower than garnet cores and rims. We suggest that coupling of Li with electrons facilitates rapid diffusion from a potential fluid source into the garnet along interstitial pathways resulting in diffusive fractionation of Li. A flux of reducing fluids into rocks during subduction provides the source for both Li and electrons. This mechanism links a fluid characteristic that is difficult to measure (Eh) to the arrested diffusion profiles observed in d^7Li in subduction-related garnets. It has the potential to allow the application of geospeedometry to arrested profiles of d^7Li in garnets such as those observed in this study.