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Competing Pb Transport Mechanisms in U-Pb Thermochronometers

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Geodynamic processes impart characteristic thermal signatures to minerals in the lithosphere. U-Pb thermochronology offers a potentially rewarding technique to harness such thermal history information from apatite, rutile and titanite residing in the middle and lower crust. However, application of U-Pb thermochronology is predicated on Fickian-type volume diffusion being the dominant mode of intracrystalline Pb transport. Here, we assess the relative importance of Fickian and non-Fickian Pb transport mechanisms in a suite of lower crustal rutile- and titanite-bearing metabasites from the Grenville Province. Combined U-Pb and trace element analysis of rutile reveals both diffusive and step-like intracrystalline profiles within the same sample. Despite peak metamorphic temperatures > 800 ˚C, titanite megacrysts from the interior portion of the Grenville orogen exhibit U-Pb and trace element systematics consistent with short lengthscale diffusive transport. Further, concentrations of Pb correlate with Sr. Combined, these observations could be explained by Pb diffusion occurring by an energetically expensive coupled substitution mechanism. Recrystallisation and precipitation processes controlled U-Pb zonation within the grain margins. Observations drawn from the Grenville dataset have implications for the application of U-Pb thermochronology to resolve deep lithosphere dynamics.