The behaviour of monazite at high temperature and high stress in the lower crust

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Monazite is fast becoming the go to geochronometer for establishing the timing of metamorphic, deformational and hydrothermal events in crustal rocks. This is principally due to monazite forming in rocks that are petrologically useful (e.g. metapelites), it's susceptibility to recrystallization (both fluid and deformation driven) and the suite of trace elements it incorporates during growth. In dry conditions (i.e. the melt-depleted lower crust) monazite has a high closure temperature. It therefore has the ability to record the timing of prograde to peak metamorphic conditions. The reactivity of monazite in the presence of fluid allows the timing of post-peak fluid and melt crystallisation events to be constrained. Under high-stress monazite will recrystallise, forming new crystals that can be used to constrain the age of deformational events – this feature is particularly useful as high-grade reworking of lower crustal rocks often leave no geochronological record within other accessory minerals (e.g. zircon). However, it has long been recognised that monazite can record a cryptic range and/or distribution of ages that are difficult reconcile with how we traditionally believe the lower crust responds to deformational events – e.g. the anhydrous nature of lower crustal rocks and the preservation of granulite facies mineral assemblages.

Here we present datasets collected by a suite of microanalytical techniques on monazite grains from lower-crustal rocks that have experienced deformation, fluid-rock interaction and ultrahigh temperature metamorphism. To better understand how monazite behaves in these environments we integrate electron probe, electron backscatter diffraction, laser ablation split stream petrochronology, transmission electron microscopy and Atom Probe Tomography datasets to image and quantify behaviour of key elements from the micro- to the nanoscale. When used sequentially, these techniques provide a detailed view of the processes that re-distribute U-Th-REE-Y-Pb at the nanoscale. Understanding how monazite behaves under different stress and thermal conditions is the key to using this geochronometer to develop and refine event chronologies in the lower crust.