Petrographically-controlled elemental mobility in monazite and rutile in ultrahigh temperature granulites

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In situ age and trace element determinations of monazite and rutile grains from an ultrahigh temperature (UHT) metapelite hosted leucosome from the Napier Complex using laser split-stream analysis reveals highly variable behavior in both the U–Pb, REE and trace element systematics that are directly linked to the petrographic setting of individual grains.

Monazite grains armored by garnet and quartz retain a concordant 2.48 Ga age that is the same as the age for peak UHT metamorphism in the Napier Complex. Yttrium in the armored grains are unzoned with contents around 700 ppm in the garnet-hosted monazite and range between 400-1600 ppm in the monazite enclosed within quartz. A monazite grain hosted within a mesoperthite grain records a spread of concordant ages from 2.42 to 2.20 Ga and Y contents ranging between 400 to 1700 ppm. This grain exhibits core to rim zoning in both Y and age with the cores enriched in Y relative to the rim and younger ages in the core relative to the rim. A monazite grain that sits on a grain boundary between mesoperthite and garnet records the largest spread in ages– from 2.42 to 2.05 Ga. The youngest ages in this grain are within a linear feature that reaches the core and is connected to the grain boundary between the garnet and mesoperthite, the oldest ages are observed where monazite is in contact with garnet. Yttrium in the grain is enriched in the core and depleted at the rim with the strongest depletions where monazite in adjacent to grain boundaries between the silicate minerals or in contact with garnet.

By contrast, rutile which is petrologically part of the peak-UHT assemblage and therefore inferred to have grown at c. 2.48 Ga records a complex discordant array of ages with the oldest concordant ages at 1.90 Ga with a spread down concordia to 1.70 Ga and a lower, imprecisely defined intercept at 0.55 Ga. The most discordant rutile grains sit within the residual garnet-sillimanite-spinel domains and record Zr-in rutile temperatures of <800 °C. The least discordant and oldest grains sit within the leucosome and record Zr-in-rutile temperatures of >1000 °C. There is no correlation between grain size and age/degree of discordance.

The age and chemical relationships outlined above illustrate decoupling between the geochemical and geochronological systems in monazite and rutile. Individual grains are suggestive of a range of processes that modify these systems, including volume diffusion, flux-limited diffusion and recrystallisation, all operating at the scale of a single thin section and primarily controlled by the host minerals and their microstructural setting. These relationships, while complicated, can be
interpreted in terms of the thermal history of this rock allowing the potential identification of a previously cryptic thermal event. This would not be possible without the petrographic information for the location of individual grains enabled through analysis of the different accessory minerals in thin section.