Resolving lithospheric thermal histories using accessory phase speedometry

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Geophysical processes impart characteristic thermal signatures to the lithosphere. Traditionally, the thermal evolution of the lithosphere is recovered through the interpolation of discrete temperature-time points, generated by assigning estimates of nominal closure temperatures to volume-averaged radiometric ages. Whilst informative, bulk thermochronology potentially fails to resolve short-lived (10^2—10^5 years) thermal events associated with important processes such as magmatism and fluid flow. Rather, the highest resolution record of thermal history information is captured by intracrystalline concentration profiles [1] [2]. With the advent of high-resolution microbeam techniques, such profiles can now be routinely measured on sub-micron spatial increments, affording the opportunity to invert for *T(t)* [3]. However, the success of this approach is contingent on verification that Fickian-type diffusion is the dominant transport mechanism. Here, using numerical models, we present an overview of the potential utility of this approach to recover continuous thermal history information from the U-Th-Pb system in accessory phases. We also explore the potential to splice *T(t)* information obtained from trace element diffusion profiles with *T(t)* segments obtained from the U-Th-Pb system. Focusing on rutile—a widely-used U-Pb thermochronometer and single-phase thermometer—we will test theoretical predictions with LA-ICPMS U-Pb and trace element depth profile data from lower-crustal metamorphic rutile. These data show that rutile speedometry provides an underutilised tool to trace transient thermal events in a temperature range directly relevant to the geological evolution of the lower crust.

[1] Dodson (1986) *Mat. Sci. Forum* **7**, 145-154; [2] Harrison *et al.* (2005) *Rev. Min. Geochem.* **58**, 389-409; [3] Smye and Stockli (2014) *Earth Planet. Sci. Letters* **408**, 171-182.