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Exploring the versatility of rutile thermochronology

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Rutile U-Pb thermochronology has become an increasingly powerful tool for determining the timing and conditions of petrological, magmatic and tectonic processes. We investigate the fundamentals of rutile U-Pb thermochronology and explore its versatility through case studies dating volcanic eruptions and the cooling of tectonic terranes.

U-Pb dating of rutile in xenolith cargo provides an unconventional means to date volcanic eruptions. To test this, we analyzed rutile in crustal xenoliths from ultrapotassic basalts (Dunkeldik field, Pamir) and diamond-bearing mantle xenoliths from kimberlites (Mir kimberlite, Yakutia). Rutile from the Pamir yielded 11.17 ± 0.06 Ma[1], which matches at greater precision the c. 11 Ma Ar-Ar age of the host basalt. Rutile intergrown with diamond in the Mir kimberlite yielded the eruption age (c. 363 Ma), whereas rutile inclusions *in* diamond yielded ages that were c. 15 Myr older, possibly dating rutile entrapment in diamond[2].

In-situ U-Pb thermochronology can be used in conjunction with diffusion zoning analysis to determine cooling histories from single rutile grains. This approach was tested on an Archean granulite from the Saglek Block (SB), Labrador, Canada, and an exhumed UHP eclogite from the Western Gneiss Complex (WGC), Norway. Using rectangular spots to increase spatial resolution, while maintaining high precision, we were able to resolve age gradients over 140 Ma (SB) and 30 Ma (WGC) on the scale of 40-50 µm (SB) and 200 µm (WGC). The data were used to constrain time-resolved histories of cooling from 800 to 500 °C for both terranes.

Rutile U-Pb thermochronology is a useful technique that is largely complementary to other thermochronological methods. The examples shown here indicate that this technique may be particularly useful for: 1) dating the eruption of (ultra-)mafic lavas that lack conventional chronometric minerals, and 2) constraining the time-resolved cooling history of tectonic terranes in a temperature domain that is relevant for investigating exhumation processes, yet out-of-range for other thermochronometers.

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