A novel approach to in-situ rutile thermochronology

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Accessory mineral micro-analysis provides a diverse and versatile toolbox for deciphering the timing and conditions of petrological processes. Here we present a novel approach to using U-Pb thermochronology of rutile by exploring the use of Pb as a diffusive species in kinetics-based thermometry. Using the high spatial and analytical resolution of laser ablation multi-collector ICPMS, we constrain Pb diffusion profiles in rutile from the UHP zone of Western Gneiss Complex (WGC), Norway. These data, combined with Pb-based thermometry, allow us to constrain a full thermal history from single grains.

Millimeter-sized single crystals of rutile from a phlogopitite vein in eclogite were mounted and polished to expose their geometric cores. Modern laser ablation systems allow for the analysis of transects of rectangular spots (c. 15x45 µm) ensuring ablation of a significant volume while maintaining the required radial spatial resolution. Transects yield well-defined Pb diffusion profiles, with U-Pb ages ranging from c. 415 Ma in the cores to c. 380 Ma in the outermost rims (±2%, 2σ on individual spots). Diffusion zoning length was used with well-established Pb diffusion parameters [1] to determine peak temperature conditions. The result, c. 810 ± 25°C, is consistent with 800 ± 25°C and c. 780°C estimated for the same sample using conventional and Zr-in-rutile thermometry, respectively. The cooling history is reconstructed through age zoning analysis and diffusion modeling, and agrees with constraints from $^{40}Ar/^{39}Ar$ dating.

The cooling history deduced from in-situ micro-analysis of single rutile crystals is consistent with, and further refines, that established for the WGC through decades of $^{40}Ar/^{39}Ar$ dating. The recognition that both thermometric and thermochronologic constraints can be obtained from rutile U-Pb analysis demonstrates the great potential of this technique in lithosphere research.

References:

[1] Cherniak (2000) *Contrib. Mineral. Petrol.* 139. 198-207.