Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.36757

High-resolution ToF-SIMS mapping as a tool for improving (U-Th)/He age accuracy

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Spatial heterogeneity in parent isotopes (U, Th) within minerals used for (U-Th)/He dating can strongly influence the accuracy and precision of resulting ages (e.g., [1]). Despite this, most (U-Th)/He workflows still assume homogeneous parent-nuclide distributions, even though minerals such as zircon commonly exhibit pronounced uranium and thorium zonation. Here, we introduce a new approach that uses time-of-flight secondary ion mass spectrometry (ToF-SIMS) to characterize parent-isotope distributions at high spatial resolution. ToF-SIMS provides essentially non-destructive, two-dimensional isotopic maps with less than 50 nm lateral resolution in acquisition times on the order of tens of minutes per crystal. We present a ToF-SIMS-based method for rapid, high-resolution mapping of U and Th in minerals and demonstrate how these data can be incorporated into improved alpha-ejection corrections for (U-Th)/He dating. This approach enhances both the accuracy and precision of (U-Th)/He ages and provides more robust inputs for thermal history modelling by enabling better parameterization of parent-nuclide distributions.

[1] Meesters & Dunai, 2002: Solving the production-diffusion equation for finite diffusion domains of various shapes: Part I. Implications for low-temperature (U-Th)/He thermochronology. *Chemical Geology*, 186(3-4), 333-344.