Goldschmidt 2021 Abstract
https://doi.org/10.7185/gold2021.6978

Isotopic forward modelling: A new tool to interpret U-Pb thermochronometry data

CHRIS MARK[1], NATHAN COGNÉ[2], PIETER VERMEESCH[3], ANDREW J SMYE[4], DAVID M CHEW[5] AND J STEPHEN DALY[1]

[1]University College Dublin
[2]Université Rennes 1
[3]University College London
[4]Pennsylvania State University
[5]Trinity College Dublin

Presenting Author: chris.mark@ucd.ie

The availability of high-temperature thermochronometers suitable for generation of continuous thermal histories at mid- to lower-crustal temperatures (i.e., ≥ 400 °C) is limited. Available thermochronometers include the recently developed apatite and rutile U-Pb thermochronometers, sensitive to temperatures ≤ 550 and 640 °C [1-3]; and arguably also the K-Ar system in white mica (sensitive to temperatures ≤ 500 °C).

Recent work has focused on U-Pb analysis of apatite and rutile by sector-field and multi-collector LA-ICPMS to generate single-crystal U-Pb age profiles. Such profiles can be inverted to yield continuous thermal histories for high-temperature processes (e.g., [4]). However, both rutile and especially apatite routinely incorporate non-negligible amounts of common-Pb during crystallisation (as opposed to radiogenic Pb generated by *in-situ* radionuclide decay), rendering them discordant in U-Pb isotope space. This common-Pb must be corrected for during age calculation. Such a correction necessitates critical assumptions regarding the isotopic composition of the common-Pb, and also the diffusive response of common- and radiogenic-Pb to heating. Additionally, both apatite and rutile can exhibit crystal growth and dissolution-reprecipitation reactions in the same temperature ranges at which measurable Pb diffusion occurs: neither behaves as a pure thermochronometer in all circumstances (e.g., [5-6]).

Here, we exploit the observation that common-Pb is isotopically distinct from radiogenic Pb to predict the U-Pb isotopic composition of a given crystal arising from a proposed thermal history by forward modelling. We show that common-Pb can be exploited to validate the assumption of Pb-loss by volume diffusion; the thermal history predicted by age profile inversion; and age profiles arising from volume diffusion (as opposed to (re)crystallisation). We present a case study from the Eastern Alps.

[1] Chamberlain, K., & Bowring, S., Chem. Geol., 172, 173–200 (2000);

[2] Kooijman, E., et al., Earth Planet. Sci. Lett, 293, 321–330, (2010);

[3] Cochrane, R., et al., Geochim. Cosmochim. Acta, 127, 39–56, (2014);

[4] Smye, A.J., et al., Chem. Geol., 494, 1–18 (2018).

[5] Chambers, J.A., & Kohn, M.J., Am. Mineral., 97, 543–555 (2012);

[6] Harlov, D.E., et al., Contrib. Mineral. Petrol, 150, 268–286 (2005).