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Overview

Denyszyn and others couple atom probe tomography (APT) and numerical modeling to examine α-recoil processes in the U-Pb system of baddeleyite. They find that only one of the two samples (Great Dyke of Mauritania) shows any heterogeneity in U and Pb distribution, and they disregard the other sample (Hart dolerite), concluding that it is an interior region of a crystal exposed along a cleavage plane. Through APT, the authors identify both 238U and 206Pb profiles that reflect a combination of crystallization and recoil effects. They estimate a mean recoil length for the 238U-series (80–90 nm) that is larger than prior estimates and identify some plausible causes for this discrepancy.

Overall, I find the work and conclusions very sound, and I find this to be an important and relevant contribution to the U-Pb and U-series communities' understanding of recoil processes at a very fine scale 1. My primary criticism of this work is the lack of clarity and organization in the figures, captions, and some of the text, which collectively make it difficult to efficiently interpret the authors' findings. Because the scientific work is sound and the conclusions relevant to the field of geochronology, I would recommend the manuscript for publication in Geochronology if the following comments are sufficiently addressed. In addition to these specific comments, I encourage the authors to review the manuscript with special attention to clear figures, prose, and descriptive figure captions.

Graham H. Edwards

General Comments:
• The introduction is well-written and provides a very thorough background.
• I found it cumbersome to interpret figures with unlabelled y-axes. While the labels were floated in the plots as text boxes, the authors should label axes directly wherever possible (e.g. Figs. 3, 4, 6–9, 11) and position the y-axis and corresponding tick labels outside of the plot area to ensure they are as legible as possible (Figs. 3,4,7). I recognize that the authors prepared their figures in Excel, which offers limited customization capabilities, but all of these edits are possible in Excel and will significantly improve figure readability.

All graphic figures have been redrafted to show labels and numbering outside the plot area as suggested by the reviewer.

• The authors refer with some frequency to Supplementary Data, including three spreadsheets. While I take no issue with referring to this supplementary data, these spreadsheets are poorly curated and have inadequate metadata. In the case of Supplementary Data File 3, this does not appear to contain the data the authors describe on line 274. Moreover, Supplementary Data Files 2 and 4 are multi-page xlsm files. For clarity, the key plots should be presented as figures with descriptive captions

so that readers can efficiently interpret the authors' key points. I think it is good practice to include the xlsm files to illustrate the methodological process, but these should not be the primary format of presenting/describing nuanced supplementary data.
• For clarity in the results and discussion, I advise the authors to use a consistent and specific set of directions (e.g. edge, interior) that consistently describe orientation relative to the original sample rather than terms like "left" (lines 219–30) that are dependent on the orientation of the APT specimen.
• Some of the text-based figure captions (lines 510–41) do not correspond with the current figure numbers. In general, the authors should double check that captions and in-text references correspond with appropriate figures and supplementary data files.

Supplementary Data File 3 does contain the results from modelling alpha recoil affected Pb/U profiles from U clusters. Explanatory sheets have been added to each of the Excel data files that should clarify their contents.

• I find the use of a convolution of the U distribution with the redistribution distribution appropriate for estimating the distribution of recoil transported radiogenic Pb. However, I think there should be a more extended discussion at the beginning of §2.3 justifying this approach. Lines 168–9 give this a good start, but I think most readers would benefit from more detail on this specific method.

The discussion in question (now at line 170) has been expanded to give a more detailed description of the convolution process.

• The Cr caps appear to be at angles to the z-axis of the FIB-milled specimens. This is curious, as the authors model systems with the z-axis orthogonal to the crystal surface. The authors should comment on how the needle-shaped specimens are oriented relative to the surfaces of grains they were milled from. Are the caps just apparently skewed or does this reflect the angle of the needles relative to the crystal surface.

The Cr cap of the Hart Dolerite sample (M2), is in this case at an angle. This is likely due to either irregularities in the surface topography of the sample at the nm scale, and/or the crystal surface not being exactly horizontal at the time of FIB milling. At any rate, the modelling was carried out on the Mauritania sample (M5) and not this specimen. A sentence to this effect has been added (line 120).

• The authors conclude that the Hart dolerite is an exposed cleavage plane and do not consider it further. However, they consider spaces between bladed crystals as fast diffusion pathways of atom loss by recoil. They should comment on how these specific systems differ. (Presumably, the cleavage plane was exposed by a very recent breakage and was within strong crystal lattice previously, but I still think an explicit statement is worthwhile).

(now at line 213)
We have now added "recently exposed cleavage plane" to clarify.

Comments by line #:

97 I think this is based on the observations of Davis and Davis (2018), right? I think it's worth referencing the relevant study again with this statement.

This reference has been added at line 109.

201–10 Please mention how the abundances across the transect are calculated. Are they calculated from the entire disk of each depth bin? Also please mention that a distance of zero refers to the tip of the specimen (and the corresponding crystal surface). I could figure it out by comparing figs. 5 and 6A, but an explicit statement in the text and corresponding figure captions (e.g. 6) would be very helpful.

This has been added at line 220. The discussion of measurements and modelling has now been split into two subsections (3.1 and 3.2).

228–9 Please elaborate on the statement "but deviates from the measured profile near the start of the high U peak because of accumulation of recoiled Pb."

This paragraph (now at line 245) has been revised at lines 260-261 and 264 to make the description clearer.

230 Wouldn't 206Pb recoiled from the left be relatively inconsequential compared to Pb recoiled from the 238U peak? The process should be described in more detail.

'Left' was mistakenly written instead of 'right'. The discussion has been corrected and clarified at lines 261-263.

274 Supplementary Data File 4? Supplementary Data File 3 reports elemental abundances. (GCHRON-2023-15-Supp Data File-3-R80_02479-v01-Full Mass spec Proxigram_plot.xlsx)

'Supplementary Data File 4' instead of 3 was mistakenly referred to at line 315 of the reviewed version. This has been corrected at new line 387. More description of the cluster data has also been given in lines 281-283 and 287.

306–9 This sentence is unclear, as Fig. 3 depicts model results. If this bears on the shape of high-to-low U transitions, it should be explained in more detail, or a different figure should be referenced.

Fig 3 should have been Fig 5. This has been corrected at new line 378.

Figs. 1 & 2 Ideally present the same samples in each panel A and panel B rather than alternating.

The figure labels are now consistent across the two figures.

Fig. 3 I'm curious that it's a Normal distribution with σ = 82 nm that fits the profile. The standard deviation must be a function of the average R (40 nm), but is this mathematical relationship straightforward/quantifiable?

Presumably it is but the mathematical reasoning behind the Central Limit Theorem is beyond the scope of the manuscript and probably the abilities of the authors, which is why Wikipedia is so useful. We have referenced Bárány and Vu, 2007 as the most recent publication on the subject.

Fig. 7 Please put panels A and B on equal x-axis scales to make comparing between the two panels easier.

In order to model 206Pb/238U over the range of measurement (panel A) it is necessary to use a U profile (panel B) that includes this range of measurement as well as extrapolated values above and below so that the calculation encompasses the total range of alpha recoil effects. The two are not meant to have the same scale, which is why they are split into separate panels. Panel B is extremely busy, as noted by a previous reviewer so we have used symbols that are as large and distinctive as possible. We feel that compressing it to the range of measured values in panel A would unnecessarily degrade its readability.

Fig. 9 Mention in the caption that the curve is a splined fit to help guide the eye and does not represent actual MSWD values.

This is now done in the caption.

Fig. 11 Use consistent directionality in panels A & B (x increases in different directions).

Fig 11 has been redrafted to accord with the reviewers suggestion, as well as to show other trace elements that are enriched in the clusters.