Dear Frank and coauthors,

Thank you for revising your submission based on the feedback from the three reviewers. I think these revisions have made your manuscript a stronger contribution. I have some minor points that I think you will be able to address quickly, after which I anticipate accepting your manuscript for publication.

FT inaccuracies as the dominant source of overdispersion: The revised version of the manuscript emphasizes/doubles down on your hypothesis that FT inaccuracies due to parent nuclide zonation are the dominant driver of age overdispersion (e.g., bolded text at line 389, added lines 498-499 in the discussion). As you point out in section 3.4 however, zonation will also lead to nonhomogeneous radiation damage within crystals, which could lead to complex helium diffusion kinetics and also produce age dispersion. I'm wondering if you can provide some rationale as to why you think FT corrections will be dominate over such kinetics effects? I suspect that the answer might require some nuance; e.g., radiation damage-induced complex diffusion kinetics might be much more important for old samples with protracted cooling histories, whereas FT inaccuracies might have a greater influence on rapidly cooled late Cenozoic samples.

**Thanks for pointing this out. We also think the appropriate response is fairly nuanced here. Most importantly, we are explicitly NOT trying to make an argument for the lack of importance of kinetic effects on age dispersion. Rather, we are trying to interpret this studies new data to its logical conclusion. By this we mean that the data clearly demonstrates that zonation driven Ft inaccuracy is another (non kinetic), potentially large magnitude uncertainty source that we have never been able to measure before. And we now can measure it. Because we do not intend to make an argument against the importance of kinetic effects, we would rather not introduce new text making that argument. So to clarify our thinking on this topic we have added a new short paragraph to the discussion shortly after the bolded hypothesis around line 389 that explains our thinking here.**

You also bring up implications for 4He/3He thermochronology in section 3.3.; I think it would be valuable to also mention here what role the parent nuclide mapping could have in the continuous ramped heating (CRH) approach that the Lehigh group has developed, which in my opinion is quite complementary to and more accessible than

4He/3He. At least some of the published CRH datasets document helium release characteristics that are complex but unlikely to be explained by parent nuclide zonation alone. For example (and I realize this paper literally just came out), Guo et al. (2024) document that samples from depths in the KTB borehole at which all helium should be diffusively lost in fact contain significant helium and have nonzero, overdispersed (U-Th)/He ages. This result cannot be explained by zonation-induced FT inaccuracies.

**Thank you for this helpful comment. We have added some text regarding CRH along with the section about 4/3, as well a few citations.**

Line 509: is there a word missing after 'known'? Or should excited lines be removed from the parentheses?

**Thanks for pointing this out, the parenthetical needed to be removed. We fixed this.**

Line 511: It's not clear why you transition to a bulleted list here – is there a sentence missing before the list?

**It works for us to remove the bullets and write out the lines in paragraph form.**

Figure A1: It's not clear in some cases which labels go with which plotted components (e.g., Ca pileup, Y, and Compton/Elastic). Can you relabel for clarity?

**We added a second frame in this figure so that we could both show the selected elemental components (A), as well as a more clearly labelled version without components shown (B).**

Thank you for taking the time to carry out these last edits, I look forward to receiving your revised manuscript.

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June 24, 2024

Guo, H., Zeitler, P.K. and Idleman, B.D., 2024. Behavior of helium diffusion sinks in apatite: Evidence from continuous ramped heating analysis of borehole and well-

characterized samples. Earth and Planetary Science Letters, 641, p.118828. https://doi.org/10.1016/j.epsl.2024.118828